TVET CERTIFICATE V in PRODUCTION TECHNOLOGY

SURFACE GRINDING MACHINE OPERATIONS

PRTGM501 **Operate surface grinding machine**

Competence

REQF Level: 5

Credits: 6

Learning hours: 60

Sector: Mining and Manufacturing

Sub-sector: Production Technology

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Purpose statement

This module describes the skills, knowledge and attitudes required to operate surface grinding machine and maintain its working principles. At the end of this module, participants will be able to analyze the work, select machine, equipment and tools, and operate surface grinding machine by insuring safe personal and machine safety precautions.

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Learning Unit 1 – Apply safety precautions for grinding machine

LO 1.1 – Identify PPE

- **Content/Topic 1: Types of PPE**

Definition

PPE is defined as all equipment designed to be worn, or held, to protect against a risk to health and safety for workers from hazard. This includes most types of protective clothing, and equipment such as eye, foot and head protection, safety harnesses, life jackets and high visibility clothing, respirators, goggles, face masks, gloves, footwear and aprons.

1. **helmet:** Those are for Head protection from any dropped material or tools to the head It is important to plumbers who need to spend time on rooftops, up ladders and scaffoldings.

Figure 1.helmet

2. Gloves

Use gloves whenever you are required to handle rough, scaly, or splintery objects. Special flameproof gloves are designed for gas and electric welding in order to limit danger and damage from sparks and other hot, flying objects. Be sure to follow all regulations prescribed for the use of gloves. Gloves must not be worn around rotating machinery unless sharp or rough material is being handled. If such is the case, extreme care should be used to prevent the gloves from being caught in the machinery.

Figure 2.Gloves

3. Safety Shoes

Safety shoes protect feet and prevent injury or loss of toes. Some safety shoes are designed to limit damage to your toes from falling objects. A steel plate is placed in the toe area of such shoes so that your toes are not crushed if an object falls on them. Other safety shoes are designed for use where

danger from sparking could cause an explosion. Such danger is minimized by elimination of all metallic nails and eyelets and the use of soles which do not cause static electricity

Figure 3.Safety shoes

4. Overcoat/overall

Overcoat /overalls, are made to protect human 's regular clothing. There are some workplaces which demands care and protection while using machinery and equipment. Organizations and Governmental institutes make sure that people at the workplace are wearing PPE (personal protective equipment).

Figure 4.overall

5. Ear Protection

Proper hearing protection is a must when working with or around certain types of power tools. Some tools are capable of producing dangerously high noise levels which, if ignored, can result in serious hearing loss or injury. Types of hearing protection include: a variety of disposal and re-useable ear plugs, ear muffs or ear canal caps Use hearing protection regularly.

Figure 5.Ear Protection

6. mask

A mask is usually a single use, disposable item that should be worn for protection against nuisance dusts such as saw dust, grain of chips, chalk and potting soil. These masks are generally not suitable for use with toxic or infectious substances.

Figure 6.mask

7. Goggles

Safety goggles are intended to shield the wearer's eyes from impact hazards such as flying fragments, objects, large chips, and particles. Goggles fit the face immediately surrounding the eyes and form a protective seal around the eyes. This prevents objects from entering under or around the goggles

Figure 7.Goggles

- **Content/Topic 2: Classification and function of PPE**

1. Respiratory protection

Respiratory Protective Equipment (RPE) is a particular type of Personal Protective Equipment (PPE), used to protect the individual wearer against inhalation of hazardous substances in the workplace air. technical requirements and rules of proper selection of various types of respiratory protection equipment i.e. filters, filtering half masks, face pieces, breathing apparatus and filtering escape

devices for protection against particles (including nanoparticles), gases, vapors and oxygen deficiency.

there are two general types of respiratory protective equipment (RPE), based on the principle by which protection is provided to the user. The two types are the following:

- Respirators (filtering equipment) i.e.: filter, gas filter, combined filter, filtering half-mask.
- Breathing apparatus (isolating equipment) i.e.: self-contained breathing apparatus (open-circuit and closed circuit), compressed line breathing apparatus.

Figure 8.Respiratory protection

2. Eye protection

Serves as a guard against the hazards of impact, splashes from chemicals or molten metal, liquid droplets (chemical mists and sprays), dust, gases and welding arcs. Eye protectors include safety spectacles, eye-shields, goggles, visors, welding filters, face shields and hoods. Make sure the eye protection has the right combination of impact/dust/splash/molten metal protection for the task and fits the user properly.

Figure 9.Eye protection

3. **Hearing protection**

Proper hearing protection is a must when working with or around certain types of power tools. Some tools are capable of producing dangerously high noise levels which, if ignored, can result in serious hearing loss or injury.

The main types of hearing protector are:

- **Earmuffs** – which should totally cover your ears, fit tightly and have no gaps around the seals. Don't allow hair, jeweler, glasses or hats interfere with the seal. Keep the seals and insides clean and don't stretch the headband.
- **Earplugs** – go right in the ear canal. Practice fitting them and get help if you are having trouble. Clean your hands before you fit them and don't share them.
- **Semi-inserts/canal caps** – are held in or across the ear canal by a band usually plastic. Check for a good seal every time you put them on.

When selecting hearing protectors, the employer should take account of the following:

- Protection should be sufficient to eliminate risks from noise but not so much protection that the wearers become isolated.
- Consider the work and working environment, e.g. physical activity, comfort and hygiene.
- Compatibility with other protective equipment, e.g. hard hats, masks and eye protection.

Hearing protectors should be issued to employees:

- where extra protection is needed above what has been achieved using noise control;
- as a short-term measure while other methods of controlling noise are being developed. The use of hearing protection should not be used as an alternative to controlling noise by technical and organizational means. The Regulations require an employer to:
- provide employees with hearing protectors and ensure they are used fully and properly when their noise exposure exceeds the upper exposure action values
- provide employees with hearing protectors if they ask for them and their noise exposure is between the lower and upper exposure action values
- identify hearing protection zones – areas of the workplace where access is restricted, and where wearing hearing protection is compulsory

4. **Hand and arm protection**

Gloves, gauntlets, mitts, wrist cuffs and armlets provide protection against a range of hazards such as abrasion, temperature extremes, cuts and punctures, impact, chemicals, electric shock, skin infection, disease or contamination. Avoid using gloves when operating machines such as bench drills where gloves can get caught. Barrier creams may sometimes be used as an aid to skin hygiene but are no substitute for proper PPE. Wearing gloves for long periods can lead to skin problems but using

separate cotton inner gloves may help prevent this. Some people may be allergic to materials used in gloves, e.g. latex.

5. **Head protection**

Includes industrial safety helmets to protect against falling objects or impact with fixed objects; industrial scalp protectors to protect against striking fixed obstacles, scalping or entanglement and caps and hairnets to protect against scalping and entanglement. Some safety helmets incorporate or can be fitted with specially designed eye or hearing protection and can include neck protection for use during welding. Do not use head protection if it is damaged – always have it replaced. (Bruce J. Black, 2015)

Content/Topic 3: Standard operation procedures

1. **GENERAL PROCEDURE Standard operation procedures (SOP)**

PPE is the least preferred control method to reduce the risk of exposure to a hazard. PPE shall be used when no other risk control methods are available or practicable, where required by legislation or to increase protection in conjunction with other control methods.

- ✓ PPE must only be used in the manner for which it is intended and must not be modified in any way
- ✓ PPE must be visually inspected before each use and any damaged PPE must not be used.
- ✓ PPE needing repair must be removed from use and appropriately tagged as unserviceable until it is suitably repaired or replaced. Reusable PPE must be cleaned in accordance with the manufacturer's instructions to maintain a high level of hygiene.
- ✓ Workers requiring PPE shall be trained in its correct use, maintenance, fault detection, disposal and storage requirements.
- ✓ PPE shall be stored in a dedicated, readily accessible area free from contaminants
- ✓ Sites must document and monitor any necessary PPE maintenance or replacement schedules
- ✓ Workers and contractors undertaking work on behalf of QUU at a non-QUU site shall comply with the PPE requirements of the non-QUU site, providing that they meet the minimum QUU PPE requirements.
- ✓ All workers shall ensure PPE is in serviceable conditions at all times.
- ✓ PPE must only be selected from the Preferred Supplier List

2. **HEAD PROTECTION**

Occupational Protective Helmets – Selection, Care and Use. Hard hats are required for all QUU workers, contractors and visitors in designated "Safety Helmet Areas" and during overhead works.

- Hard hats must be replaced every 2 years from issue date.

- Caps and other non-religious apparel must not be worn under hard hats.

3. Eye Protection

Recommended Practice for Occupational Eye Protection.

- Safety spectacles with side shields must be used in areas where the risk of eye damage from flying particles exists.
- Goggles must be used when extra eye protection is required.
- Face shields are considered additional protection for high temperatures, high density / impact particles or against chemical splashes and are not an alternative to goggles.
- Contact lenses must not be worn during welding or near welding activities, or whilst handling or working near dry or wet chemicals.
- Eye protection worn at night must be clear (non-tinted).
- Tinted safety glasses that offer UV protection are recommended when working outside during daylight hours.

4. HEARING PROTECTION

- QUU will establish and maintain a Hearing Conversation Program.
- Selection of hearing protection must be on the basis of attenuation of the different frequency component of the offending noise. WRAPs must include the required hearing protection.
- All QUU workers must conduct a personal fit check of the hearing protection device before each use to ensure it is appropriately fitted. QUU workers must be deemed competent to conduct a personal fit check.
- Hearing protectors must be worn throughout the period of exposure to noise above 85 dB(A) as per the WHS Noise Standard Operating Procedure PRO421.

5. HAND PROTECTION

Safety Footwear – QUU approved laced ankle high boots are compulsory at all work site locations except where the risk of foot injury has been assessed as being low (e.g. in an office environment). Boots must be worn in the manner instructed by the manufacturer.

6. RESPIRATORY PROTECTION

- Selection, Use and Maintenance of Respiratory Protective Devices. The risk assessment of the respiratory hazard must be made to ensure the correct degree of protection is provided (e.g. full face, half face, correct filters etc.).
- All asbestos removal tasks must document in the SWMS the requirement of Respiratory Protective Equipment (RPE).
- All QUU workers and contractors required to wear respiratory protection must undertake a facial fit test to identify the appropriate make and size of respirator for their face shape. Fit

testing of QUU workers is to be conducted by a competent person. Fit checks ensure the respirator is sealed over the bridge of the nose and mouth and that there is no gap between the respirator and the face.

- All QUU workers must conduct a personal fit check of the respiratory device before each use to ensure it is appropriately fitted. QUU workers must be deemed competent to conduct a personal fit check prior to the commencement of work

7. PROTECTIVE CLOTHING

- QUU workers are to wear the uniforms provided.
- Those workers who work with or near electricity must wear appropriately rated clothing.
- All QUU workers, visitors and contractors are to ensure that they wear button cuffed long shirts and long trousers to provide 50+ SPF sun protection. Cotton-only uniforms must be worn when performing welding or flame cutting tasks or in work areas where there is a risk of fire.
- High-visibility retro-reflective protective clothing must be worn at night, in conditions where visibility is poor (such as at dawn and dusk) or where there is a high risk of interaction between personnel and vehicles or mobile plant and equipment.
- Workers undertaking welding tasks must wear task-specific eyewear, gloves aprons and other PPE as identified by risk assessment.

8. DISPOSABLE PPE

To prevent the potential transmission of communicable, infectious and parasitic diseases, all employees working in the belt press or around sewage must wear the following:

- ✓ P2 disposable masks
- ✓ Disposable coveralls
- ✓ Disposable boot covers
- ✓ Occupational Protective gloves and Face shields where splashing may occur

For all workers involved in asbestos removal, appropriate disposal PPE will be provided on site. Please refer to WHS Hazard and Risk Management Standard Operating Procedure PRO363 for further details.

LO 1.2 – Identify safety precautions at workplace

Content/Topic 1: Classification of safety hazards at the workplace

1. Physical hazards

Of all the hazards in your workplace, physical hazards might the least obvious. Despite their name, physical hazards aren't always something that you can see or touch. Physical hazards affect workers in extreme weather conditions or harmful working environments. Workers who are exposed outside in the sun for a prolonged period of time can suffer physical hazards which can cause long term effects to their health. Physical hazards can be any factors within the environment that can harm the body without necessarily touching it.

A. Slippery floors

In general, Slips happen where there is too little friction or traction between the footwear and the walking surface or it is due to a loss of traction between the shoe and the walking surface or an inadvertent contact with a fixed or moveable object which may lead to a fall. There are a variety of situations that may cause slips, trips and falls.

- Wet or greasy floors
- Dry floors with wood dust or powder
- Uneven walking surfaces
- Polished or freshly waxed floors
- Loose flooring, carpeting or mats
- Transition from one floor type to another
- Missing or uneven floor tiles and bricks
- Damaged or irregular steps; no handrails
- Sloped walking surfaces
- Shoes with wet, muddy, greasy or oily soles
- Clutter
- Electrical cords or cables
- Open desk or file cabinet drawers
- Damaged ladder steps
- Ramps and gang planks without skid-resistant surfaces
- Metal surfaces – dock plates, construction plates
- Weather hazards – rain, sleet, ice, snow, hail, frost
- Wet leaves or pine needles

❖ **Prevention falls due to slips and trips**

Both slips and trips result from some a kind of unintended o

Both slips and trips result from some a kind of unintended or unexpected change in the contact between the feet and the ground or walking surface. This fact shows that good housekeeping, quality of walking surfaces (flooring), selection of proper footwear, and appropriate pace of walking are critical for preventing fall incidents.

- **Flooring**

Floor surfaces require sufficient grip to prevent slipping, especially in areas which may become wet or contaminated. The greater the thickness or viscosity of the contaminants, the greater the slip resistance of the flooring required to protect against slipping.

Changing or modifying walking surfaces is the next level of preventing slip and trips. Recoating or replacing floors, installing mats, pressure-sensitive abrasive strips or abrasive-filled paint-on coating and metal or synthetic decking can further improve safety and reduce risk of falling. However, it is critical to remember that high-tech flooring requires good housekeeping as much as any other flooring. In addition, resilient, non-slippery flooring prevents or reduces foot fatigue and contributes to slip prevention measures.

- **Footwear**

In workplaces where floors may be oily or wet or where workers spend considerable time outdoors, prevention of fall incidents should focus on selecting proper footwear. Since there is no footwear with anti-slip properties for every condition, consultation with manufacturers' is highly recommended.

B. Objects in walkways

Exterior Walkway Exterior walkways are natural surfaces, such as parking lots, fields, playing fields, paths, walks, or footpaths, or a combination thereof. Exterior walkway conditions that may be considered substandard and in need of repair include conditions in which pavement is broken, depressed, raised, undermined, slippery, uneven, or cracked to the extent that pieces may be readily removed.

Fall Slips and trips frequently lead to falls. Falls occur when the body shifts too far, throwing off one’s center of balance. A person is injured by the exchange of energy between the person falling and the objects upon which he or she is falling. The degree of injury depends upon the distance of the fall and how the energy is exchanged.

C. Unsafe or misused machinery

Hazards associated with working near or on machinery vary depending on the exact machine used but can include exposure to:

- moving parts (e.g., risk of injuries from entanglement, friction, abrasion, cutting, severing, shearing, stabbing, puncturing, impact, crushing, drawing-in or trapping, etc.)
- energy (e.g., electrical, electromagnetic, magnetic, etc.)
- heat or cold
- noise
- vibration
- radiation
- gas or liquid under pressure (e.g., injuries from injection or ejection by hydraulic systems, pneumatic systems, compressed air, paint sprayers, etc.)
- psychosocial hazards (e.g., stress, job content, work organization, cognitive factors, etc.)

Because there are many different types of machines and processes, a risk assessment should be conducted for each machine or situation, and in some cases, before each use. It may be necessary to involve individuals with specialized or technical expertise (i.e., engineer, safety professional, manufacturer, etc).

Machinery guarding and protection against other hazards

- **Electricity supply**

Where machinery has an electricity supply, it should be designed, constructed and equipped in such a way that all hazards of an electrical nature are or can be prevented, in accordance with national law and practice.

- **Fire**

Machinery should be designed and constructed in such a way as to prevent any risk of fire or overheating posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery.

- **Explosion**

Machinery should be designed and constructed in such a way as to prevent any risk of explosion posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery. Where machinery is intended for use in a potentially explosive atmosphere, it should be designed and manufactured to exclude or minimize ignition sources and comply with any national laws and standards applicable to explosive atmospheres.

- **Noise**

Machinery should be designed and constructed in such a way that risks resulting from the emission of airborne noise are eliminated or reduced to the lowest possible level, taking account of technical progress and the availability of means of reducing noise, in particular at source

- **Vibration**

Machinery should be designed and constructed in such a way that risks resulting from whole-body and hand-transmitted vibration produced by the machinery are reduced to the lowest possible level, taking account of technical progress and the availability of means of reducing vibration, in particular at source. The level of vibration and duration of exposure should not exceed the limits established by national laws and standards or internationally recognized standards. Vibration measurements should be used to quantify the level of exposures of workers and compared to nationally or internationally agreed exposure limits. The manufacturer of the machinery should provide information in the relevant instruction handbook concerning vibration transmitted by the machinery to the operator's hands, arms or whole body; the instructions should include information relating to the aspects of installation, assembly and use that can reduce exposure to vibration.

D. Excessive noise

Noise is any sound that the human ear finds unpleasing and disruptive to concentration. noise hazards are one of the most common workplace safety concerns. Our hearing is sensitive and it doesn't take much to temporarily impair or permanently damage it. When annoying sounds become noise hazards is when that noise begins interfering with communication and warning signals on the job and causes chronic health problems. These hazards occur when sounds workers are exposed to are greater than 85 decibels, weighted over an eight-hour shift. To give you an idea of what exactly 85 decibels is: the rustling of leaves is typically 10 decibels, a normal conversation is between 50-60 decibels, a chainsaw or drill produces 110 decibels while a jet engine is near the top of end of the scale producing about 140 decibels of sound.

Eliminating Noise Hazards

- **Machine Maintenance**

The number one cost effective engineering control used to reduce industrial noise hazards is to make sure that all machinery being used is properly maintained. Machinery where metal on metal contact is present should be lubricated regularly. This type of 'preventative maintenance' can extend the life of machinery and save production time from unexpected failures.

- **Limits shifts**

Limiting exactly how long workers are exposed to noise hazards is an administrative control that can greatly reduce negative health effects. This can be an alternative to running a costly hearing conservation program for employees, but as this case study from the American Industrial Hygiene Association (AIHA) will tell you, the costs associated with the time spent managing noise hazards will always outweigh the costs of attempting to fix worker's hearing.

- **Enclose or Isolate the Noise**

This is one way that a little engineering combined with a little capital can result in the reduction or elimination of a noise hazard. If there are large non-human operated machines in a work area, when possible, move these machines away from workers or into less populated rooms. If moving the machinery isn't an option, an enclosure can be built and appropriately labeled to reduce noise levels. If humans are required as operators, an enclosure with an entrance can be constructed and proper PPE provided. Working in these enclosures may require a shorter shift, if the sound produced inside the enclosure requires it.

- **Properly Used PPE**

This is the last resort method to deal with a noise hazards. It does not address the problem at the source but acts as a last line of defense for your ears. Proper PPE to protect hearing includes earplugs and ear muffs, often worn together. PPE should be used either in response to low level noise hazards or as a temporary solution until the source of the noise can be controlled or modified

E. Poor lighting

Poor lighting can cause several problems such as:

- Insufficient light – not enough (too little) light for the need.
- Glare – too much light for the need.
- Improper contrast.
- Poorly distributed light.
- Flicker.

Poor lighting can be a safety hazard – misjudgment of the position, shape or speed of an object can lead to incidents and injury.

Poor lighting can affect the quality of work, specifically in situation where precision is required, and overall productivity.

Poor lighting can be a health hazard – too much or too little light strains eyes and may cause eye discomfort (burning, etc.) and headaches.

When light is poorly distributed, parts of the ceiling and general surroundings will seem dark and gloomy. Substantial differences in light levels force your eyes to readjust when moving from one light level to the other. Workers may find it difficult or impossible to see properly.

You can detect poorly distributed light by:

- Looking for dark areas and uneven lighting.
- Using a light meter to check the illumination at various points throughout the workplace. With uniform general lighting, the minimum reading should not be less than two-thirds of the average value.

Correct for poorly distributed light by:

- Supplementing or replacing light fixtures with ones that distribute some light upwards.
- Painting ceiling and walls in light colors that reflect light.
- Cleaning ceilings, walls and light fixtures.

To detect insufficient light, try the following:

- Measure the average illumination throughout the workplace. Compare this to the recommended levels.
- Look for shadows, especially over work areas and on stairways.
- Ask workers if they suffer from eye strain or squint to see, or get frequent headaches.

Workers should sit in their normal working positions during measurement to give you accurate results.

To correct insufficient light:

- Replace bulbs on a regular schedule. Old bulbs give less light than new ones, so replace them before they burn out. Follow manufacturers' instructions.
- Clean light fixtures regularly. Dirt on light fixtures reduces the amount of light given off. Light fixtures with open tops allow air currents to move dust up through the fixtures so dust and dirt do not accumulate on them.
- Add more light fixtures in appropriate places.
- Paint walls and ceilings light colors so light can be reflected.
- Use more reflected light and local lighting to eliminate shadows. For example, a covered light mounted under a transparent guard on a grinding wheel provides the added light needed to clearly see the task.
- Do not position the work station with the light fixture directly behind worker.

F. Fire

There may be fire hazards associated with exposures that are unique to your particular type of operation. For example, in the metals industry, the following hazards may exist:

- Combustible metal dusts.
- Pyrophoric materials (substances that ignite instantly upon exposure to oxygen).
- Water-reactive metals.
- Combustible and flammable liquids.
- Dip tanks using hazardous materials.
- Heat-treating operations

All employers must develop effective fire safety systems to ensure that fire hazards in the workplace are suitably managed. This includes:

- staff training
- inspection and maintenance of plant and equipment
- maintaining good levels of housekeeping
- having effective waste management systems in place
- employees understanding and accepting their roles and responsibilities
- developing defect reporting systems.

Fire prevention The best prevention is to stop a fire starting

- ✓ where possible use materials which are less flammable
- ✓ minimise the quantities of flammable materials kept in the workplace or store
- ✓ store flammable material safely, well away from hazardous processes or materials, and where appropriate, from buildings
- ✓ warn people of the fire risk by a conspicuous sign at each workplace, storage area and on each container
- ✓ some items, like oil-soaked rags, may ignite spontaneously; keep them in a metal container away from other flammable material
- ✓ before welding or similar work remove or insulate flammable material and have fire extinguishers to hand
- ✓ control ignition sources, e.g. naked flames and sparks, and make sure that 'no smoking' rules are obeyed
- ✓ do not leave goods or waste to obstruct gangways, exits, stairs, escape routes and fire points
- ✓ make sure that vandals do not have access to flammable waste materials
- ✓ comply with the specific precautions for highly flammable gas cylinders such as acetylene
- ✓ after each spell of work, check the area for smouldering matter or fire
- ✓ burn rubbish in a suitable container well away from buildings and have fire extinguishers to hand
- ✓ never wedge open fire-resistant doors designed to stop the spread of fire and smoke
- ✓ have enough fire extinguishers, of the right type and properly maintained, to deal promptly with small outbreaks of fire.

2. Chemical hazard

Chemical hazards are present when a worker is exposed to any chemical preparation in the workplace in any form (solid, liquid or gas). Some are safer than others, but to some workers who are more sensitive to chemicals, even common solutions can cause illness, skin irritation, or breathing problems.

Chemicals are present in every workplace. Even in the cleanest, most modern office, employees may be routinely exposed to inks, toners and adhesives not to mention a wide range of chemicals used in cleaning and maintenance. Chemicals can exist in many forms:

- Dust, fumes, fibres, powders
- Liquids
- Gases, vapours, mists.

Any chemical, in either gas, liquid or solid form, that has the potential to cause harm is referred to as a hazardous or dangerous chemical. Such chemicals include those:

- Brought directly into the workplace and handled, stored and used for processing e.g. solvents, cleaning agents, glues, resins, paints.
- Generated by a process or work activity e.g. fumes from welding/ soldering, dust from machining of wood, flour dust, solvents.
- Generated as waste or residue e.g. fumes from soldering iron, carbon monoxide from engine or motor exhausts.

Proper consideration of safety in handling and disposal of chemicals should be observed. The following points must be observed for this purpose.

1. Carefully read the ingredient list of any product or chemical you use. The label can also tell you how to use the proper protective equipment, how to handle the chemicals, and how to respond to emergencies. The label will tell you if the substance is flammable, corrosive, or may cause cancer. It will also state whether you should use eye protection, gloves, or other equipment.
2. All hazardous and toxic chemicals (acids, alkalines, some salts, and organics) must be identified. Material information sheets must be acquired and specific warning sign must be shown for potentially dangerous chemicals.
3. In transport and transfer of chemicals, proper handling precautions provided by manufacturer must be observed. All containers for storage should be chemical resistant, leak free, and with good caps of stoppers.
4. Gloves and goggles should be used while handling chemical of toxic nature. It is preferred that at least two persons should be present at all time while working with chemicals.
5. Heating flammable solvent may cause fire. Such work must be carried out in a well-ventilation fume-cupboard.
6. When your body is contact with the chemical, flush your body with plenty of fresh water and report the accident to the laboratory technician.

7. Waste products and disposals must be discharged with proper neutralization. If the material to be disposed is extremely toxic or poisonous, the material should be kept in closed container and sent to appropriate agency for proper disposal.
8. Store materials properly, as directed on their labels. Flammable chemicals should be stored in a cool, dry place away from heat and sunlight. Some chemicals like acids must be stored separately from each other.

- **Content/Topic 2: Machine shop safety rules**

1. Always listen carefully to the teacher and follow instructions.
2. Do not run in the workshop, you could 'bump' into another pupil and cause an accident.
3. Know where the emergency stop buttons are positioned in the workshop. If you see an accident at the other side of the workshop you can use the emergency stop button to turn off all electrical power to machines.
4. Always wear an apron as it will protect your clothes and hold loses clothing such as ties in place.
5. Wear good strong shoes. Training shoes are not suitable.
6. When attempting practical work all stools should be put away.
7. Bags should not be brought into a workshop as people can trip over them.
8. When learning how to use a machine, listen very carefully to all the instructions given by the teacher. Ask questions, especially if you do not fully understand.
9. Do not use a machine if you have not been shown how to operate it safely by the teacher.
10. Always be patient, never rush in the workshop.
11. Always use a guard when working on a machine.
12. Keep hands away from moving/rotating machinery.
13. Use hand tools carefully, keeping both hands behind the cutting edge.
14. Report any damage to machines/equipment as this could cause an accident.

LO 1.3 – Identify safety precautions of surface grinding machine

- **Content/Topic 1: Surface grinding machine safety precautions**

1. Always wear safety glasses or goggles
2. Wear hearing protection
3. Use the grinding wheel suitable for the job
4. Make sure machine guards are in place
5. Never attempt to change speed when the machine is running
6. Never leave the machine alone when it is running

General Safety Precaution Guidelines while Working on Grinding Machines

1. Grinding wheels badly worn or cracked should be replaced
2. The grinding wheel should be properly balanced while mounting.
3. One should ensure that no combustible or flammable materials are nearby that could be ignited by sparks generated by grinding wheels during grinding operations.
4. One should allow the grinding wheel to reach full speed before stepping it into the grinding position. Faulty wheels usually break at the start of an operation.
5. Always use the face of the grinding wheel that is meant for grinding.
6. One should slowly move job-pieces across the face of wheel in a uniform manner. This will keep the wheel sound.
7. Grinding wheels should be checked properly timely for soundness. Suspend the wheel on a string and tap it. If the wheel rings, it is probably sound.
8. One should not use a grinding wheel that has been dropped or dealt with a heavy blow, even if there is no apparent damage.
9. Before using a new grinding wheel, let it run for a few seconds at the full speed to check and make sure that it is perfectly balanced.
10. One should not operate the grinding wheel beyond its bursting speed.
11. Follow the manufacturer's instructions for the correct use of the grinding wheels
12. Always wear goggles during grinding or allied processes.

Learning Unit 2 – Analyze the work to be done

LO 2.1 – Interpret work drawing

- **Content/Topic 1: Work drawing interpretation**

1. Sketches

We will treat "**sketching**" and "**drawing**" as one. "S**ketching**" generally means freehand drawing. "**Drawing**" usually means using drawing instruments, from compasses to computers to bring precision to the drawings.

Definitions

Drawing is a graphic representation of an object, or a part of it, and is the result of creative thought by an engineer or technician. When one person sketches a rough map in giving direction to another, this is graphic communication. Graphic communication involves using visual materials to relate ideas. Drawings, photographs, slides, transparencies, and sketches are all forms of graphic communication.

- ✓ **Drawing** usually means using drawing instruments, from compasses to computers to bring precision to the drawing.
- ✓ **Sketching** generally means freehand drawing.

2. Views

views that are often present in a manufacturing drawing. Each serves a certain purpose. Bear in mind that adding views should follow the same logic as dimensioning – include as little as possible and as much as necessary.

A tip for good engineering practice – only include a view if it contributes to the overall understanding of the design.

- **Isometric View**

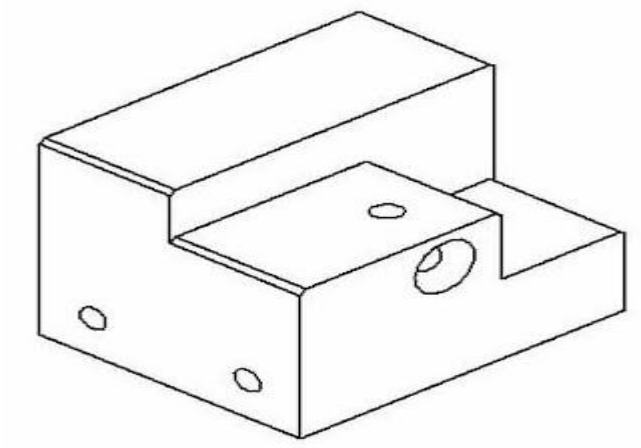


Figure 10.Isometric View

Isometric drawings show parts as three-dimensional. All the vertical lines stay vertical (compared to front view) and otherwise parallel lines are shown on a 30-degree angle.

The lines that are vertical and parallel are in their true length. Which means you can use a ruler and the scaling of the drawing to easily measure the length straight from a paper drawing, for example. The same does not apply to angled lines.

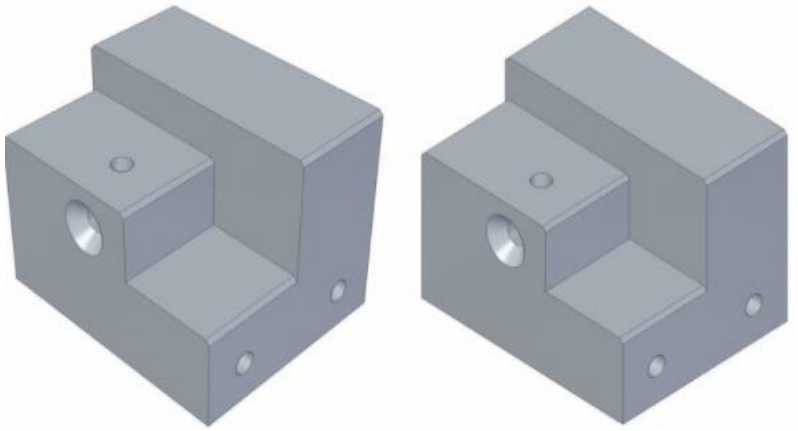


Figure 11.Left – perspective; right – isometric

It is important to distinguish the isometric view from a perspective view. A perspective view is an artistic one that represents an object as it seems to the eye. Engineers stay true to the dimensions rather than optical illusions.

- **Orthographic View**

This is the bread and butter of an engineering drawing. An orthographic view or orthographic projection is a way of representing a 3D object in 2 dimensions.

Thus, a 2D view has to convey everything necessary for part production. This kind of representation allows avoiding any kind of distortion of lengths.

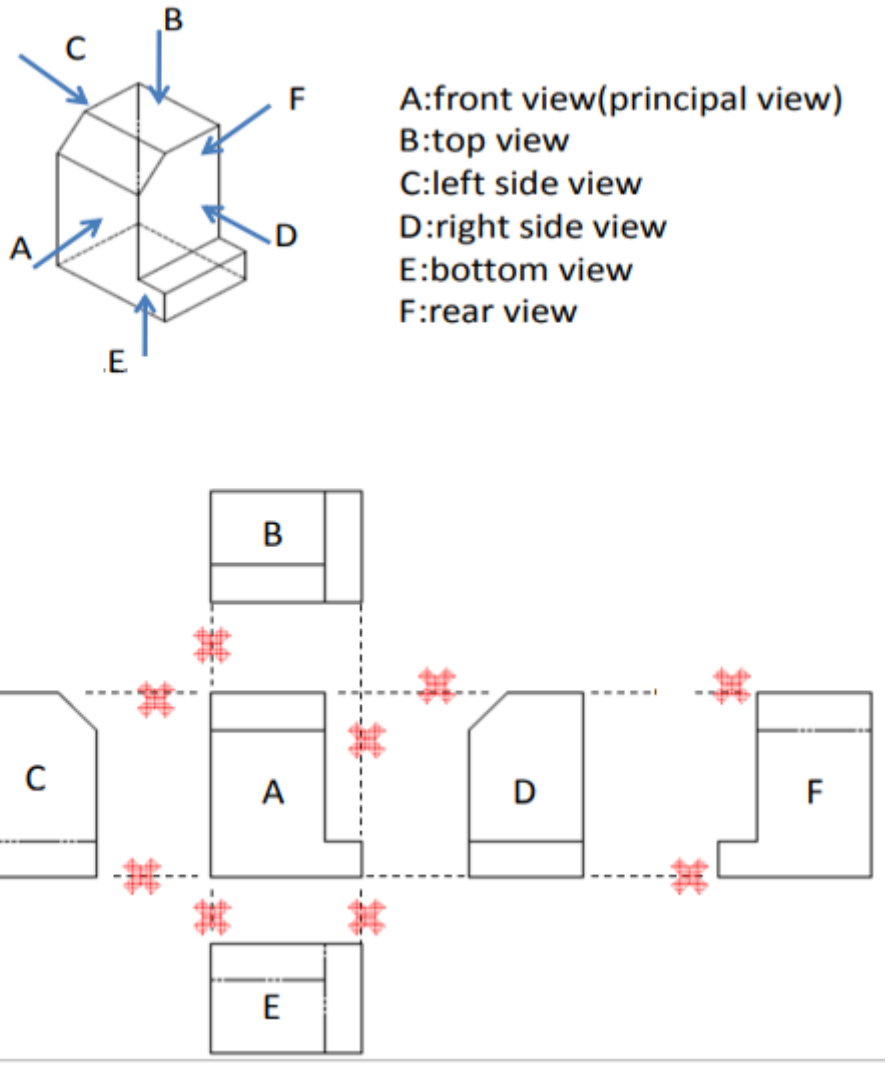


Figure 12.Orthographic projection

The positioning of the views differs a bit regionally. For example, look at the image below to compare the US and ISO layouts.

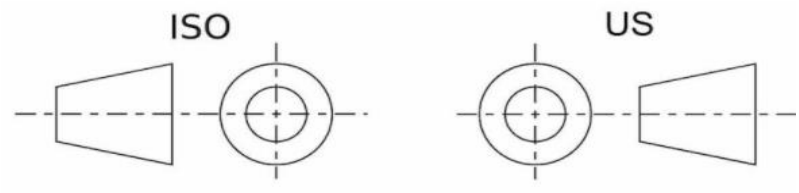


Figure 13.Symbol of third angle projection

The one on the left is called first-angle projection. Here, the top view is under the front view, the right view is at the left of the front view, etc. The **ISO** standard is primarily used in Europe.

On the right, you can see a third-angle projection. The right view is on the right, top view on the top of the front view, etc. This system is especially popular in the **US** and Canada.

Section View

A section view can easily display some of the part features that are not evident when looking just from the outset. Cross section is the preferred option compared to hidden lines as it brings more clarity. The cross hatching feature is and indicator for cross sectional views.

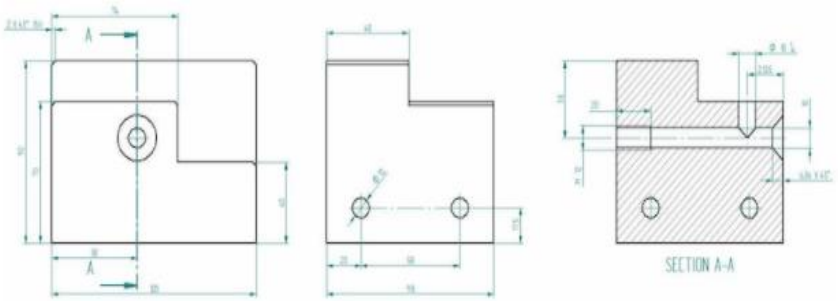


Figure 14. Section View

Detail View

The detail view gives us a close-up of a selected section of a larger view. This can be especially useful if an otherwise large part includes many important dimension in a small area. Using the detail view improves the readability of these measurements.

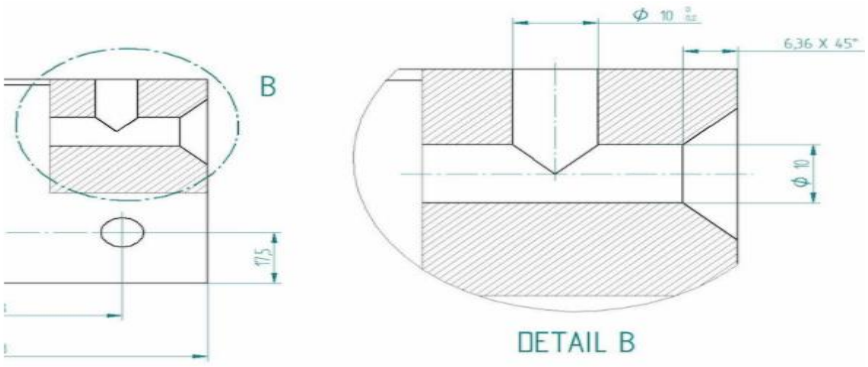


Figure 15. Detail View

3. Scale

The proportion by which we either reduce or increase the actual size of the object on a drawing is known as drawing to scale or simple scale.

Scale is the ratio of the linear dimension of an element of an object as represented in the drawing, to the real linear dimension of the same element of the object itself. Wherever possible, it is desirable to make full size drawings, so as to represent true shapes and sizes. If this is not practicable, the largest possible scale should be used. While drawing very small objects, such as watch components and other similar objects, it is advisable to use enlarging scales. The scales are either flat or triangular and the material used in their construction may be wood, celluloid, metal, etc. In drawing, scale should not be selected arbitrarily, but standard recommended scales should be adopted as far as

possible. If all drawings are made to the same scale should be indicated in or near the title block. Where it is necessary to use more than one scale on a drawing, the main scale only should be shown in the title block and all the other scales, adjacent to the item reference number of the part concerned or near the drawings.

a) **Uses of scale**

The following are the main uses of scales in engineering practice

6. The scales are used to prepare reduced or enlarged (increase) size drawings
7. The scales are used to set off dimensions
8. The scales are used to measure distances directly.

b) Sizes of scale

1. Full size scale

The scale in which the actually measurements of the object are drawn to the same sizes on the drawing is known as full size scale. It is written on the stick as under

1:1 – drawing made to actual size

2. Reducing scale: The scale in which the actual measurements of the object are reduced to some proportion is known as reducing scale. (E.g. vehicles, machines, plants, bridges)

The standard reducing proportions are:

1:2 – Drawing made to one half of the actual size

1:5 – drawing made to one fifth of the actual size

1:10 – drawing made to one tenth of the actual size

1:20 – drawing made to one twentieth of the actual size

1:50 – drawing made to one-fiftieth of the actual size

1:100 – drawing made to one-hundredth of the actual size

3. Enlarging scale: the scale in which the actual measurements of the object are increased in some proportion is known enlarging scale (e.g. elements of optical industry). The standard proportions are:

2:1 – drawing made to twice the actual size

5:1 – drawing made to five times the actual size

10:1 – drawing made to ten times the actual size.

c) **Recommended scales**

The recommended scales for use on technical drawings are given in Table below. The scale and the size of the object in turn, will decide the size of the drawing.

Table Recommended scales

Category	*Recommended Scales*		
Enlarged scales	50:1	20:1	10:1
	5:1	2:1	
Full size			1:1
Reduced scales	1:2	1:5	1:10
	1:20	1:50	1:100
	1:200	1:500	1:1000
	1:2000	1:5000	1:10000

Figure 16.recommended scales

Generally, it is easier to produce and understand a drawing if it represents the true size of the object drawn. This is of course not always possible due to the size of the object to be drawn, that is why it is often necessary to draw enlargements of very small objects and reduce the drawing of very large ones, this is called "SCALE".

However, it is important when enlarging or reducing a drawing that all parts of the object are enlarged or reduced in the same ratio, so that the general configuration of the object is saved.

Thus, scales are multiplying or dividing of dimensions of the object. The scale is the ratio between the size represented on the drawing and the true size of the object.

Scale= Dimension to carry on the drawing ÷ True Dimension of the object.

Examples:

1. Dimension carried on the drawing = 4mm.

True dimension= 40mm

Scale = 4 ÷ 40 = 1:10

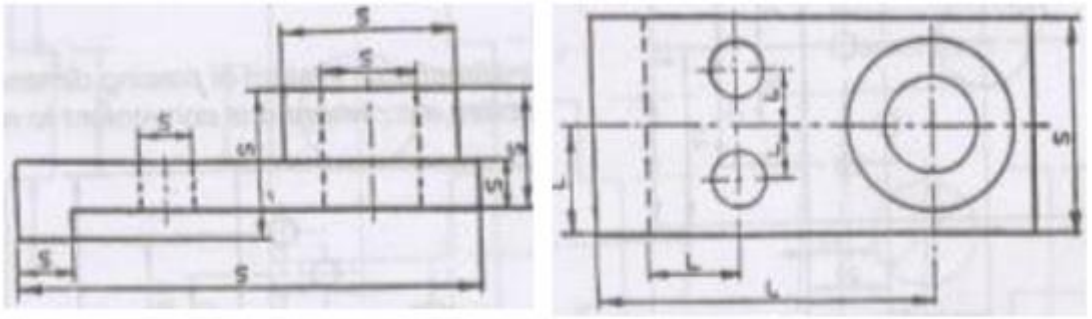
4. **Dimension**

A drawing of a component, in addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features/ information on a drawing, using lines, symbols, figures and notes is called dimensioning.

Types of dimension

a) Size dimension

The dimensions which indicate various sizes of the object such as length, breadth, diameter, etc are known as size dimensions. These dimensions are represented by the letter "S" as shown in figure

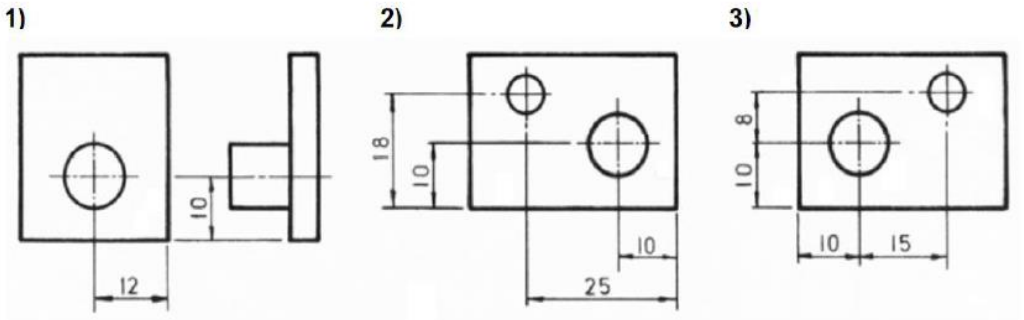


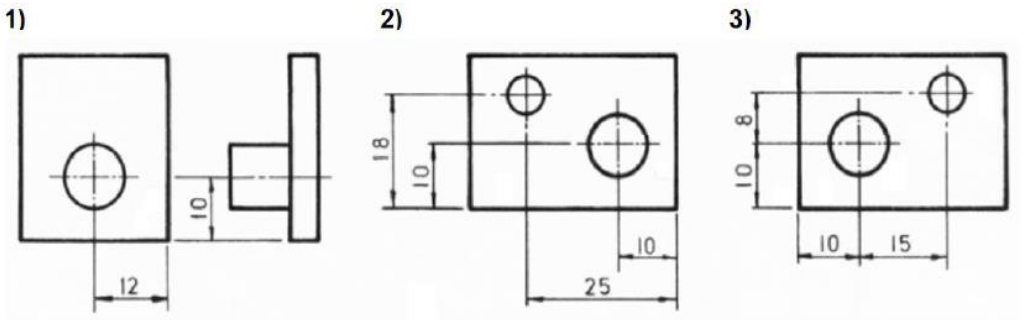
a) Size dimensions b) Location dimensions

Figure 17.Size dimension

b) Location dimensions

The dimensions which locate the position of one feature with respect to the other feature are known as location dimensions. Distance between the centres lines of the holes from the edge of features are given by location dimensions. These dimensions are marked by letter "L" as shown in the figure below.





Elements of dimensioning

The element of dimensioning includes the projection line, leader line, termination of dimension line, symbols and dimension itself. These are illustrated in above figure.

For dimensioning a drawing, four basic elements are used:

1. **Dimension line** is the thin solid line which shows the extent and direction of a dimension.
2. **Arrows** are placed at the ends of dimension lines to show the limits of the dimension. ′

3. **Extension line** is the thin solid line perpendicular to a dimension line indicating which feature is associated with the dimension.
4. **Leader line** is the thin solid line used to indicate the feature with which a dimension, note, or symbol is associated.
5. **Tolerance** is the amount a particular dimension is allowed to vary.
6. **Plus, and minus dimensioning** is the allowable positive and negative variance from the dimension specified.

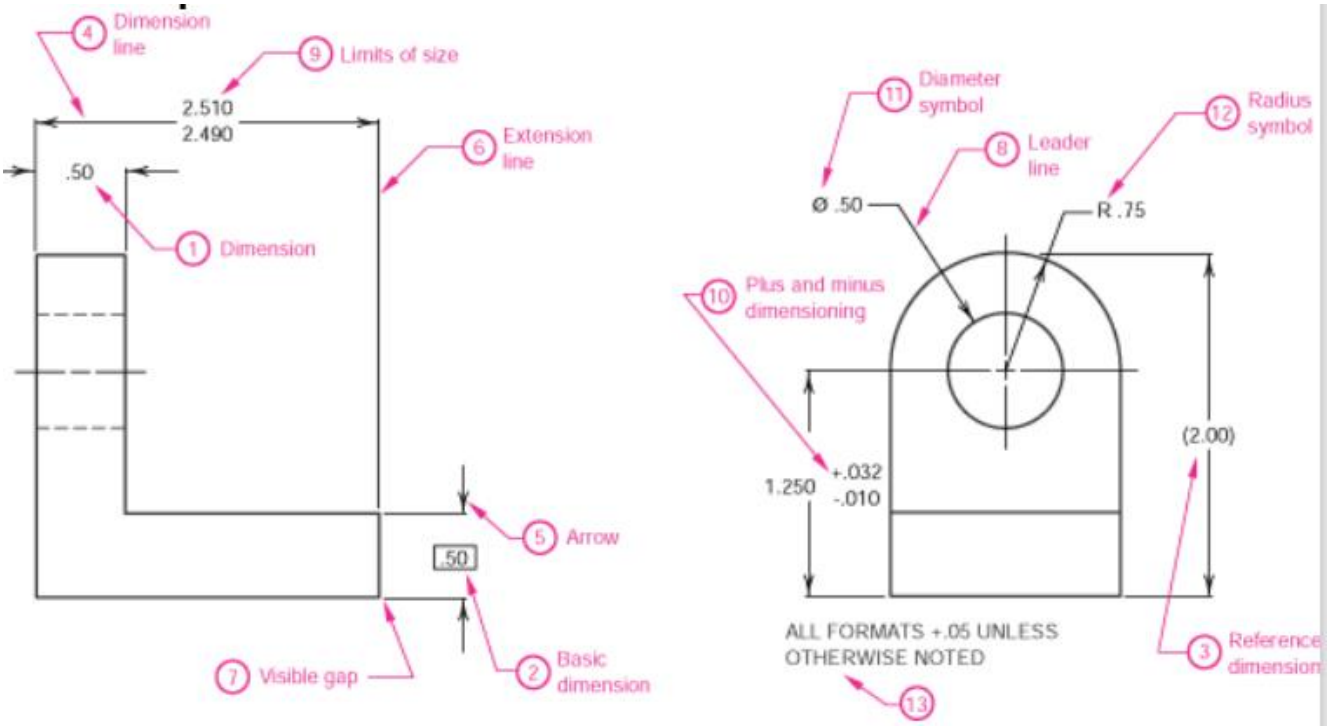


Figure 18.element dimension

Dimensioning symbols

Description	Symbol	Usage
diameter	ϕ	Put before dimension value of diameter.
radius	R	Put before dimension value of radius.
spherical diameter	Sϕ	Put before dimension value of diameter of sphere.
spherical radius	SR	Put before dimension value of radius of sphere.
square	□	Put before dimension value of square.
thickness of board	t	Put before dimension value of thickness of board.
45 degree chamfers	C	Put before dimension value of 45° chamfers.

5. Assembly

Many engineers' drawings make the mistake of trying to include all the information about each individual part in an assembly drawing. To avoid this, remember the purpose of these engineering drawings during the creation process – they must make the assembling easy.

Exploded views, section views, numbered parts, general dimensions, cut outs, detail views (or close-ups) are all tools you can use to achieve this goal.

It should be clear where each part goes and how it is attached – whether it needs welding, bolted connections, riveting or something else. The bill of materials is there to help you, so make sure the information available there is correct regarding part numbers, names and quantities.

Assembly Drawings demonstrate how a number of separate subassembly drawings, detailed parts, standard components and specifications come together in a unified assembly.

Assembly Drawings must provide sufficient information to enable the assembly of a component.

- Assembly Drawings must have a number of views to show how parts fit together.
- Section views to show how parts fit and to eliminate hidden detail.
- Dimensions to indicate range of motion or overall size of assembly for reference purposes.
- Individual components identified with balloons and leader lines.
- Parts list (or BOM – Bill of Materials) relates to balloon numbers on drawing
- Revision table
- May require multiple views on separate page for very large assemblies

Enough Orthogonal Views

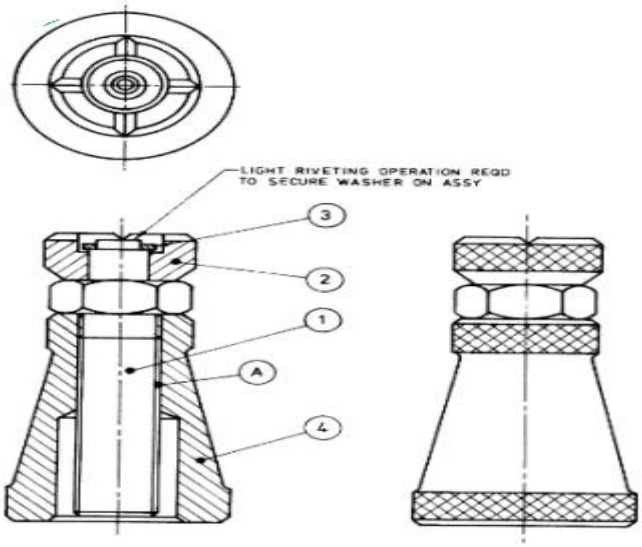


Figure 19.Enough Orthogonal Views

Enough equally spaced views are needed in order to demonstrate to the reader of the drawing how the assembly fits together

Dimensions

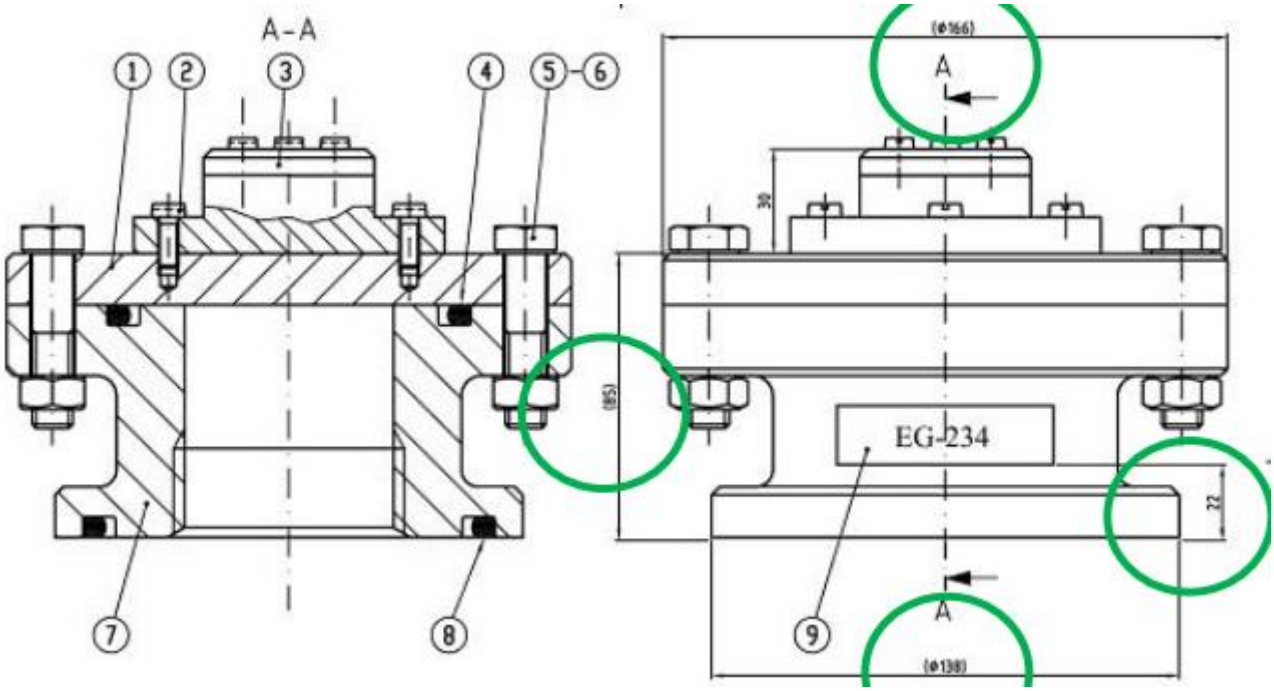


Figure 20.Dimensions

In the Assembly Drawing above notice how dimensions are used to give an overall representation of size. Dimensions are not included on individual detail components or standard hardware.

Parts List

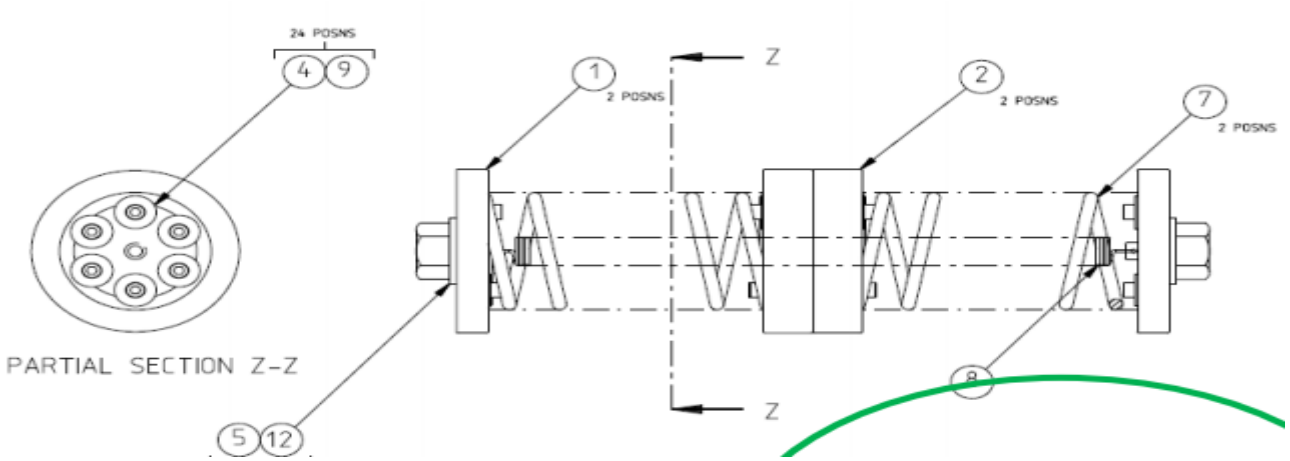


Figure. 21Parts List

In the assembly drawing above notice the arrangement of the numbering of the individual sub assemblies, components and standard hardware. They are numbered from the bottom of the parts list upwards. The relevant quantities and materials (missing) should also be stated.

Sub Assembly Drawings

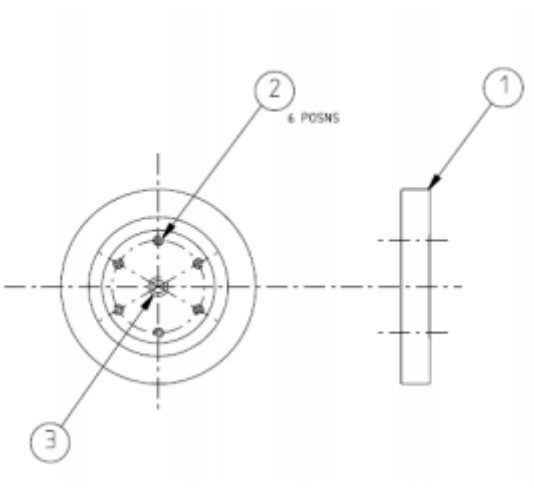


Figure 22.Sub Assembly Drawings

Sectional Views on Assembly Drawings

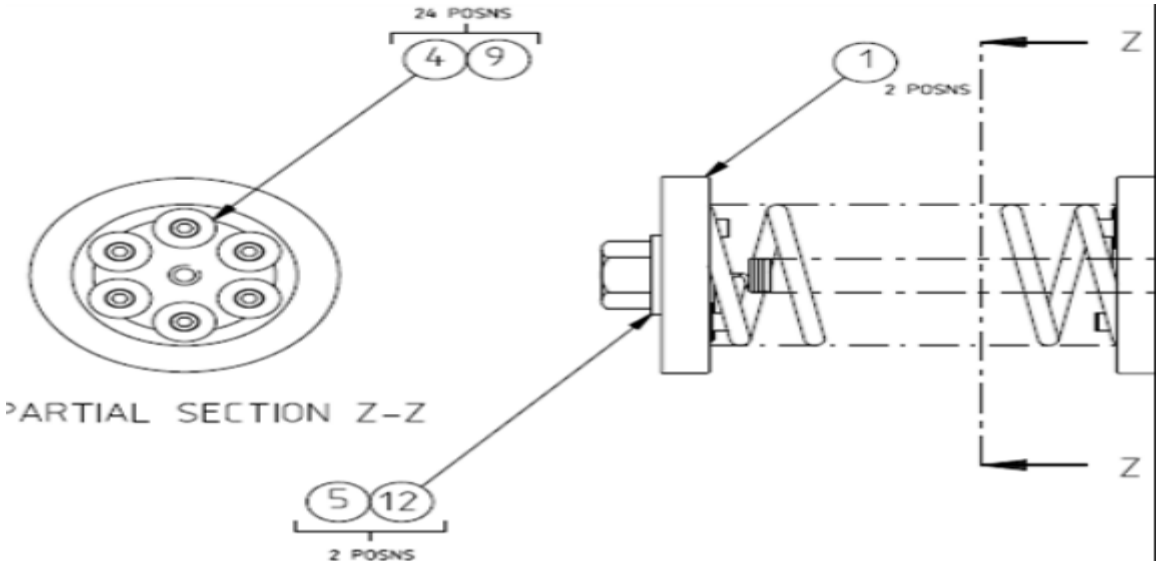


Figure 23. **Sectional Views on Assembly Drawings**

Working or Detailed Assembly

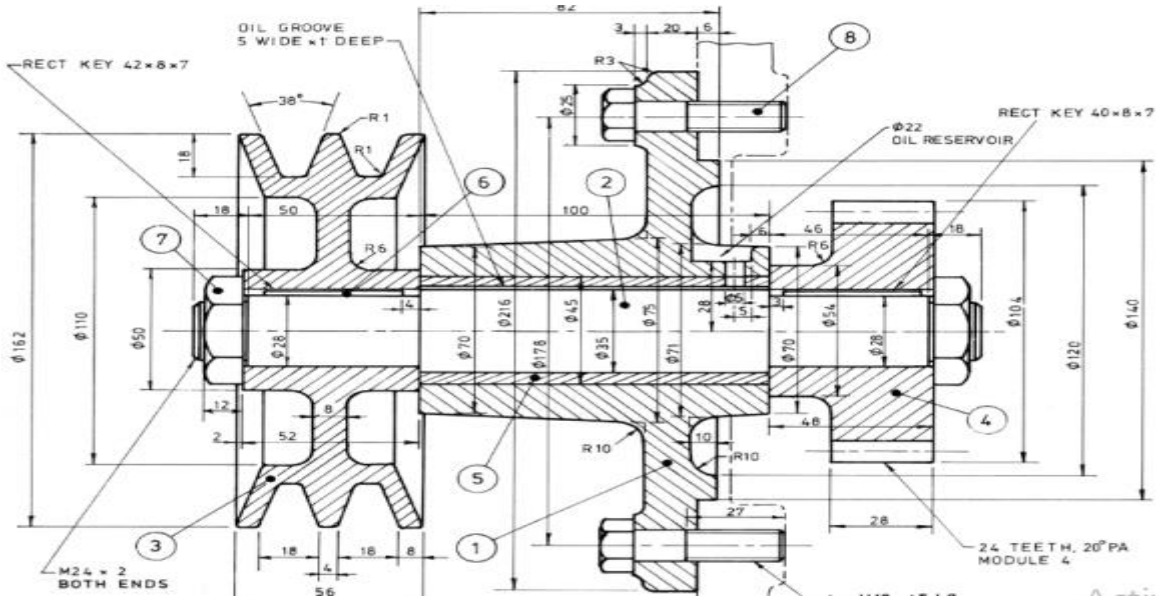


Figure 24.Working or Detailed Assembly

Working or Detailed Assembly Drawings are a combined detail and general assembly drawing which fulfils the function of both types.

- Some Features of Working Assembly or Detailed Assembly Drawings
- Only simple assemblies are drawn in this manner.
- Information is cluttered.
- Not recommended as the tasks of manufacture and assembly are very different and may be split across vendors.
- Only use when you have no option e.g. one part to be manufactured requires the co existence of another

6. Drawing symbols

SYMBOL FOR:	ASME Y14.5M–1994	ISO	CAN/CSA-B78.2–M91
STRAIGHTNESS			
FLATNESS			
CIRCULARITY			
CYLINDRICITY			
PROFILE OF A LINE			
PROFILE OF A SURFACE			
ALL AROUND–PROFILE			
ANGULARITY			
PERPENDICULARITY			
PARALLELISM			
POSITION			
CONCENTRICITY/COAXIALITY			
SYMMETRY			
CIRCULAR RUNOUT			
TOTAL RUNOUT			
AT MAXIMUM MATERIAL CONDITION			
AT LEAST MATERIAL CONDITION			(PROPOSED)
REGARDLESS OF FEATURE SIZE	NONE	NONE	NONE
PROJECTED TOLERANCE ZONE			
DIAMETER			
BASIC DIMENSION			
REFERENCE DIMENSION			
DATUM FEATURE		OR	
DATUM TARGET			
TARGET POINT			
DIMENSION ORIGIN			
FEATURE CONTROL FRAME			
CONICAL TAPER			
SLOPE			
COUNTERBORE/SPOTFACE		(PROPOSED)	
COUNTERSINK		(PROPOSED)	
DEPTH/DEEP		(PROPOSED)	
SQUARE (SHAPE)			
DIMENSION NOT TO SCALE	15	15	15
NUMBER OF TIMES/PLACES	8X	8X	8X
ARC LENGTH	105	105	105
RADIUS	R	R	R
SPHERICAL RADIUS	SR	SR	SR
SPHERICAL DIAMETER	S∅	S∅	S∅
BETWEEN		NONE	(PROPOSED)

7. Tolerance limit

A tolerance is the total amount by which a given dimension may vary. A tolerance should be expressed in the same form as its dimension. The tolerance of a decimal dimension should be expressed by a decimal to the same number of places.

8. Fits

Fit types

Clearance fit occurs when two tolerance mating parts will always leave a space or clearance when assembled. shaft is always slightly smaller than the hole.

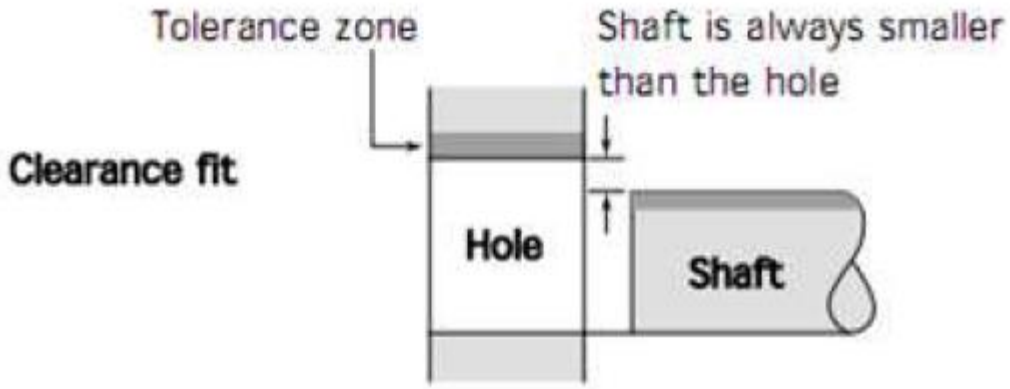


Figure 25.Clearance fit

Interference fit occurs when two tolerance mating parts will always interfere when assembled.

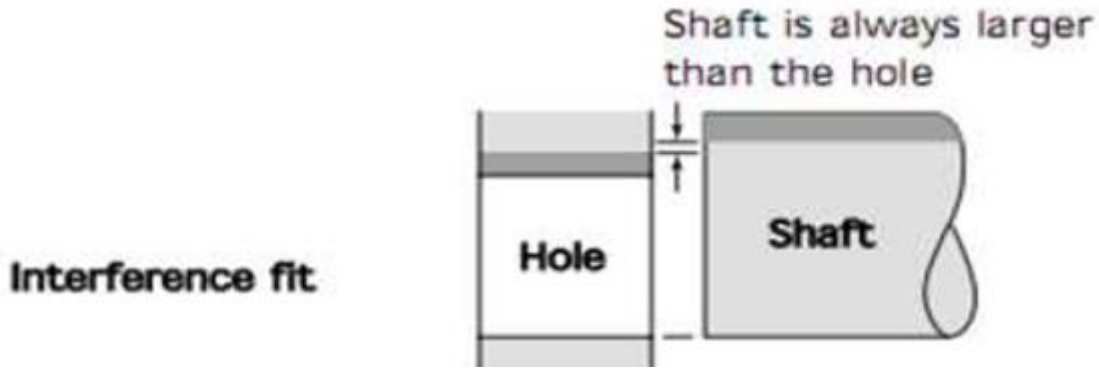


Figure 26.Interference fit

Transition fit occurs when two tolerance mating parts will sometimes be an interference fit and sometimes be a clearance fit when assembled.

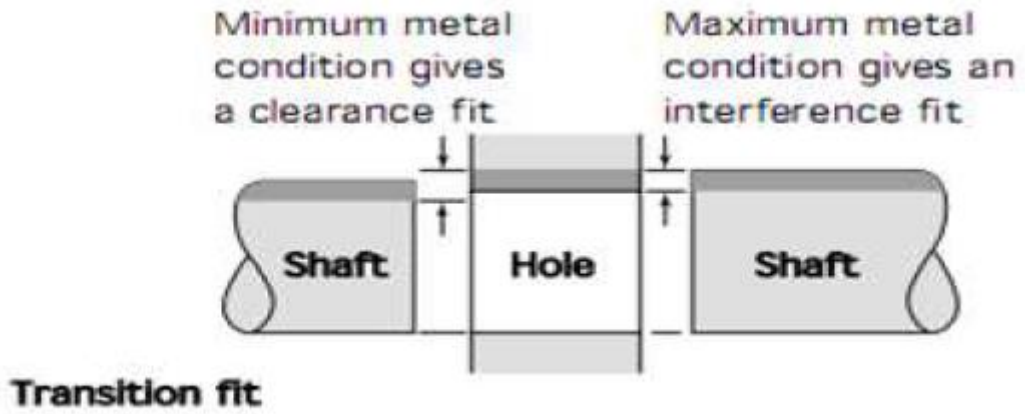


Figure 27.Transition fit

9. Roughness and smoothness symbols

Surface Finish Symbols:

The surface texture of a component often affects its performance. Therefore, one has to specify the surface finish that is required for acceptable performance. Figure illustrates the surface texture features, and how the finish mark is used for communicating the desired finish.

The different terms used in describing the surface finish can be explained as follows:

- **Surface Texture** is the variation in the surface in the form of roughness, waviness, lay, and flaws.
- **Roughness** refers to the finest of the irregularities in the surface. They are caused by the process(es) used to smooth the surface.

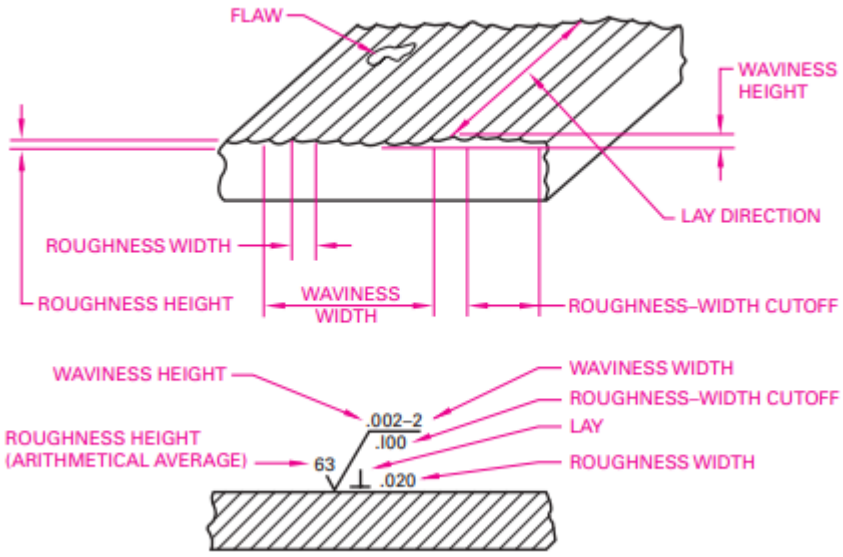
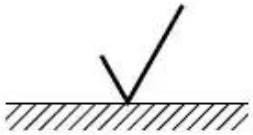


Figure 28.roughness characteristic

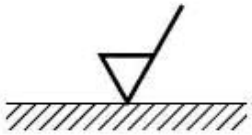
- **Roughness Height** is the average deviation from the mean plane of the surface (micrometres or microinches).
- **Roughness Width** is the width between successive peaks and valleys of the roughness.
- **Roughness width cutoff** is the largest spacing of irregularities including average roughness height.
- **Waviness** is the widely spaced variation (millimeters, or inches) exceeding the roughness width cutoff. It is assumed that the roughness is superimposed on a surface that is wavy in nature.
- **Waviness height** is the crest to trough height variation of the waves.
- **Waviness width** is the wave length i.e. distance from crest to crest or from trough to trough.
- **Lay** is the orientation of the surface pattern. This is determined by the manufacturing processes used.

- **Flaws** are defects, or irregularities, that occur more or less at random over the surface. These defects can be such things as cracks, blow holes, ridges, scratches etc.
- **Contact Area** is the surface that will make contact with a mating surface.

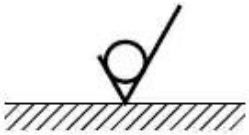
When pictorially representing the surface texture, the symbol that indicates the target surface is expressed with two lines having different lengths with an angle of 60° between them.



Symbol indicating the surface



Symbol indicating a surface that requires material removal



Symbol indicating a surface that does not require material removal

This surface roughness indication method pictorially displays information such as the surface roughness value, cutoff value, sampling length, machining method, crease direction symbol, and surface waviness on the surface indication symbol as shown below.

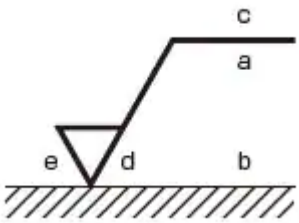


Figure 29.surface finish symbol

- a: Passband or sampling length and surface texture parameter symbol and value
- b: Indications of the second and subsequent parameters when multiple parameters are required
- c: Machining method
- d: Crease and its direction
- e: Machining allowance

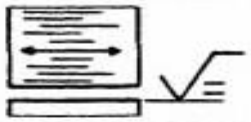
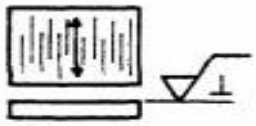
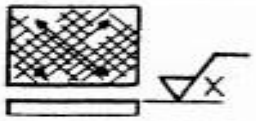
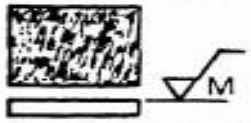
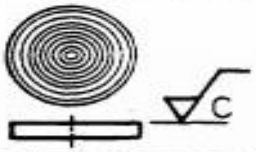
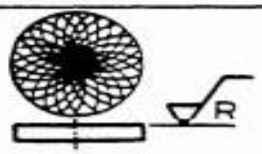
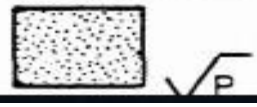
Lay Symbol	Meaning	Example Showing Direction of Tool Marks
=	Lay approximately parallel to the line representing the surface to which the symbol is applied.	
⊥	Lay approximately perpendicular to the line representing the surface to which the symbol is applied.	
X	Lay angular in both directions to line representing the surface to which the symbol is applied.	
M	Lay multidirectional.	
C	Lay approximately circular relative to the center of the surface to which the symbol is applied.	
R	Lay approximately radial relative to the center of the surface to which the symbol is applied.	
P	Lay particulate, nondirectional, or protuberant.	

Figure 30.Surface Finish Symbols

The Surface Texture Symbol is shown in figure 11.12 at the bottom indicating where one may indicate the magnitude of the different surface texture characteristics plus the orientation of the Lay. Figure 22. shows, in the upper left hand corner, the way the surface texture symbol should be drawn relative to the text's character height. How one may indicate different surface finish requirements is indicated by some the other versions of the symbol:

The **Basic Surface Texture Symbol** indicates that the surface may be produced by any method.

The **Material Removal by Machining** symbol (with the horizontal bar closing the V opening) indicates that machining is required to achieve the desired surface finish. This means that a material allowance has to be made to make this possible.

The **Material Removal Allowance** symbol indicates the amount of stock that one should remove by machining. A tolerance on this number may be indicated in a note.

The **Material Removal Prohibited** symbol with circle in the V, indicates that the surface must be produced by processes like casting, forging, hot finishing, cold finishing, die casting, injection moulding, or powder metallurgy.

It should be noted that numbers can be added as indicated in figure. to clarify the surface texture requirements. An average or a maximum and minimum roughness can be specified in the location indicated. The maximum waviness height and spacing may be specified. The direction of lay may be indicated. The roughness sampling length (roughness width cutoff) may be indicated (0.80 mm is assumed if nothing is specified). The maximum roughness may also be specified right next to the Lay symbol. The lay symbol may be:

1. the **Perpendicular** symbol shown in figure. indicating that the lay direction is perpendicular to the line to which the symbol is applied;

2. the = symbol which indicates that the lay direction is parallel to the line;

3. the **X** symbol indicates that the Lay is angular in two directions relative to the line representing the surface;

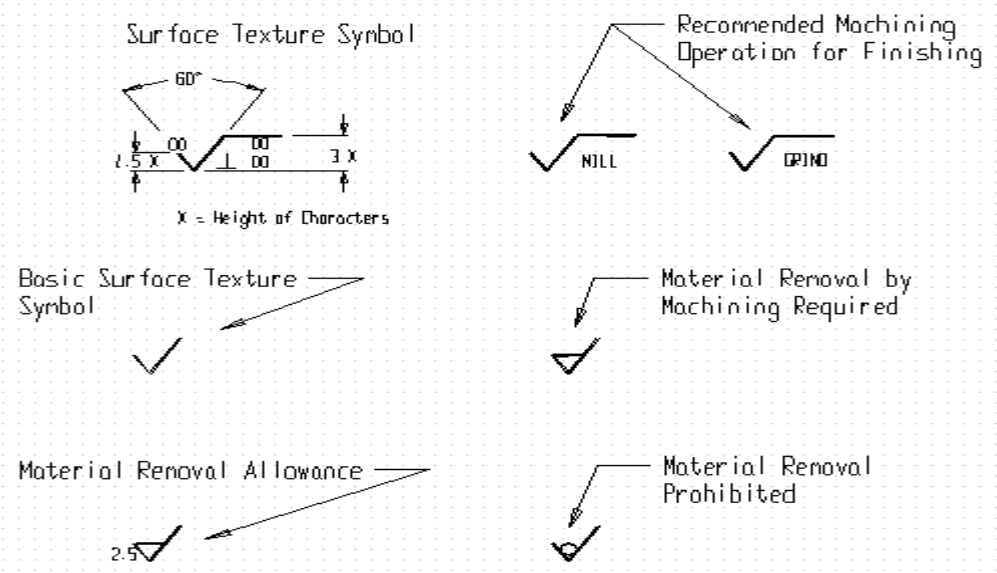


Figure 31.Surface control symbols

4. the **M** symbol indicates a multidirectional Lay;

5. the **C** symbol indicates that the lay is approximately circular relative to the centre of the surface;

6. the **R** symbol indicates that the lay is approximately radial relative to the centre of the surface;

7. the **P** symbol indicates that the Lay is particulate, non-directional, or protuberant.

Applications of the surface texture symbols are given in (a) below. Note that the symbols read from the bottom and/or the right side of the drawing and that they are not drawn at any angle or upside down.

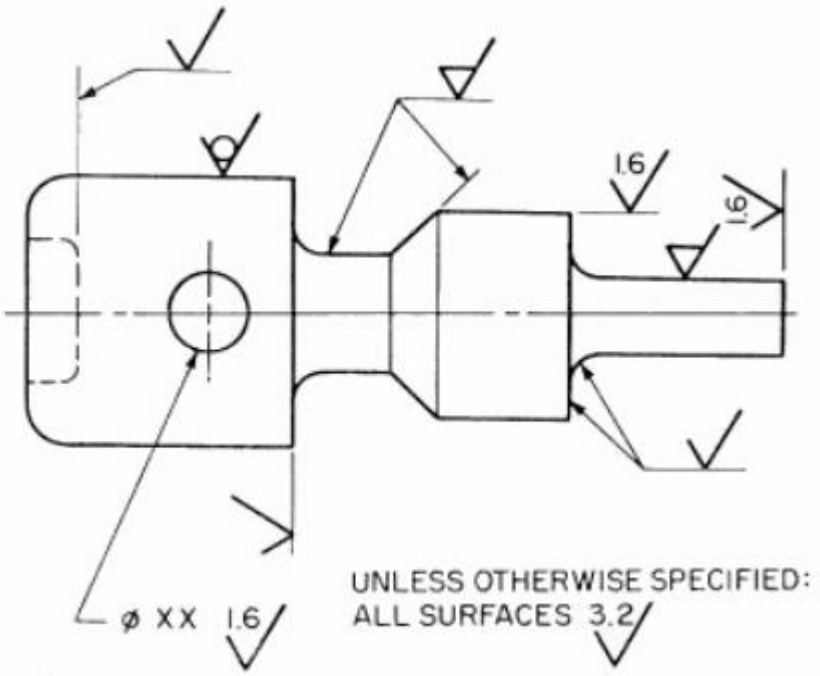


Figure 32.Applications of the surface texture symbols

LO 2.2 – Identify work piece material

Content/Topic 1: Types of materials

Metals are those substances that are hard and holds the property of thermal and electrical conductivity (except tungsten). These materials are lustrous in nature and thus polishing of such elements gives rise to a reflecting surface.

Non-metals are materials that are soft and possess poor electrical and thermal conductivity. This means that non-metals restrict the flow of electric current through them. However, graphite stands here as an exception because it exhibits good electrical conductivity.

Key Differences Between Metals and Non-Metals

1. Metals are considered to be **electropositive** in nature due to their ability to donate electrons. Whereas non-metals are **electronegative** as they generally accept electrons.
2. Metals are generally found in solid-state but non-metals exist in all the 3 states of matter i.e., solid, liquid and gas.
3. Metals shows the property of **malleability** while non-metals are non-malleable.
4. Metals are generally those substances that have a shiny surface and thus are **lustrous**. Whereas non-metals have non-shiny appearance and thus falls under the category of non-lustrous substances.
5. The bond formed between metals is said to be **metallic bonding**. While the bond formed between two non-metals is a **covalent bond**.

6. Metal possesses **high tensile strength** as there exists strong attraction between molecules. However, due to weak intermolecular forces, the tensile strength of non-metals is low.
7. Metals holds the left side position on the periodic table. But non-metals are usually found on the right side in the periodic table.
8. Metals exhibit high melting and boiling point except mercury. As against the melting and boiling point of non-metals are generally low except carbon and silicon.
9. Metals show the property of **ductility** as can be easily drawn into wires on applying force. However, non-metals are not ductile but carbon is a non-metal that exhibits ductility.
10. Usually, metals are referred as cations while non-metals as anions.
11. Metals are said to be good reducing-agents. But non-metals are referred as good oxidizing-agent.
12. Metals possess very high density in comparison to non-metals.

Applications

Metals

- Development of machine tools
- In parts automobiles
- Satellites
- In electricity systems

Non-metals

- For medicinal purposes
- In chemical fertilizers
- In the purification systems
- For making crackers

- **Content/Topic 2: Mechanical properties**

1. Hardness

Hardness is defined as the ability of a metal to cut another metal. A harder metal can always cut or put impression to the softer metals by virtue of its hardness. It is a very important property of the metals and has a wide variety of meanings. It embraces many different properties such as resistance to wear, scratching, deformation and machinability.

2. Brittleness

Brittleness is the property of a material opposite to ductility. It is the property of breaking of a material with little permanent distortion. The materials having less than 5% elongation under loading behaviour are said to be brittle materials. Brittle materials when subjected to tensile loads snap off

without giving any sensible elongation. Glass, cast iron, brass and ceramics are considered as brittle material.

3. Malleability

Malleability is the ability of the material to be flattened into thin sheets under applications of heavy compressive forces without cracking by hot or cold working means. It is a special case of ductility which permits materials to be rolled or hammered into thin sheets.

A malleable material should be plastic but it is not essential to be so strong. The malleable materials commonly used in engineering practice in order of diminishing malleability are lead, soft steel, wrought iron, copper and aluminium.

Aluminium, copper, tin, lead, steel, etc. are recognized as highly malleable metals.

4. Ductility

Ductility is termed as the property of a material enabling it to be drawn into wire with the application of tensile load. A ductile material must be strong and plastic. The ductility is usually measured by the terms, percentage elongation and percent reduction in area which is often used as empirical measures of ductility. The materials those possess more than 5% elongation are called as ductile materials. The ductile material commonly used in engineering practice in order of diminishing ductility are mild steel, copper, aluminium, nickel, zinc, tin and lead.

5. Elasticity

Elasticity is defined as the property of a material to regain its original shape after deformation when the external forces are removed. It can also be referred as the power of material to come back to its original position after deformation when the stress or load is removed. It is also called as the tensile property of the material.

6. Plasticity

Plasticity is defined the mechanical property of a material which retains the deformation produced under load permanently. This property of the material is required in forging, in stamping images on coins and in ornamental work. It is the ability or tendency of material to undergo some degree of permanent deformation without its rupture or its failure.

Plastic deformation takes place only after the elastic range of material has been exceeded. Such property of material is important in forming, shaping, extruding and many other hot or cold working processes. Materials such as clay, lead, etc. are plastic at room temperature and steel is plastic at forging temperature. This property generally increases with increase in temperature of materials.

7. Toughness

A material is tough if it is capable of absorbing a great deal of energy before it fractures. A tough material will withstand repeated flexing or bending before it begins to crack or break. The working

parts of power presses must be tough to withstand the repeated blows in pressing operations. As previously stated, mechanical properties indicate a material's reaction to the application of forces and their values are determined through a series of standard tests. These tests are carried out on small specimens of the material under test until deformed or destroyed. Such tests are referred to as destructive tests. These tests include tensile, compressive, torsion, bend and impact testing and are used to determine the mechanical properties already outlined.

8. Stiffness

It is defined as the ability of a material to resist deformation under stress. The resistance of a material to elastic deformation or deflection is called stiffness or rigidity. A material that suffers slight or very less deformation under load has a high degree of stiffness or rigidity.

For instance suspended beams of steel and aluminium may both be strong enough to carry the required load but the aluminium beam will "sag" or deflect further. That means, the steel beam is stiffer or more rigid than aluminium beam. If the material behaves elastically with linear stress-strain relationship under Hooks law, its stiffness is measured by the Young's modulus of elasticity (E). The higher is the value of the Young's modulus, the stiffer is the material. In tensile and compressive stress, it is called modulus of stiffness or "modulus of elasticity"; in shear, the modulus of rigidity, and this is usually 40% of the value of Young's modulus for commonly used materials; in volumetric distortion, the bulk modulus.

9. Strength

Strength is defined as the ability of a material to resist the externally applied forces with breakdown or yielding. The internal resistance offered by a material to an externally applied force is called stress. The capacity of bearing load by metal and to withstand destruction under the action of external loads is known as strength. The stronger the material the greater the load it can withstand. This property of material therefore determines the ability to withstand stress without failure. Strength varies according to the type of loading. It is always possible to assess tensile, compressive, shearing and torsional strengths. The maximum stress that any material can withstand before destruction is called its ultimate strength. The tenacity of the material is its ultimate strength in tension.

10. Creep

When a metal part when is subjected to a high constant stress at high temperature for a longer period of time, it will undergo a slow and permanent deformation (in form of a crack which may further propagate further towards creep failure) called creep.

11. Resilience

Resilience is a property which is totally opposite to stiffness. A beam made of stiff material will deflect to a lesser extent as compared to another made of resilient material under identical loading condition.

LO 2.3 – Measure the work piece

- **Content/Topic 1: Types of measuring tools**

a) Non precision measuring tools

1. **Steel Ruler**

Steel rule is generally employed for purpose of measuring rough dimensions and laying out them.

It is always advisable to start measuring from 1 cm mark because the end of the rule is generally worn out. Some people confuse rules and scales. A scale is a measuring device used by architects and engineers that assists them in making drawings to a scale other than full size. A rule is used to measure actual sizes.

Figure 33.steel ruler

2. Tape measure

A measuring tape is a flexible form of ruler. It consists of a ribbon of cloth, plastic, or metal strip with linear measurement markings. It is a common measuring tool. Its flexibility allows for a measure of great length to be easily carried in pocket or toolkit and permits one to measure around curves or corners.

Figure 34.Tape measure

b) Precision measuring tools

1. **Vernier calliper**

Vernier Calipers Vernier calipers (work like slide calipers. The vernier calipers can make very accurate outside or inside measurements. A vernier caliper is used by loosening the two locking screws, allowing the movable jaw to slide along the rule until desired position is obtained. The locking screw

is then retightened securing the movable jaw. Any fine adjustments to the vernier scale are made using adjustment control. The locking screw is then secured and vernier caliper is ready to read.

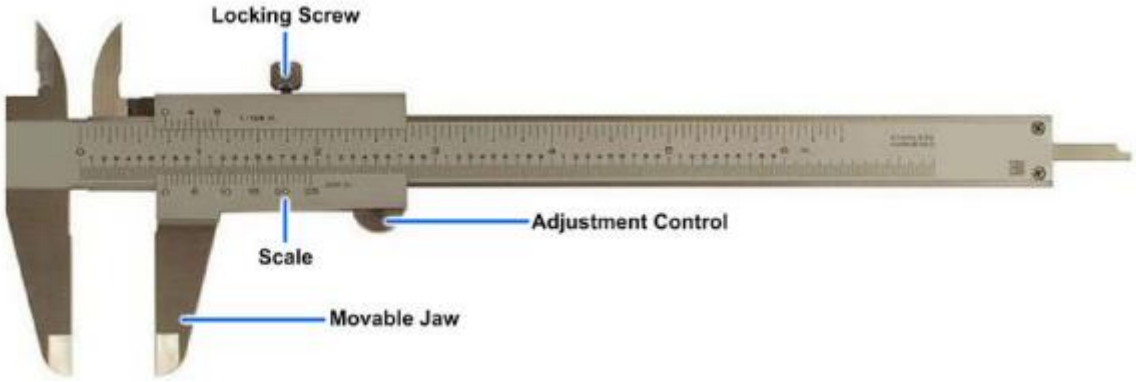


Figure 35,Vernier caliper.

Reading a Vernier Caliper To read a vernier caliper , you must be able to understand both the steel rule and vernier scales. The steel rule is graduated in 0.025 of an inch. Every fourth division (representing a tenth of an inch) is numbered. The vernier scale is divided into 25 parts and numbered 0, 5, 10, 15, 20, and 25. These 25 parts are equal to 24 parts on the steel rule. The difference between the width of one of the 25 spaces on the vernier scale and one of the 24 spaces on the steel rule is a thousandth of an inch. Read the measurement as shown in Figure 4-8. Read the number of whole inches on the top scale to the left of the vernier zero index and record: 1.000 inch. Read the number of tenths to the left of the vernier zero index and record: 0.400 inch. Read the number of twenty-fifths between the tenths mark and the zero index and record: 3 x .025 = .075 inch. Read the highest line on the vernier scale (3) that lines up with the lines on the top scale and record (Remember 1 /25 = 0.001 inch): 11/25 or 0.011 inch.

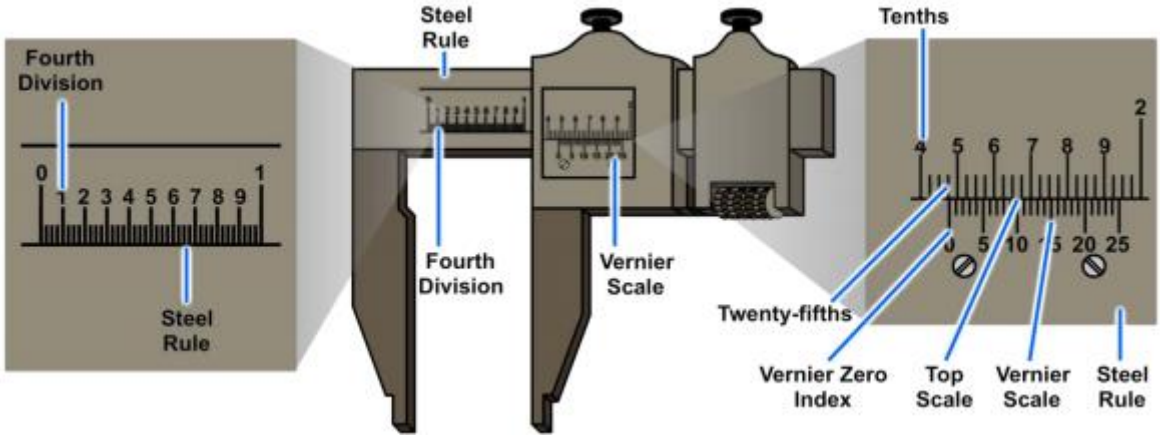


Figure 36.— Reading a vernier caliper.

Reading a Metric Caliper The steel rule is divided into centimeters (cm) and the longest lines represent 10 millimeters (mm) each. Each millimeter is divided into quarters. The vernier scale is divided into 25 parts and is numbered 0, 5, 10, 15, 20, and 25. Read the total number of millimeters to the left of the vernier zero index and record: 32.00 mm. Read the number of quarters between the millimeter mark and the zero index and record: 0.25 mm (1 quarter). Read the highest line on the vernier scale aligning with the line on the scale and record: 0.18 mm.

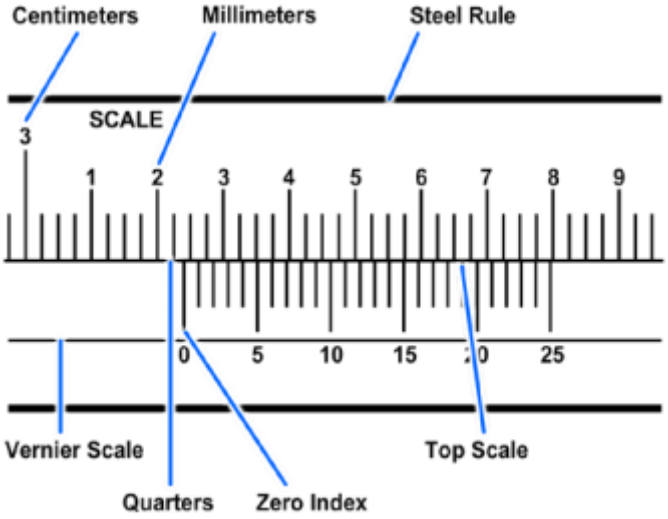


Figure 37.Reading a metric Caliper

Care of Calipers Observe the following guidelines when working with calipers:

- Store calipers in separate containers provided.
- Keep graduations and markings on all calipers clean and legible.
- Do not drop any caliper. Small nicks or scratches can cause inaccurate measurements.
- Protect caliper points from damage.

2. **Micrometers**

The micrometer relies for its measuring accuracy on the accuracy of the spindle screw thread. The spindle is rotated in a fixed nut by means of the thimble, which opens and closes the distance between the ends of the spindle and anvil as shown. The pitch of the spindle thread, i.e. the distance between two consecutive thread forms, is 0.5mm. This means that, for one revolution, the spindle and the thimble attached to it will move a longitudinal distance of 0.5mm. (Ervin Henley MRC (SW) Karrie Colema, September 2015)

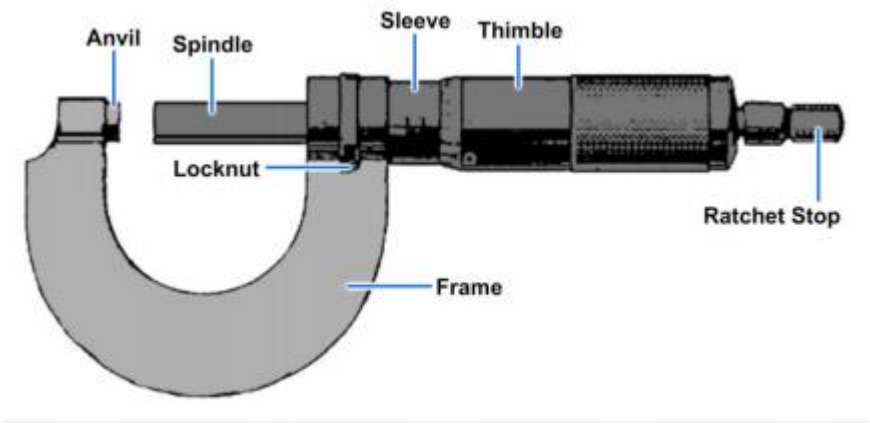


Figure 38.micrometer

On a 0–25mm micrometer, the sleeve around which the thimble rotates has a longitudinal line graduated in mm from 0 to 25mm on one side of the line and subdivided in 0.5mm intervals on the other side of the line. The edge of the thimble is graduated in 50 divisions numbered 0, 5, 10, up to 45, then 0.

A reading is therefore the number of 1mm and 0.5mm divisions on the sleeve uncovered by the thimble plus the hundredths of a millimetre indicated by the line on the thimble coinciding with the longitudinal line on the sleeve.

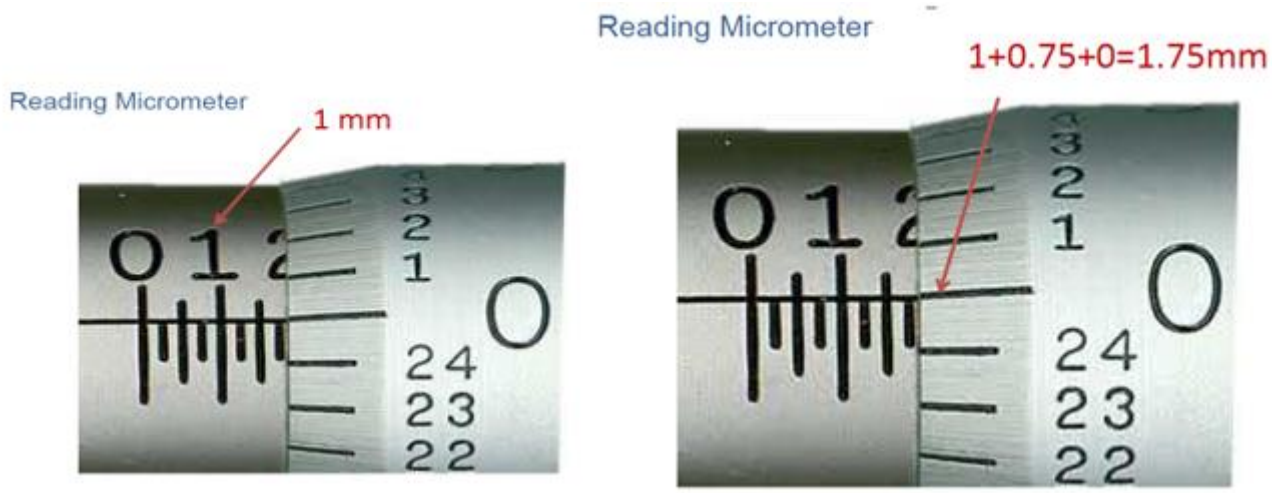
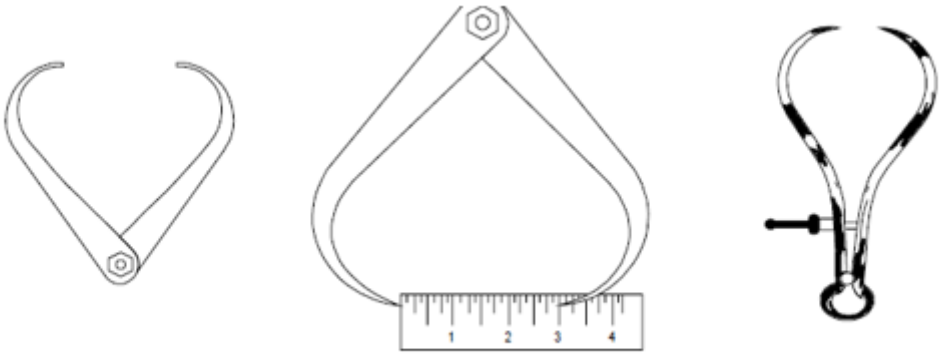


Figure 39reading micrometer

3. Caliper

Callipers are generally of two types inside and outside to make internal or external measurements. They do not have direct scale reading. They transfer the measurement from jobs to scale or vice versa. Fig. shows a simple outside calliper. The calliper is held in a rule as shown in Fig.to read the size. It is used to make external measurement such as thickness of plates, diameter of sphere and cylinders. Fig. shows the standard spring joint outside calliper.



.1Simple outside caliper, 2.caliper held in ruler,3. standard spring joint outside caliper

Figure 40.calipers

Dial Indicators

Dial indicator is used for sensing or detecting small movements or size variations in a work piece

The dial indicators are also known as dial gauges and are shown in (a, b). They are generally used for testing flatness of surfaces and parallelism of bars and rods. They are also used for testing the machine tools. They are available in both metric as well as in inches' units. Inches dial indicator of 0.001" measuring accuracy is in commonly used but they are also available up to an accuracy of 0.0001".

The commonly used metric dial indicator has an accuracy of 0.01 mm. Those having 0.001 mm accuracy are also available; however, they are used in highly precision measurement work.

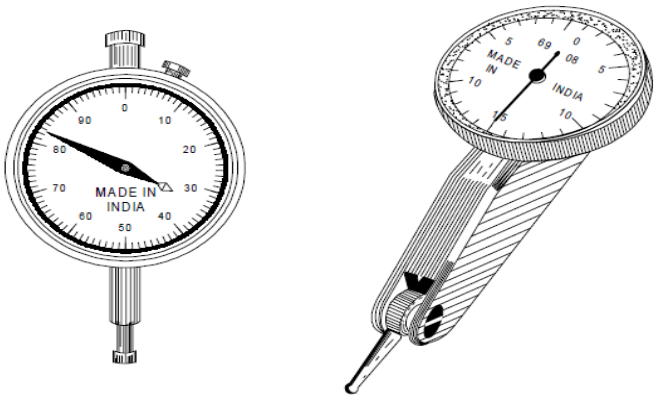


Figure 41.Dial Indicators

- **Content/Topic 2: Use of measuring tools**

A measuring tool is anything used to take a count of quantitative data, such as weight, length, time or temperature. Rulers and scales are two common types of measuring tools. Measuring tools are essential for many different types of jobs or exercises. For measuring length, rulers are the accepted choice

- **Steel Rule**

Steel rule is generally employed for purpose of measuring rough dimensions and laying out them. It is always advisable to start measuring from 1 cm mark because the end of the rule is generally worn out

- **Circumference Rule** It is commonly used for measuring or laying out or as a straight edge. The specialty in this rule is that the circumference can be taken directly, below the diameter dimension.
- **Straight Edges** There are two types of straight edges namely four edge type (Fig. (a)) and bridge type (Fig. (b)) which are made of carbon tool steel and alloy steel. They are generally flat graduated bar of steel with one longitudinal edge beveled. Straight edges come in various lengths commonly varying from 2.5 mm up to one meter and above. They are mostly used for scribing long straight lines.

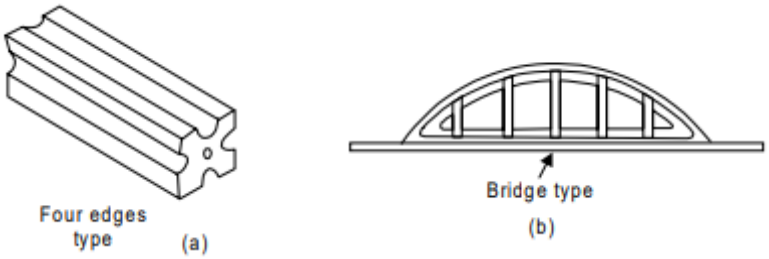


Figure 42.Straight Edges

- **Flat Steel Squrae**

It is a piece of flat hardened steel with graduations on either end. It is commonly used for marking lines in the perpendicular direction to any base line.

- **Divider** It is used for marking and drawing circle and arcs on sheet metal.
- **Trammel** is used for marking and drawing large circles or arcs, which are beyond the scope of dividers.
- **Surface Gauge or Scribing Block**

the surface gauge which is a principal marking tool used generally in the fitting and the machine shops. It is made in various forms and sizes. It consists of a cast iron sliding base fitted with a vertical steel rod. The scriber or marker is positioned or set into an adjustable device using a knurled nut at one end. The scriber can be loosened or tightened by means of the nut. The marker is used to set it at any desired inclination, moved to and fro inside the hole accommodating it or adjust its height along the vertical pillar. It is commonly used in conjunction with either a surface plate or marking table. It is used for locating centres of round rod held in V- block, describing straight lines on work held firmly in its position by means of a suitable device like angle plate and also in drawing a number of lines parallel to a true surface. This device is a very simple form of surface gauge and it is largely being replaced by a more accurate instrument called universal surface gauge. (Singh, 2006)

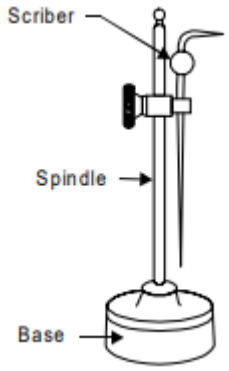


Figure 43.Surface Gauge or Scribing Block

LO 2.4 – Estimate the cost of work

- **Content/Topic 1 : Definition of BOQ**

Billing of Quantities (BOQ)

Bill of Quantities also referred to as BOQ, is a document formulated in the construction industry to specify materials, labours, and their cost. It serves as a communication tool between client, consultant & the contractor. It is usually prepared by a cost consultant or a surveyor.

The quantities may be measured in number, length, area, volume, weight or time. Preparing a bill of quantities requires that the design is complete and a specification has been prepared

- **Content/Topic 2 : Elements of Bill of quantity(BOQ)**

The Bills of Quantities may serve a number of functions as:

i. A breakdown of the tendered price, with no contractual status, but providing information for the selection from tenderers.
ii. An estimate measure of the work for the tendered price, to be used to arrive at a revised contract price once the actual quantities of work carried out are measured. This is the remeasure form of contract.
iii. A schedule of rates as the contract basis for valuing variations in the work.
iv. A basis for measure of the value of work completed for interim payments.

Primarily there are two types of BOQs

a) Bill of Materials - is a comprehensive inventory of the raw materials, assemblies, subassemblies, parts and components, as well as the quantities of each, needed to manufacture a product. In a nutshell, it is the complete list of all the items that are required to build a product. A good BOM always includes certain essential elements:

BOM level: Each part or assembly in the BOM must receive a number or ranking that explains where it fits into the BOM hierarchy. This makes it easier for anyone to understand the BOM.

b) Serial number

Part number: The BOM should assign a part number to each item, which allows anyone involved in the manufacturing cycle to reference and identify parts instantly. To avoid confusion, each part must receive only one-part number.

Part name: Each part, material, or assembly should also include a detailed, unique name that allows anyone to identify the part easily without having to reference other sources.

Phase: Make sure to record the lifecycle stage of each part in the BOM. For example, for parts that are the process of being completed, a term like "In Production" can be used. Other terms, such as "Unreleased" or "In Design" can be used for parts that have not yet been approved. Such terms are especially helpful during new product introductions since they allow progress to be tracked easily.

c) Items/Descriptions

The quantities described in the bill are measured in length, area, volume, weight, time or number. Preparation of the bill implies the completion of both design and specifications attributed to it. A contractor, guided by the bill's list of items, offers its price for each item.

BOQ descriptions for each module can consist of the following:

- Short description of the billable action
- Names of products, materials and their chemical make-up, if any
- Exclusions (e.g. actions that are not in the scope of work)
- Dimensions of the materials/items required (e.g. length, width, weight, diameter, percentages, ratios, etc.)
- Volume/area of size covered in the billable action
- Any additional tasks or tools required to complete billable action
- Regulations and/or standards required of your billable actions/materials
- Disposal, handling and/or maintenance information
- Limitations to scope of work
- Warranty periods, if any

Example table one

ITEM	DESCRIPTION	UNIT	QTY	Unit price		Total cost	
				J.D	Fils	J.D	Fils
SECTION (12): ELECTRICAL WORKS							
cont. 12/2	f- Solar Heater electrical point with 3x4 mm² wires in PVC conduits with all accessories needed.	No.	1				
	g-Hand Drayer electrical point with 3x4 mm² wires in PVC conduits with all accessories needed.	No.	1				
12/6	**Numbers:** Supply, install, connect &commission power socket outlets, including conduits, conduit fittings, pull boxes, accessories and circuit wiring or cables between socket outlet up to its sub-panel board as specified and as shown in drawings.						
	a- 13A, 3 Pin power single socket outlet, with switch.	No.	22				
	b- 13A, 3 Pin power double socket outlet, with switch.	No.	19				
	c- 13A single phase socket outlet, IP44 with cover..	No.	2				
	d- 13A, 3 Pin power double socket outlet, with switch connected to UPS panel	No.	20				

Example table two

S.N.	Description	Unit	Quantity	Rate per unit		Total Amount
				In Figure	In words	
1	E/w Excavation of soft clay & salty soil including disposal upto 10m lead & 1.5 m lift	cum	414.00	72.29	Seventy two and twinty nine paisa only	29,928.06
3	Structure back filling works 15 cm layer ways compaction two third of quantity	cum	136.17	118.75	One hundred eighteen and seventy Five paisa	16,170.19
5	Boulder solling works with supplying of materials	cum	1.20	1446.12	One thausand four hundred fouty six and	1,735.34
6	P.C.C. 1:3:6 work with materials all complete	cum	0.96	10438.95	Ten thausand four hundre	10,021.39
7	P.C.C. 1:2:4 work with materials all complete	cum	12.00	11935.64	Eleven thausand nine hundred thirty five and	143,227.68
8	Supply of form work with shuttering, staging etc. and erecting, fitting, fixing, centering etc all complete including dismantling as per drawing and specification	sq.m	121.00	715.82	Seven hundred fifteen and eight two paisa only	86,614.22
9	Renforcment steel work for curtoff wall with supllying ,cutting , bending , binding , placing all comlete	kg	594.33	91.77	Ninety one and Seventy seven paisa only	54,541.66
					Total = NRs.	**342,238.54**
					Payle Amount	**285,000.00**
					Contribution	57,238.54

2.1 Item specifications

Item specifications are one of the key requirements for a high-quality, legally defensible standards-based assessment. Item specifications help define important characteristics of the items (i.e., test questions) developed for each standard. These item specifications provide guidelines to help clarify the focus of what is to be assessed, what items may include, and what items may not include (i.e., assessment limits). Item specifications are used by item writers, item editors, and item reviewers as a common reference throughout the item-development process, from initial writing to final approval.

Example table of item specifications

Item	details	specification
steel frame	corner fitting	standard container fitting
	base frame	3.0mm steel plate
	secondary frame	2.5mm steel plate
	stand column	2.5mm steel plate
	roof frame	2.5mm steel plate
	Forklift slot	3.0mm steel plate
	strength plate	6mm steel plate
panel	wall panel	50mmEPS sandwich panel
	wall panel	50mmEPS sandwich panel
	ceiling plate	50mmEPS sandwich panel
	surface plate	0.5mm color steel plate
base	base floor	1220*2440 plywood floor
	surface floor	porcelain tiles with 20mm cement mortar (1:2) on top of the strong timber with appropriate adhesive material and 1" chicken mess
door and window	door	aluminum sandwich panel door
	window	aluminum sliding window 0.9m*1.2m

2.2 Unit Prices

unit price is the price for one item or measurement, such as a pound, a kilogram, or a pint, which can be used to compare the same type of goods sold in varying weights and amounts.

UNIT PRICE ANALYSIS						
Project : Project Code M27018351809 Location :						Works Item No. 3.4 Fill from within 30 metres
Work Item:	Fill from within 30 metres - excavation within the road corridor, spreading, watering, leveling and compacting (without haulage)					Unit - 1 M3
No	Description	Unit	Task Rate	Productivity	Unit Price (US$)	Amount (US$)
A	**LABOUR Cost for Leveling to form and forming camber**					
1	Skill labour for Setting Out (25%)	M^3	24	0.01042	9.0	0.094
2	Unskilled Labour - Excavation	M^3	1.2	0.83333	4.5	3.750
3	Semi Skilled labour(Gang Leader)	M^3	18	0.05556	7.0	0.389
	Sub Total					4.233
B	**TOOLS/EQUIPMENT Cost for Leveling to form and forming camber**					
1	Pedestrian Roller	M^3 per day	73.5	0.0136	$ 150	2.041
2	Water browser	M^3 per day	73.5	0.0136	$ 100	1.361
3	Hand Tool (5% of item A)	%				0.212
	Sub Total					3.401
C	**MATERIAL**					
	Sub Total					0.000
D	TOTAL DIRECT COST FOR 1 M3 OF LEVELING TO FORM CAMBER ACTIVITY IS					7.634

2.3 Total Prices

Total Price means the total sum payable by the debtor under a hire-purchase agreement or a conditional sale agreement, including any sum payable on the exercise of an option to purchase, but excluding any sum payable as a penalty or as compensation or damages for a breach of the agreement

Example

S/N	MATERIALS	DIMENSIONS	QUANTITY	UNIT PRICE (N)	TOTAL PRICE (N)
1	Transparent Glass	1250×900mm	1	2,400.00	2,400.00
2	Metal Sheet	850×750mm	1	2,000.00	2,000.00
3	Plywood (3/4" thick)	1000×1000mm	4	1,000.00	4,000.00
4	Wire Mesh	-	3yards	500.00	1,500.00
5	Nails	-	4kg	150.00	600.00

2.7 Labor cost 30% of material total price

Labor costs are those costs associated with employing labor including direct wages, food contributions, transport, and social costs, including payments for health and retirement. The cost of supervision may also be spread over the labor costs.

Industries started a new batch of paint on October 1. The new batch consists of 8,700 cans of paint, of which 7,500 was completed and transferred to finished goods. During October, the manufacturing process recorded the following expenses: direct materials of $10,353; direct labor of $17,970; and applied overhead of $9,000. The inventory still in process is 100% complete with respect to materials and 30% complete with respect to conversion. What is the cost of inventory transferred out and work in process? Assume that there is no beginning work in process inventory.

Solution

Units to account for	Units		
Beginning work in process	0		
Units started into production	8,700		
Total units to be account for	8,700		
	Materials	**Conversion**	**Total**
Work in process completion %	100%	30%	
Units accounted for			
Completed and transferred out	7,500	7,500	7,500
Ending work in process	1,200	360	1,200
Total units to account for	8,700	7,860	8,700
Costs to account for	**Materials**	**Conversion**	**Total**
Beginning work in process	0	0	0
Incurred during the period	$10,353	$26,970	$37,323
Total costs to account for	$10,353	$26,970	$37,323
Equivalent units	8,700	7,860	
Cost per equivalent unit	$ 1.19	$ 3.43	$ 4.62

2.8 Taxes

Many equipment owners must pay property taxes or some type of usage tax on equipment. Taxes, like interest, can be calculated by either using the estimated tax rate multiplied by the actual value of the equipment or by multiplying the tax rate by the average annual investment.

Taxes and Duties The contractor shall include all local taxes except VAT for the materials and services to be procured locally in his unit rate for various item of works included in the Bill of Quantities. The unit rate for materials, goods and equipment to be imported from overseas shall INCLUDE VAT and other import duties such as custom duties, cess, excise duty, etc. The Employer is not responsible to pay any VAT or custom duty for any imported items to be incorporated in the permanent works.

2.9 Grand total

Item	Description	Total (US$)
1.	**Total of Item # 1**	
2.	**Total of Item #2**	
	Grand Total (US$) – Not including Value Added Tax (VAT)	

Grand Total (in letters):----------

2.10 Contingencies

Contingency sum refers to an item that a bill of quantities includes. This term is used to describe additional unforeseen costs of items or services that may occur during the execution of work according to the project.

Contingency sum can be divided into two types. The first one describes a specific item that may become a subject to adjustments or when it requires additional services that are not accurately described in the bill of quantities (however, some work concerning this item should be envisaged). An example of this type of contingency sum may be 'additional alterations to services associated with the installation of kitchen appliances'. This type of contingency sum is normally estimated by the client's project quantity surveyor.

The second type of the contingency sum implies additional money that can be attributed to any item included in a bill of quantity. An example to illustrate this type is: 'additional work to be executed by the contractor when the contract administrator requires so'. Normally, the contractor's quantity surveyor or commercial manager approximates this type of contingency sum.

Example: Contingency or management reserve

Cost base line is the Sum of project cost estimate and contingency reserve;

i.e.Cost Baseline Project Cost Estimate + Contingency Reserve Project

budget is the sum of project cost base line and the management reserve; i.e. Project Budget = Cost Baseline + Management Reserve Therefore, Management Reserve is not a part of the cost baseline but it is a part of the project budget and Contingency Reserve is a part of cost baseline as well as project budget.**Invalid source specified.**, **Invalid source specified.**

- ✓ Content/Topic 2 Formats of BOQ

The main sections included in the bill of quantities are Form of Tender, Information, Requirements, Pricing schedule, Provisional sums, and Day works

Item #	Description	Unit	Qty of Work	Rate in £	Total in £
	VERTICAL HOT WATER SUPPLY FOR BATH				
	1st Floor Suite				
1	Supply and install ¾" (19mm) copper pipe for hot water up to 8psi, complete as per specs	m	56	1,065	59,640
2	Supply and install ½" (12.7mm) copper pipe to supply to appliances (sink, shower)	m	23	865	19,895
	2nd Floor Suite				
3	Supply and install ¾" (19mm) copper pipe for hot water up to 8psi, complete as per specs	m	56	1,065	59,640

(BOQ) >>> Billing Of Quantity					
S/NO	Description	Unit	Qty	Unit Price	Total
1	Cement	Number	300	520	156000
2	Sand	CFT	1000	20	20000
3	Arregate	CFT	2000	18	36000
4	Door	Number	8	4000	32000
5	Window	Number	8	6500	52000
			Total Amount		296000

- ✓ Content /Topic3 Definition of invoice

An invoice is a document issued to customers by a seller asking for payment of goods or services. It is also known as a bill or tab. Invoice is a document presented to the customer before or after supplying the goods or services. It is a legal document that can be annulled with a credit note if issued

incorrectly.If you are a seller, you are not allowed to simply remove an invoice from sales records. Your Businesses is probably registered for VAT (value added tax) and you need to issue invoices in line with specific regulatory requirements.

✓ Content /Topic 4. Elements of an invoice

4.1. Company information

If you are the payer, you want to be sure that your company's legal name, business address, business phone number and fax number (if applicable) are listed accurately and included near the top and bottom of the invoice. If you are the payee, you want to be sure to include the same information at the top and bottom of the invoice as well. You want to be sure to differentiate which company is the payer and which is the payee by labeling each.

As the one making the payment, you should label the payee as "Sold To"; this indicates who is responsible for making the payment.

4.2. Date

State the day the business invoice was created. This is especially important if your payment terms dictate that invoices be paid within 30, 60, or 90 days of the invoice date, for example.

4.3. Tin number

Giving each invoice its unique number or code helps both you and your customer stay organized. Use a unique identifier for each business invoice to differentiate between multiple customers or multiple invoices to the same customer. Most online invoice solutions will auto-generate a unique invoice number for you, though you can decide on the format you wish to use. For example, you can assign invoice numbers chronologically (like Invoice #0001, Invoice #0002, and so on) or use a specific format for each client (like Invoice #CustomerA0001, #CustomerB0002, and so forth).

Along with each company's respective payer and payee information, you'll want to include the date on which the invoice is issued and an invoice number or another unique identifier. You can structure your ID based on any system or stylistic preference, whether it's a simple file number, unique billing code or date-based purchase order number. If you are the one sending the invoice to an organization and asking for payment, perhaps for freelance work, check with the organization to see if there are any unique company details they need included, such as an internal purchase order (PO) number or billing code. For many larger organizations, PO numbers and/or billing codes are the only way they can expediently deal with an invoice. Details like these can mean the difference between getting paid on time and getting paid next quarter.

4.4. Use of goods and services

This section of the invoice can be as detailed or generic as you like. The most important parts of the listing include:

- Name of the good or service provided
- Date the good or service was provided
- Rate for the good or service provided
- Quantity of the good or service provided

You may want to consider adding sub-sections for each item that includes price modifications, item descriptions or other information as needed.

4.5. Global itemized fees

If there are any taxes, handling fees or other charges that need to be levied, each of these should be listed as a separate line item. This is important for some organizations that need to apply these different fees to different budgets for their internal books to balance.

4.6. Total amount

While it may seem trivial, it's worth mentioning: Make sure that the total amount due is prominently displayed on the invoice.

4.7. Adds on, Account Number, Delivery Date and Invoice number

While the previous seven items are really important to include on an invoice, there are a few other elements you can include if you choose, such as:

- **Message Field**: This can be used to say "thank you" to a client or make reference to something unique to the project.
- **Tax Identification Number**: Some businesses may file their invoices using their clients' TIN. Since it is a government-issued number that is unique to each business, it's worth including, especially if you handle a high volume of invoices.

While there are no legal guidelines for an invoice, including the elements listed above will help ensure your invoice is handled correctly and paid promptly.

Account number. An account number is a unique string of numbers and, sometimes, letters and other characters that identifies the owner of an account and grants access to it.

LO 3.1 – Identify grinding machine

- **Content/Topic 1: Introduction to grinding machines**

Introduction

Grinding is a metal cutting operation like any other process of machining removing metal in comparatively smaller volume. The cutting tool used is an abrasive wheel having many numbers of cutting edges. The machine on which grinding the operation is performed is called a grinding machine.Grinding is done to obtanin very high dimensional accuracy and better appearance. The accuracy of grinding process is 0.000025mm. The amount of material removed from the work is very less.

- **Content/Topic 2: Types of grinding machine**

A. Cylindrical grinding machine

Cylindrical grinders are generally used to grind external surfaces like cylinders, taper cylinders, faces and shoulders of work.

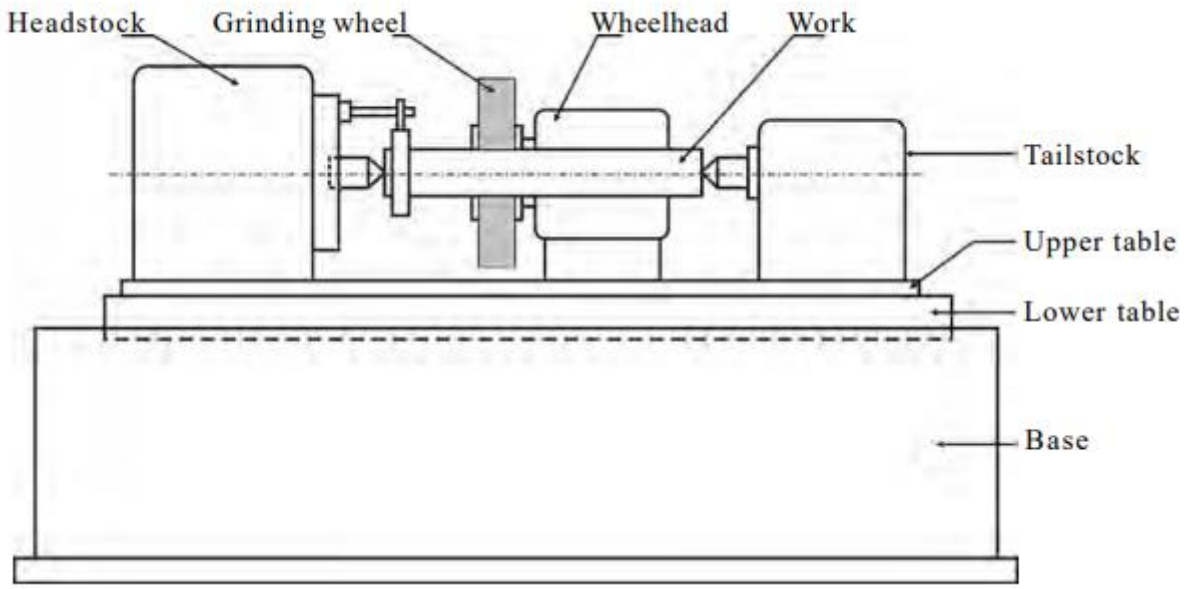


Figure 44.Cylindrical grinding machine

parts of Cylindrical centre type grinders :

Base

The base is made of cast iron and rests on the floor. It supports the parts mounted on it. The top of the base is accurately machined and provides guideways for the table to slide on. The base contains the table driving mechanisms.

Tables

The tables are mounted on top of the base. There are two tables namely lower table and upper table. The lower table slides on the guideways on the bed. It can be moved by hand or by power within required limits. The upper table can be swiveled upto ±10o and clamped in position. Adjustable dogs are clamped in longitudinal slots at the side of the lower table. They are set up to reverse the table at the end of the stroke.

Headstock

The headstock is situated at the left side of upper table. It supports the workpiece by means of a centre and drives it by means of a dog. It may hold and drive the workpiece in a chuck. It houses the mechanism meant for driving the work. The headstock of a universal grinding machine can be swiveled to any required angle.

Tailstock

The tailstock is situated at the right side of the table. It can be adjusted and clamped in various positions to accommodate different lengths of workpieces.

Wheelhead

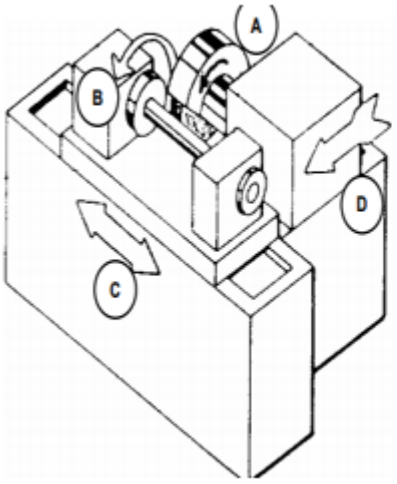
The wheelhead may be moved at right angles to the table ways. It is operated by hand or by power to feed the wheel to the work.The wheelhead carries a grinding wheel. Its driving motor is mounted on a slide at the top and rear of the base. The grinding wheel rotates at about 1500 to 2000 r.p.m.

This machine is used to produce external cylindrical surface. The surfaces may be straight, tapered, steps or profiled. Broadly there are three different types of cylindrical grinding machine as follows:

1. Plain centre type cylindrical grinder
2. Universal cylindrical surface grinder
3. Centre less cylindrical surface grinder

1. Plain centre type cylindrical grinder

this machine and various motions required for grinding action. The machine is similar to a centre lathe in many respects. The workpiece is held between head stock and tailstock centres. A disc type grinding wheel performs the grinding action with its peripheral surface.



A: rotation of grinding wheel
B: work table rotation
C: reciprocation of worktable
D: infeed

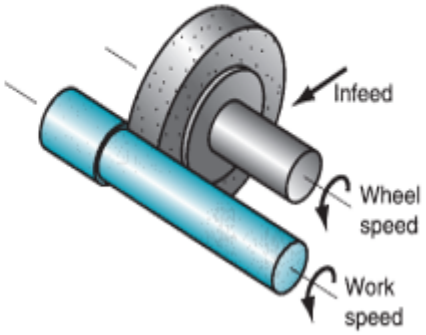
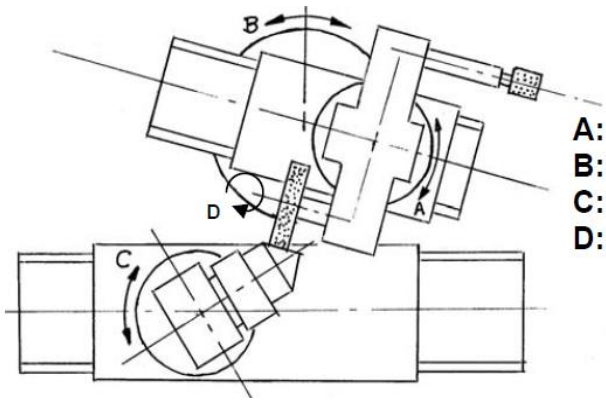


Figure 45.Plain centre type cylindrical grinder

2. **Universal cylindrical grinder** is similar to a plain cylindrical one except that it is more versatile. In addition to small worktable swivel, this machine provides large swivel of head stock, wheel head slide and wheel head mount on the wheel head slide.



A: swivelling wheel head
B: swivelling wheel head slide
C: swivelling head stock
D: rotation of grinding wheel

Figure 46.universal cylindrical grinding machine

This allows grinding of any taper on the work piece. Universal grinder is also equipped with an additional head for internal grinding. Schematic illustration of important features of this machine is shown in Fig above.

centreless grinder This grinding machine is a production machine in which outside diameter of the workpiece is ground. The workpiece is not held between centres but by a work support blade. It is rotated by means of a regulating wheel and ground by the grinding wheel. In through-feed centreless grinding, the regulating wheel revolving at a much lower surface speed than grinding wheel controls the rotation and longitudinal motion of the workpiece. The regulating wheel is kept slightly inclined to the axis of the grinding wheel and the workpiece is fed longitudinally as shown in Fig.

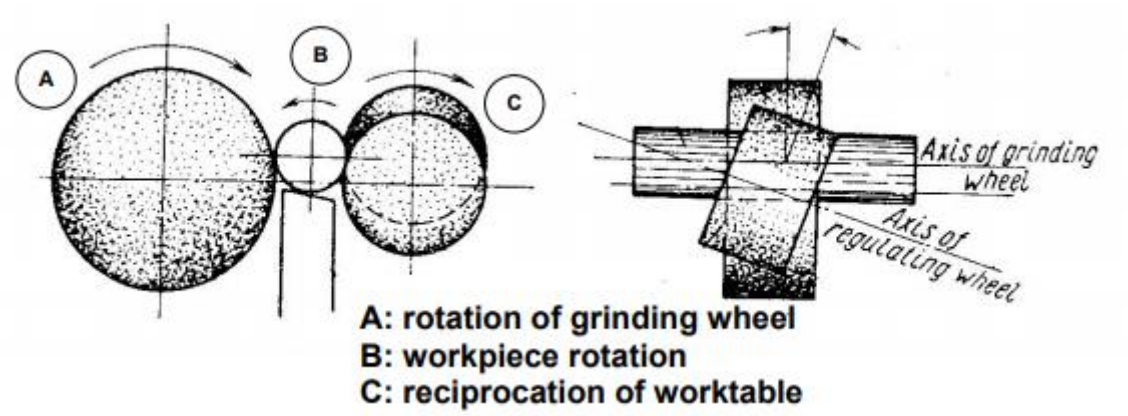


Figure 47.centreless grinder

B. Internal cylindrical grinding operates somewhat like a boring operation. The work piece is usually held in a chuck and rotated to provide surface speeds of 20 to 60 m/min (75 to 200 ft/min) [16]. Wheel surface speeds similar to external cylindrical grinding are used. The wheel is fed in either of two ways: traverse feed, Figure below or plunge feed. Obviously, the wheel diameter in internal cylindrical grinding must be smaller than the original bore hole. This often means that the wheel diameter is quite small, necessitating very high rotational speeds in order to achieve the desired surface speed. Internal cylindrical grinding is used to finish the hardened inside surfaces of bearing races and bushing surfaces.

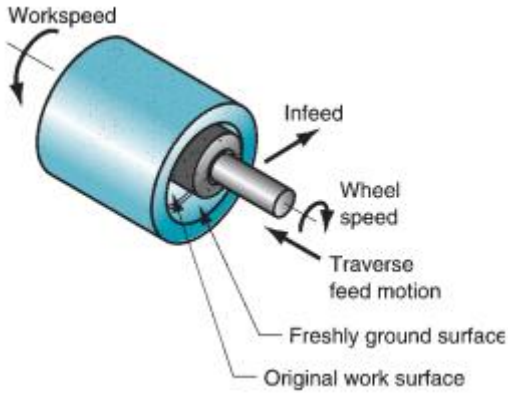
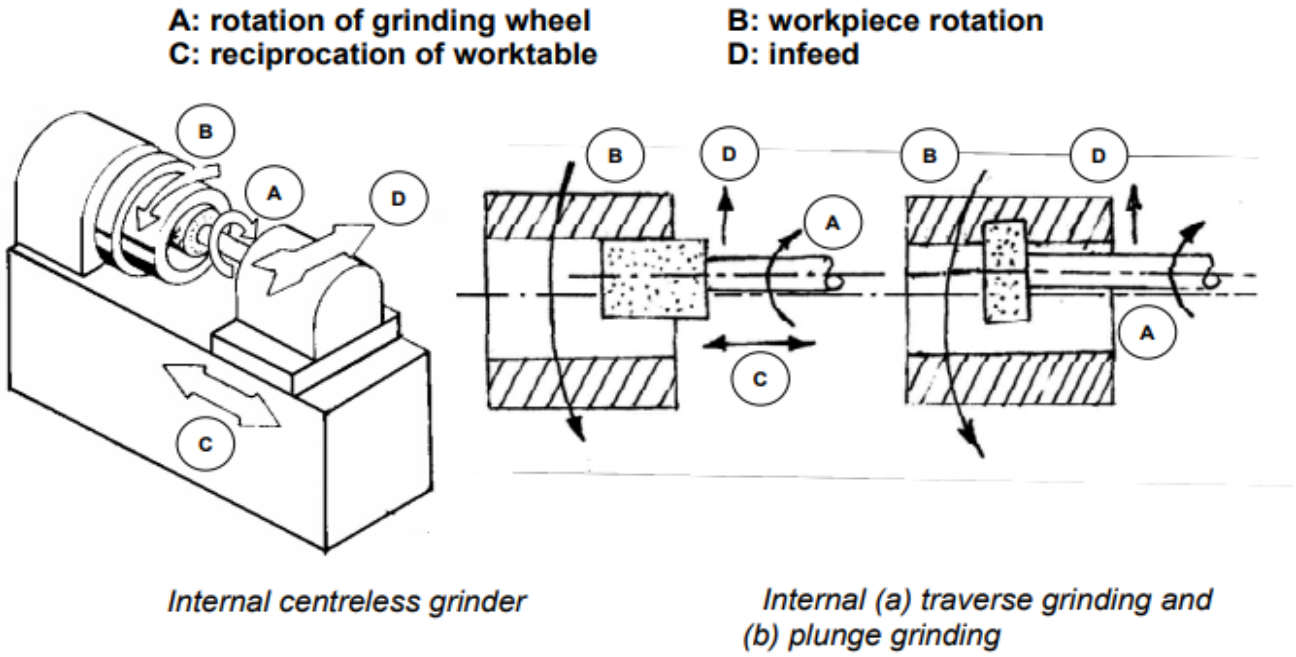


Figure 48.Internal cylindrical grinding

Chucking type internal grinder

this machine and various motions required for grinding action. The workpiece is usually mounted in a chuck. A magnetic face plate can also be used. A small grinding wheel performs the necessary grinding with its peripheral surface. Both transverse and plunge grinding can be carried out in this machine as shown in Fig.

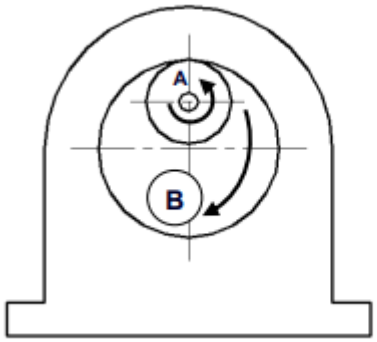


Internal centreless grinder

Internal (a) traverse grinding and (b) plunge grinding

Figure 49.Chucking type internal grinder

Planetary internal grinder Planetary internal grinder is used where the workpiece is of irregular shape and cannot be rotated conveniently as shown in Fig. In this machine the workpiece does not rotate. Instead, the grinding wheel orbits the axis of the hole in the workpiece.



A: rotation of grinding wheel
B: orbiting motion of grinding

Internal grinding in planetary grinder

Centreless internal grinder

This machine is used for grinding cylindrical and tapered holes in cylindrical parts (e.g. cylindrical liners, various bushings etc). The workpiece is rotated between supporting roll, pressure roll and regulating wheel and is ground by the grinding wheel as illustrated in Fig

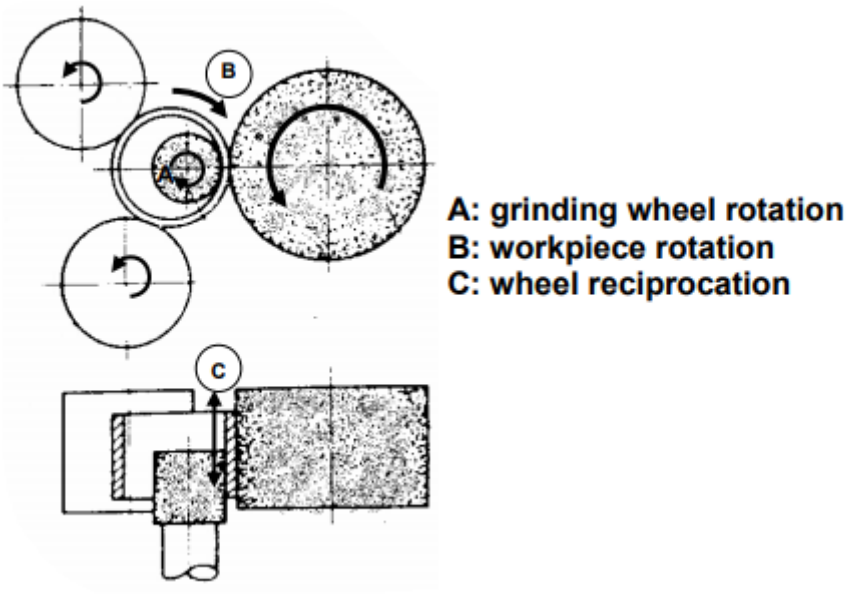


Figure 50.Internal centreless grinding

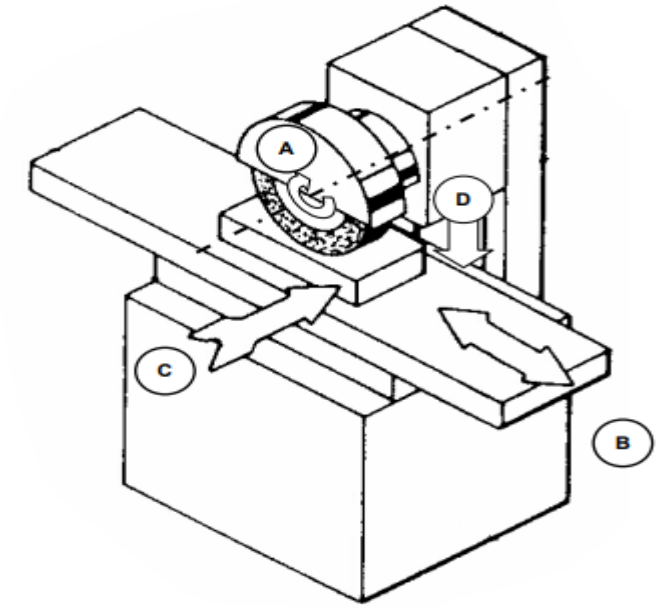
C. Surface grinding machine

- **Reciprocating**

This machine may be similar to a milling machine used mainly to grind flat surface. However, some types of surface grinders are also capable of producing contour surface with formed grinding wheel.

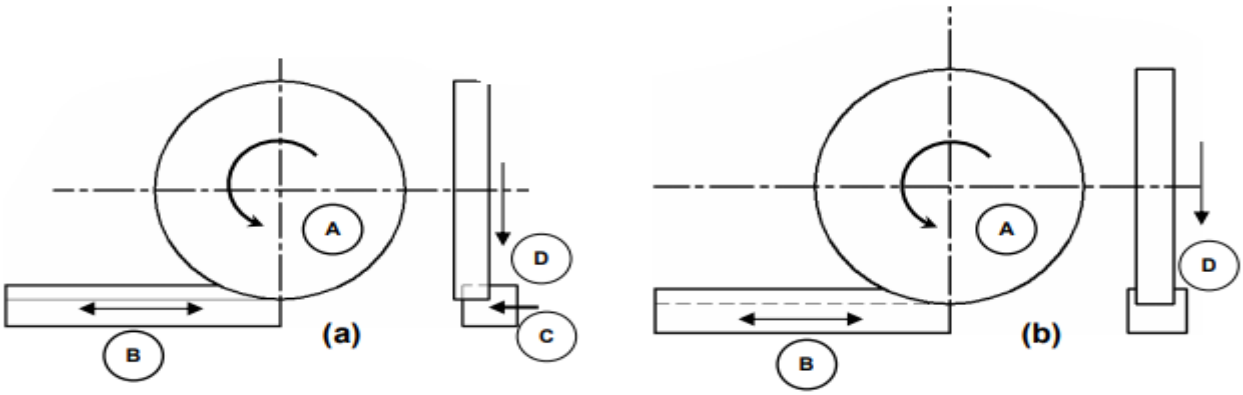
- **Horizontal spindle reciprocating table grinder**

this machine with various motions required for grinding action. A disc type grinding wheel performs the grinding action with its peripheral surface. Both traverse and plunge grinding can be carried out in this machine as shown in Fig.



A: rotation of grinding wheel
B: reciprocation of worktable
C: transverse feed
D: down feed

Figure 51.Horizontal spindle reciprocating table grinder



A: rotation of grinding wheel
B: reciprocation of worktable
C: transverse feed
D: down feed

Surface grinding (a) traverse grinding (b) plunge grinding

- **Vertical spindle reciprocating table grinder**

This grinding machine with all working motions is shown in Fig. The grinding operation is similar to that of face milling on a vertical milling machine. In this machine a cup shaped wheel grinds the workpiece over its full width using end face of the wheel as shown in Fig. This brings more grits in action at the same time and consequently a higher material removal rate may be attained than for grinding with a peripheral wheel.

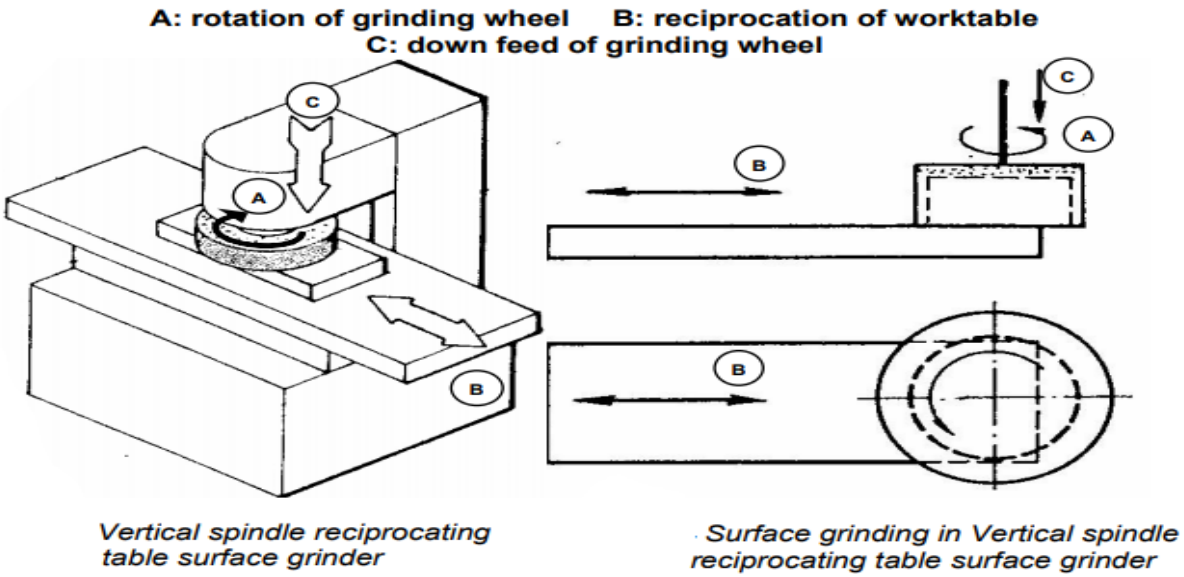


Figure 52. Vertical spindle reciprocating table grinder

- **Rotating table**
- **Horizontal spindle**

Surface grinding in this machine is shown in Fig. In principle the operation is same as that for facing on the lathe. This machine has a limitation in accommodation of workpiece and therefore does not have wide spread use. However, by swivelling the worktable, concave or convex or tapered surface can be produced on individual part as illustrated in Fig.

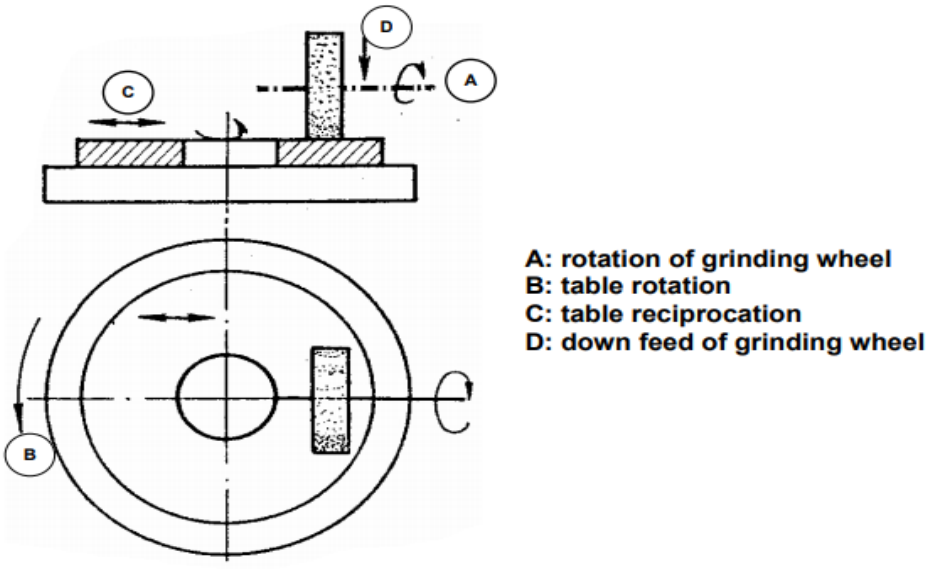


Figure 53.Horizontal spindle rotary table surface grinder

- **Vertical spindle**

Vertical spindle rotary table grinder The principle of grinding in this machine is shown in Fig. The machine is mostly suitable for small workpieces in large quantities. This primarily production type

machine often uses two or more grinding heads thus enabling both roughing and finishing in one rotation of the work table.

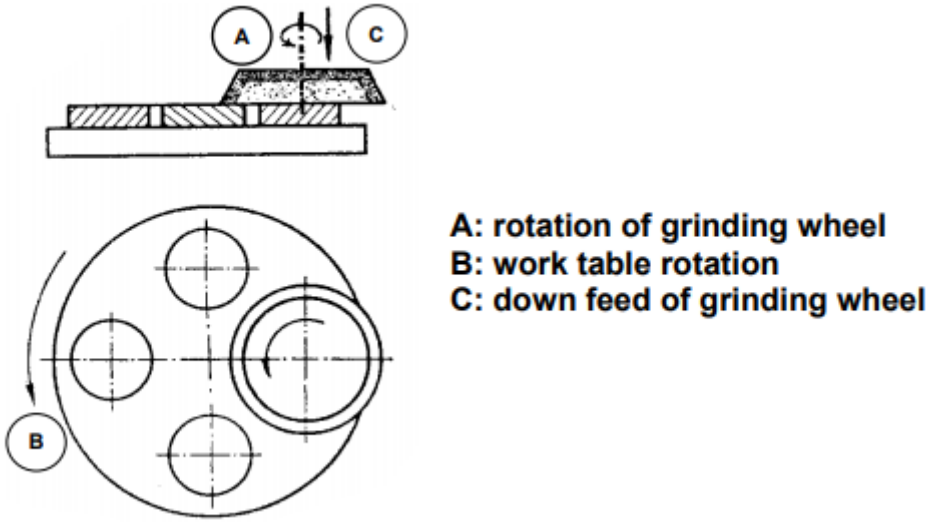


Figure 54. vertical spindle rotary table surface grinder

Tool and cutter grinder machine

Tool grinding may be divided into two subgroups: tool manufacturing and tool resharpening. There are many types of tool and cutter grinding machine to meet these requirements. Simple single point tools are occasionally sharpened by hand on bench or pedestal grinder. However, tools and cutters with complex geometry like milling cutter, drills, reamers and hobs require sophisticated grinding machine commonly known as universal tool and cutter grinder. Present trend is to use tool and cutter grinder equipped with CNC to grind tool angles, concentricity, cutting edges and dimensional size with high precision.

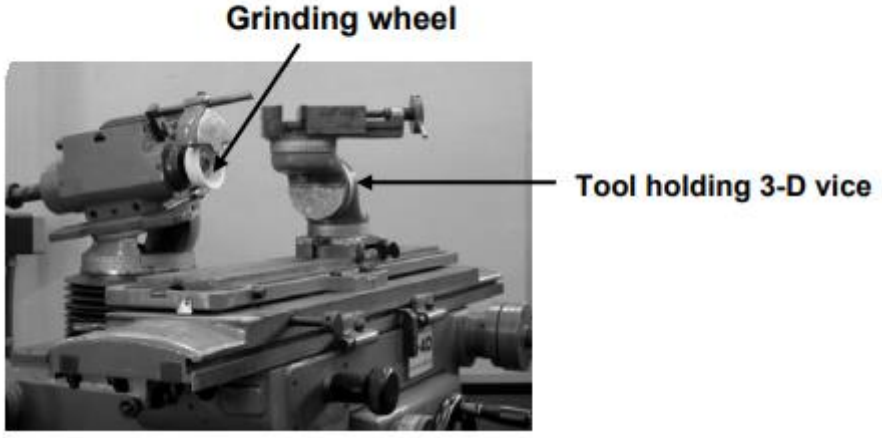


Figure 55.Pictorial view of a tool and cutter grinder

D. Special application of cylindrical grinder

Principle of cylindrical grinding is being used for thread grinding with specially formed wheel that matches the thread profile. A single ribbed wheel or a multi ribbed wheel can be used as shown in Fig.

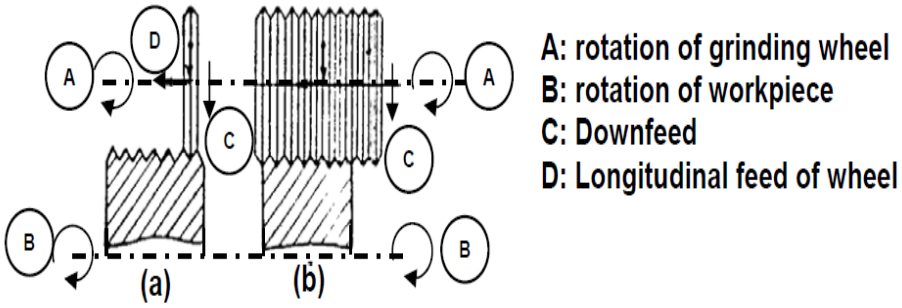


Figure 56.Thread grinding with (a) single rib (b) multi-ribbed wheel

- **Roll grinding** is a specific case of cylindrical grinding wherein large work pieces such as shafts, spindles and rolls are ground.
- **Crankshaft** or crank pin grinders also resemble cylindrical grinder but are engaged to grind crank pins which are eccentric from the centre line of the shaft as shown in Fig. The eccentricity is obtained by the use of special chuck.

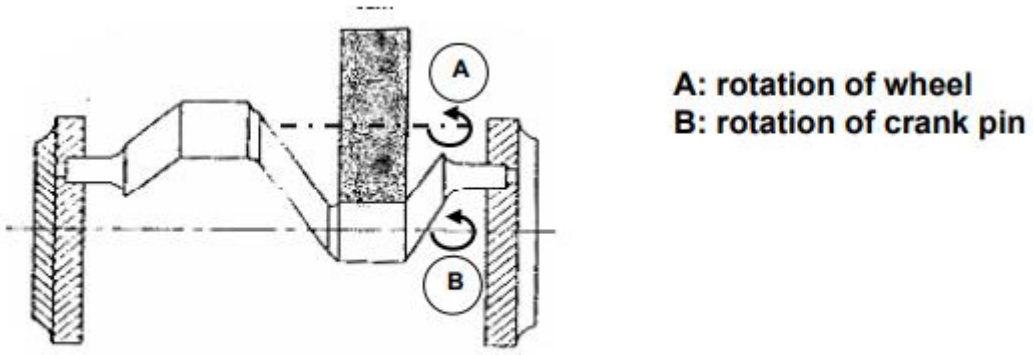


Figure 57.Grinding of crank pin

Cam and camshaft grinders are essentially subsets of cylindrical grinding machine dedicated to finish various profiles on disc cams and cam shafts. The desired contour on the work piece is generated by varying the distance between wheel and work piece axes. The cradle carrying the head stock and tail stock is provided with rocking motion derived from the rotation of a master cam that rotates in synchronisation with the work piece. Newer machines however, use CNC in place of master cam to generate cam on the work piece.

- **Tool post grinder**

A self-powered grinding wheel is mounted on the tool post or compound rest to provide the grinding action in a lathe. Rotation to the workpiece is provided by the lathe spindle. The lathe carriage is used to reciprocate the wheel head.

Description of surface grinding machine

Surface grinding is used to produce flat accurate surfaces and can be carried out on all materials, hard or soft. There may be no other way of removing metal from a hardened work piece. It is normally considered a finishing operation, but large machines are used in place of milling and shaping machines to remove large amounts of material.

A typical surface grinder is shown in Fig. and uses a 300mm diameter by 25mm wide grinding wheel. The reciprocating table and cross-slide movements are hydraulically operated, although alternative hand operation is provided.

The capacity of such a machine is the maximum length and width of surface which can be ground, in this case 500mm×200mm, and the maximum height which can go under a grinding wheel of maximum diameter.

Using a 300mm diameter wheel, the maximum height of work piece on the machine shown is 400mm.

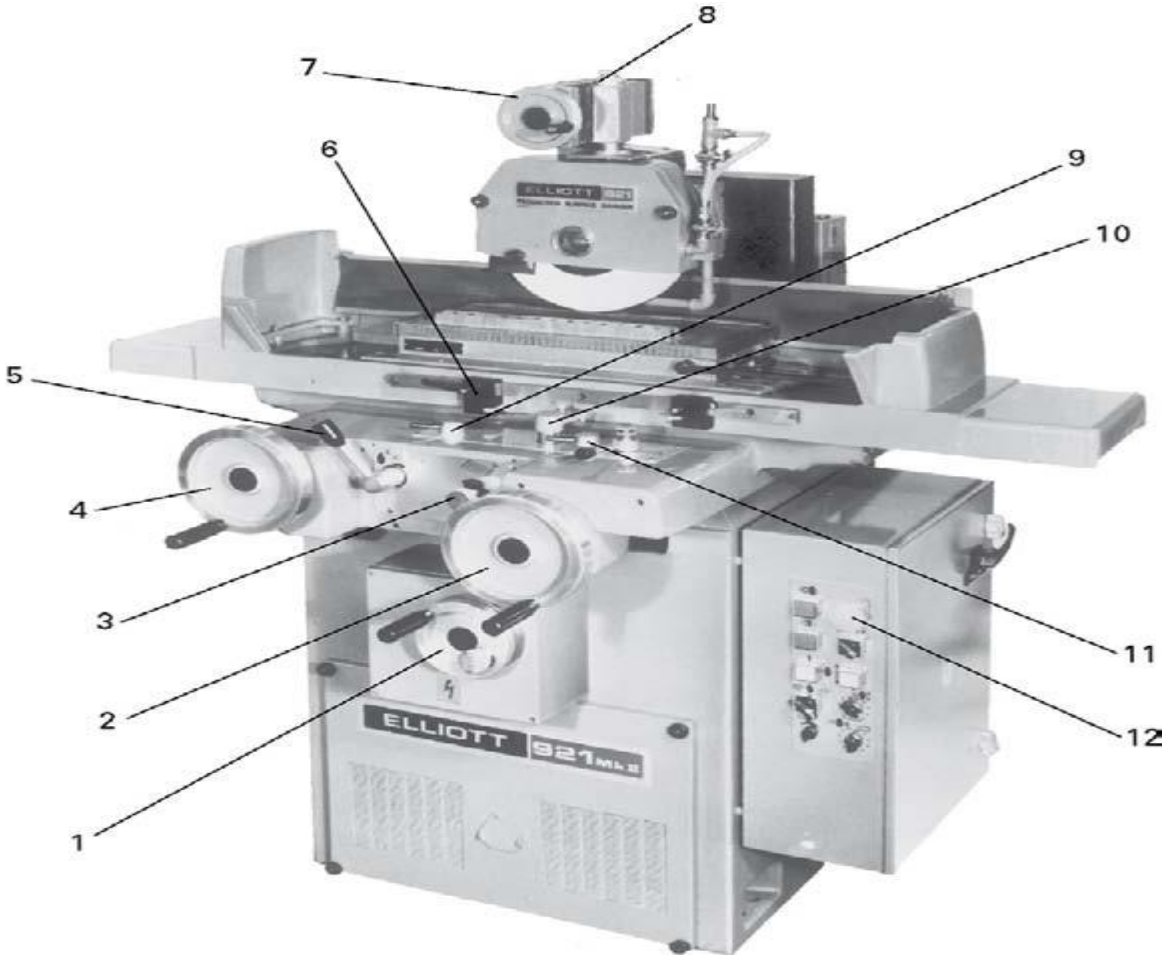


Figure 58. Surface grinding machine

1. Elements of a surface grinding machine

The main elements of a typical surface-grinding machine are shown in Fig.

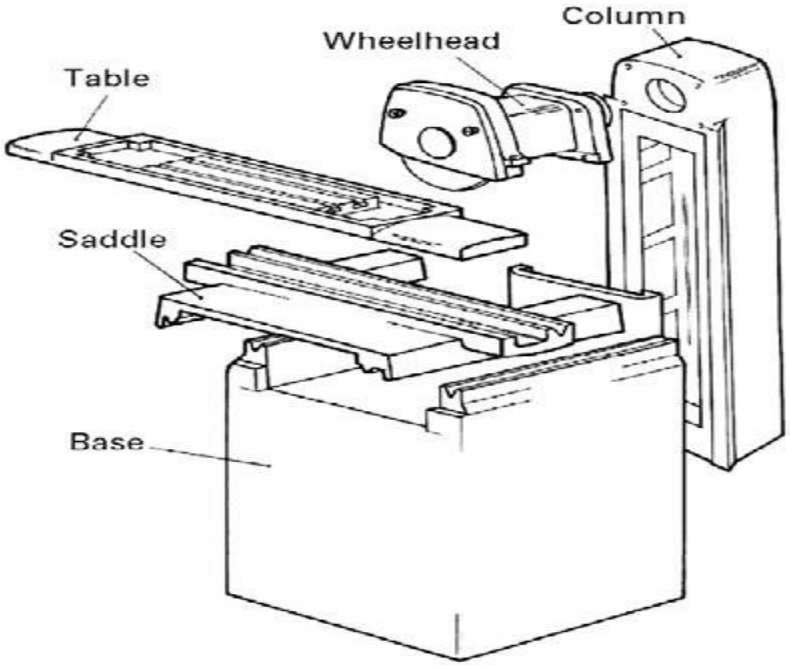


Figure 59.Main elements of surface grinder

1. Base

The base is a heavily ribbed box-section casting to ensure rigidity and complete freedom from vibration. The bottom of the base houses the hydraulic pump and fluid reservoir. At the rear of the base is a vertical dovetail sideway which guides the column. Two vee slide ways on top of the base guide the saddle and are widely spaced to maintain accuracy and rigidity.

2. Column

The column, guided on a dovetail slide, carries the wheelhead at its top end and contains the motor and belt drive to the wheel spindle. The column and wheelhead are raised and lowered through a screw and nut from a handwheel on the front of the machine. A telescopic guard is fitted to prevent grinding dust coming between the slide surfaces.

3. Wheelhead

The wheelhead carries the wheel spindle, which is mounted in precision bearings. The complete grinding-wheel collet assembly is fitted on a taper on the end of the spindle. Drive to the spindle is by vee belt and pulley from the motor mounted in the bottom of the column.

4. Saddle

The saddle is fitted on top of the base in the two vee slideways and provides the cross-traverse movement. The cross traverse can be applied automatically in continuous or incremental feed by hydraulic power or, alternatively, with a manually operated handwheel. The automatic cross movement is infinitely variable up to a maximum of 10mm. The increment of cross movement is applied at each end of the table stroke, resulting in complete grinding of the work piece surface in the manner shown schematically in Fig. 10.3. The top surface carries a vee-and-flat slideway to guide the table at right angles to the saddle movement.

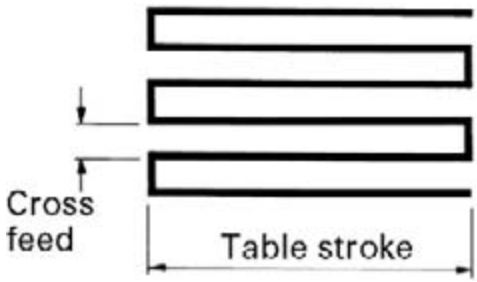


Figure 60.Schematic diagram of cross-feed movement to table stroke

5. Table

The table is guided by the vee-and-flat slideway on the saddle and can be manually operated with a hand wheel. Automatic reciprocation of the table is transmitted through a hydraulic cylinder at infinitely variable speeds from 0.6 to 30m/min. Reversal of the table movement is achieved automatically by trip dogs operating a direction-reversing valve. The trip dogs can be set to give the

required length of table stroke and position of reversal. A simplified diagram of the hydraulic circuit is shown When the direction-reversing valve A is in the position shown, the sliding valve B moves to the right.

This allows hydraulic fluid into the left of the table cylinder which is attached to the saddle. The fluid moves the piston, and the table attached to it, to the right. When the end of the table stroke is reached, the trip dog moves the direction-reversing valve, causing fluid to move the sliding valve to the left. This allows fluid into the right of the table cylinder, moving the piston and table to the left. Thus automatic continuous reciprocating movement of the table is achieved. Other connections into this circuit are made to give automatic cross movement at the end of each table stroke. Control valve C meters the amount of fluid reaching the cylinder and so controls the speed of the table movement. Relief valve D allows any pressure build-up to be released. This prevents mechanical damage in the event of accidental overload or jamming of the table, as the fluid is merely returned to the reservoir. A series of tee slots is provided on the top table surface to enable clamping of work pieces or work holding equipment.

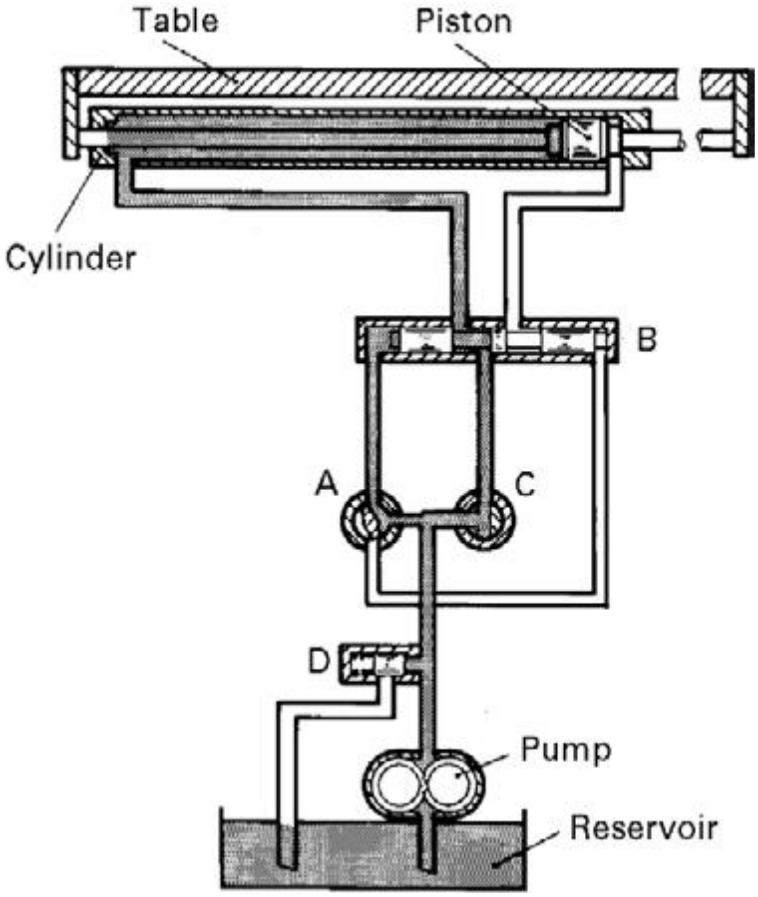


Figure 61.Simplified diagram of table hydraulics

2. Controls

Controls of a typical surface grinder are shown in Fig. Handwheel (1) raises and lowers the column. By lowering the column, a cut is put on by the wheel. Since the accuracy of the workpiece depends on

how much metal is removed, the graduations on this handwheel represent very small increments of movement, in this case 0.0025mm. Handwheel (2) provides cross movement of the saddle, graduations on this handwheel representing increments of 0.01mm.

Handwheel (4) is used to reciprocate the table by hand. Length of stroke and position of table reversal are controlled by trip dogs (6) striking the direction-reversing-valve lever (10).

The table-speed control knob (11) can be adjusted to give infinitely variable speeds from 0.6 to 30m/min. Lever (9) is used to select continuous cross feed or incremental feed at the end of each table stroke.

Where continuous cross feed is selected, lever (5) controls the speed, which is infinitely variable from 0 to 5m/min.

The rate of incremental feed is controlled by lever (3) and is infinitely variable from 0.28 to 10mm. The switch panel at the right side of the machine controls the motors for the hydraulic pump, wheel spindle, cutting fluid, etc. and carries the main isolator and a large mushroom headed stop button (12).

3. Work holding

The basic method of work holding in surface grinding is the permanent-magnet chuck, used to hold work pieces having flat surfaces. These chucks will not hold non-magnetic materials such as the non-ferrous range. The complete chuck consists of a top plate containing inserts separated from the top plate by a non-magnetic epoxyresin filler, a non-magnetic case, a moving grid containing the permanent magnets insulated from the grid and magnetised vertically and a base plate, Fig The principle upon which permanent-magnet devices operate is to establish the magnetic lines of force or flux from the permanent magnets through the work piece when switched on, and to divert or 'short circuit' the flux when switched off. This is achieved by moving the magnets in line with the top plate and so completing the circuit to the insert, grid and base plate through the work piece Fig (a). For a work piece to be gripped, it is therefore necessary for it to bridge the top plate and an insert. To switch off, the magnets are moved

out of line with the top plate, diverting the flux so that the circuit is completed not through the work piece but through the top plate, insert and base plate, Fig (b). The work piece is thus deprived of flux and is released. Other methods of work holding are used when the shape or the material from which the work piece is made does not allow direct holding on the permanent-magnet chuck. However, the devices used to hold the work pieces are invariably themselves held on the permanent- magnet chuck.

Vices are used to hold work pieces, but it should be remembered that grinding is usually a finishing operation and so any vice used should be accurate and if possible kept only for use in grinding. Care

must also be taken to avoid distortion of the component, as this will be reflected in the finished work piece. Surfaces required to be ground at right angles can be clamped to the upright surface of an angle plate. Vee blocks are used to hold circular work pieces.

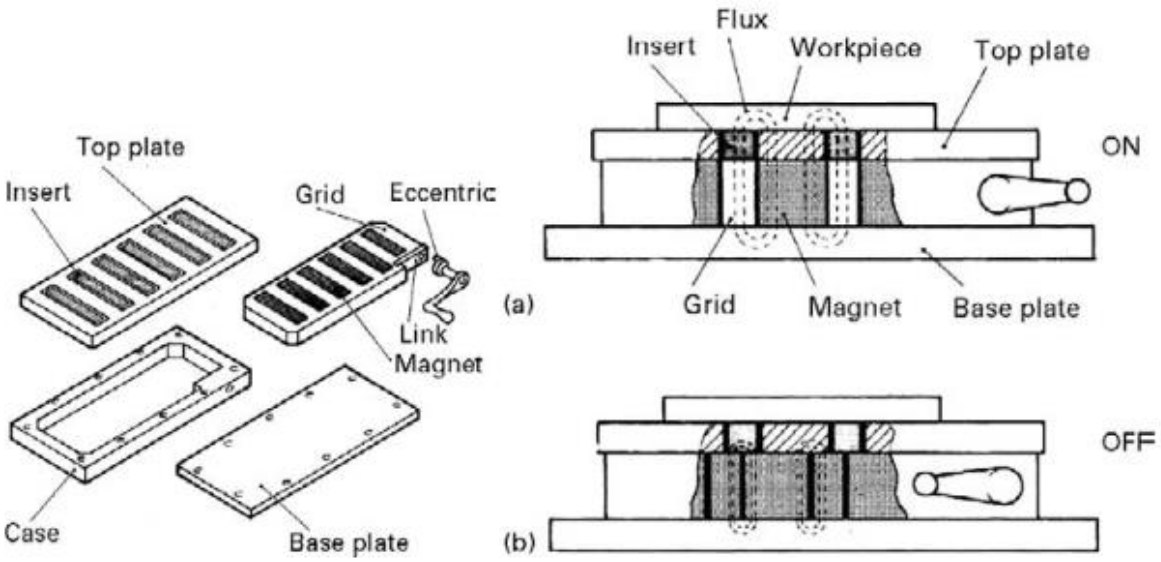


Figure 62. Permanent-magnet chuck

4. Grinding wheels

All machining operations are potentially dangerous – lack of understanding or undue care have resulted in many accidents. The use of grinding wheels, also known as abrasive wheels, which are described fully at the end of this chapter, is potentially one of the most dangerous for two reasons.

• A grinding wheel is made of small abrasive particles held together by a bonding material. Compared with metal it is extremely fragile.

• Grinding wheels are run at high speeds. A 300mm diameter wheel is run at about 2000rev/min, giving a speed at the diameter of almost 1900m/min. Compare this with a piece of steel of the same diameter being cut with a high-speed-steel cutting tool on a lathe at 30m/min. The Provision and Use of Work Equipment Regulations 1998 (PUWER) require, amongst other things, that all machinery is suitable for its intended use and is properly maintained, and that employees, including those using, mounting and managing the operation of abrasive wheels, are fully informed and properly trained in their use. Any training programme should cover, amongst others, aspects such as hazards and risks, uses, marking, storage, mounting and dressing of abrasive wheels. No attempt is to be made here to cover the detailed instruction requirements of the Regulations, merely to draw attention to them.

4.1. Dressing

A grinding wheel is made up of a large number of tiny teeth. The teeth are formed by the tiny grains of hard abrasive, held together by a bonding material. As with any other metal-cutting operation, the 'teeth'or grains must be kept sharp. To some extent a grinding wheel is self sharpening.

The ideal situation during grinding is that, as the grains which are cutting become blunt, greater force is exerted which tears the blunt grains from the bonding material, exposing fresh sharp ones. It follows that, when grinding a hard material, the grains become blunt quickly and will require to be torn from the bonding material quickly. To allow this to take place, less bonding material is used to hold the grains, the grains tear away easily when blunt, and the wheel is referred to as 'soft'.

The opposite is true when grinding a soft material: the grains do not blunt so readily and can be held in position longer, and therefore more bonding material is used. These wheels are referred to as 'hard'. Sharpness and trueness of the face can be achieved by 'dressing' with an industrial diamond. The diamond, held in a suitable holder, is positioned on the chuck under the grinding wheel. The wheel is then lowered until it touches the diamond, whereupon the diamond is moved across the surface of the wheel using the cross traverse movement, Fig. The wheel is then lowered a little and the operation is repeated until all the worn grains have been torn out and fresh ones exposed and Dressing the grinding wheel using a diamond the face is flat and true.

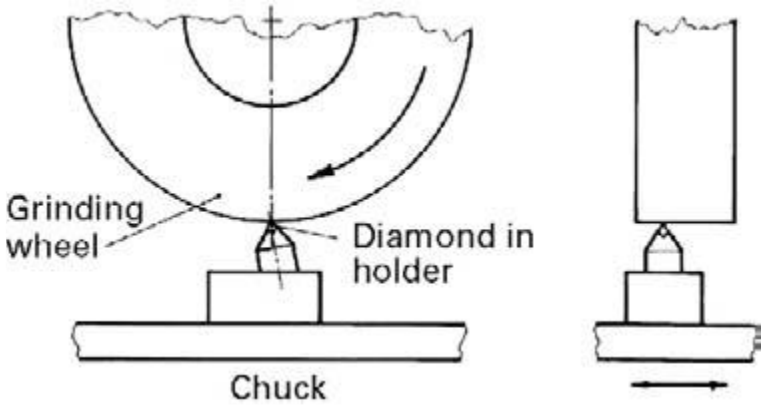


Figure 62.Dressing the grinding wheel using a diamond

The machine shown in Fig. has a built-in dressing attachment mounted above the wheel. By turning the graduated dial (8) in Fig, the diamond is lowered in contact with the top of the wheel and is traversed across the wheel surface using the hand wheel (7). An attachment of this kind saves time through not having to position and remove the diamond for each dressing nor having to lower the wheel for dressing and to raise it again to continue grinding.

4.2. Balancing

It is impossible to produce good-quality work on any grinding machine if the wheel is out of balance, thus setting up vibrations through the spindle.

The wheel is mounted on a collet, the complete assembly being removable from the spindle, Fig. The wheel spigot upon which the wheel is located has a taper bore to accurately locate on the spindle nose. The wheel flange locates on the wheel spigot and is held by three screws which, when tightened, securely hold the wheel between the two surfaces. On the outer face of the wheel flange is an annular dovetail groove which holds balance masses. These masses can be locked in any position round the groove.

When the wheel is mounted correctly and the periphery has been dressed, the collet assembly is removed from the spindle. The balance masses are then removed. A balancing arbor is inserted in the bore.

The balancing arbor has a taper identical to that on the spindle and has equal size parallel diameters at each end, Fig. (a). This assembly is placed on a balancing stand, Fig. (b), which has previously been set level. The wheel is allowed to roll on the knife edges and is left until it comes to rest, which it will do with the heaviest portion at the bottom.

A chalk mark is made at the top of the wheel, opposite the heaviest portion. The masses are then replaced in a position opposite to each other and at right angles to the chalk mark. The masses can now be moved equally a little way towards the light portion and locked. The wheel is then rolled and allowed to come to rest. If the same heavy portion again comes at the bottom, both masses are moved a little closer to the light portion and again the wheel is allowed to roll and come to rest. This process is repeated until the wheel will stop in any position and show no tendency to roll along the balancing stand. The wheel is then ready for use and should be replaced on the spindle in the correct manner.

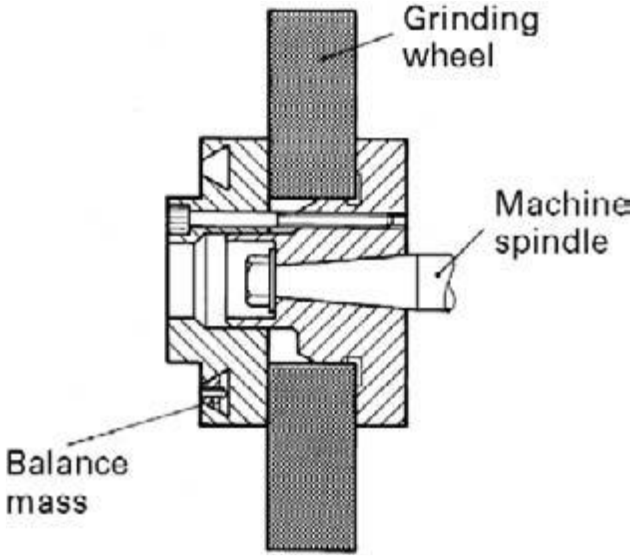


Figure 63.W heel-collet assembly

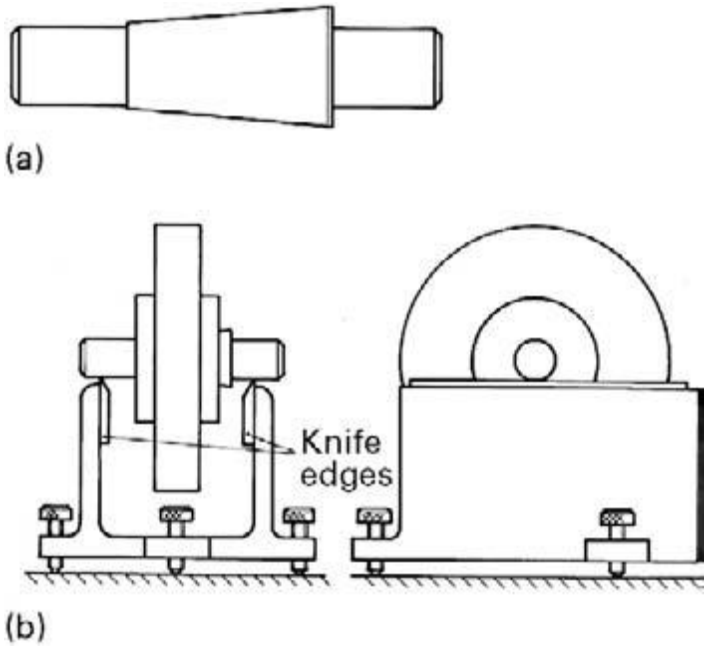


Figure 64(a) Balancing arbor and (b) stand

4.3. Guarding

Due to the fragile nature of a grinding wheel and the high speeds at which it runs, it is possible for a wheel to burst. Under the regulations, all grinding wheels must be adequately guarded and the guard be fitted at all times before the wheel is run.

A guard has two main functions: first to contain the wheel parts in the event of a burst, and second to prevent, as far as possible, the operator coming in contact with the wheel. Abrasive wheels should be enclosed to the greatest extent practicable and this will depend on the nature of the work. On surface grinders, the guard consists of a plate which encloses the front of the wheel to retain fragments, thus protecting the operator should the wheel burst. Details of the wheel enclosure angles for peripheral surface grinders supplied after the publication of BS EN 13218 in

2008 are shown in width guards are fitted to the front of the machine table to protect the operator in the event of a work piece flying off a magnetic chuck and from coolant spray.

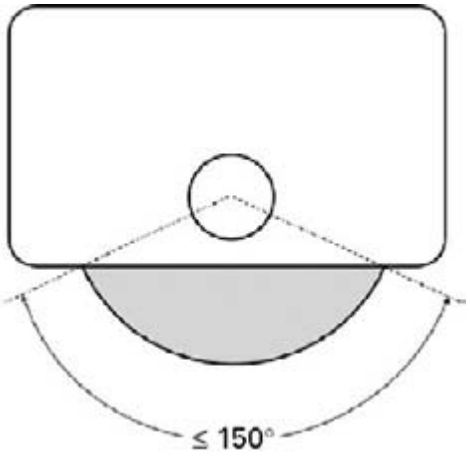


Figure 65.Wheel enclosure angle

4.4. Bonded-abrasive grinding wheels

A bonded-abrasive wheel consists of two main essentials: the abrasive, which does the actual cutting, and the bonding material or bond, which holds the abrasive together and forms the wheel shape, Fig. The ideal cutting condition of an abrasive wheel is that, when they have done their work and become dull, the abrasive grains fracture or are released from the bonding material to expose new sharp cutting grains in their place. This is repeated continuously during cutting and gives the wheel a self-sharpening effect. If the grains are released before they have done their work and become dull, the wheel wears rapidly and is said to act 'soft'.

When the strength of the bonding material is too great to allow the grains to be released when they have become dull, the wheel is said to act 'hard' and is recognizable by a glazed and shiny appearance on the cutting face.

In order to grind a range of materials efficiently under a variety of cutting conditions, different abrasives of varying grain size are arranged within different bonding materials to give a number of features or characteristics. (Groover, 2010)

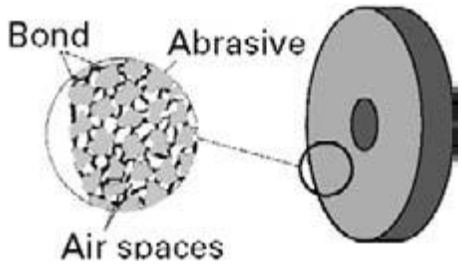


Figure 66.Abrasive-wheel features

LO 3.2 – Select grinding machine

- **Content/Topic 1 :Selection of grinding machine according to the quality of surface finish**

1. Rough grinders

The rough grinding machines are used to remove stock with no reference to the accuracy of results. Excess metal present on the cast parts and welded joints are removed by rough grinders. The main types of rough grinders are:

1. Hand grinding machine
2. Bench grinding machine
3. Floor stands grinding machine
4. Flexible shaft grinding machine
5. Swing frame grinding machine
6. Abrasive belt grinding machine

2. Precision grinders

Precision grinding is machine grinding where the traverse and or feed rates can be set and process parameters are measured and controlled. As the name indicates, here the need is more on surface finish, geometry, size control etc. Precision grinding operations include:

1. Cylindrical grinding
2. Centreless grinding
3. Internal grinding
4. Surface grinding
5. Tool and Cutter grinding
6. Thread grinding
7. Crankshaft and Camshaft grinding.

- **Content/Topic 2: Selection of Grinding machine according to types of surface to be grinded**

Factors affecting the selection of a grinding wheel

Wheel selection is dependent on the kind of material to be ground and the type of grinding operation. The eight important factors that need to be considered in the selection of a grinding wheel are:

1. Material to be ground and its hardness
2. Stock removal and surface finish
3. The grinding process - wet or dry
4. Peripheral speed of the wheel
5. The area of grinding contact - large or small
6. The grinding application

7. Condition of the grinding machine

8. The type of grinding machine

- **External cylindrical grinding**

This grinding machine is a production machine in which outside diameter of the work piece is ground. The work piece is not held between centres but by a work support blade. It is rotated by means of a regulating wheel and ground by the grinding wheel.

- **Internal cylindrical grinding**

This machine is used to produce internal cylindrical surface. The surface may be straight, tapered, grooved or profiled.

- **Surface grinding**

This machine may be similar to a milling machine used mainly to grind flat surface. However, some types of surface grinders are also capable of producing contour surface with formed grinding wheel.

- **Content /Topic4: Selection of grinding machine according to operation performed Polishing**

A. Buffing

Buffing Buffing is used to give a much higher, reflective finish that cannot be obtained by polishing. Buffing wheels are made of felt, leather and pressed & glued layers of a variety of cloth. The abrasive used are iron oxide, chromium oixde, emery, etc. The abrasive is mixed with a binder. The binder is a paste consisting of wax mixed with grease, paraffin and turpentire. It is applied either on the buffing wheel or on the work. Buffing wheels are rotated against the work to get a superior finish.

B. Lapping

Lapping is the abrading process that is used to produce geometrically true surfaces, correct minor surface imperfections, improve dimensional accuracy to provide a very close fit between two surfaces in contact. Very thin layers of metal (0.005 to 0.01 mm) are removed in lapping. Machining can be done to the accuracy of less than 1micron. To perform lapping operation, lapping shoes and lapping mixture are needed. Laps may be made of almost any material soft enough to receive and retain the abrasive grains. They are made of soft cast iron, brass, copper or lead. It is made in different shapes. Abrasive powders such as emery, corundum, iron oxide and chromium oxide are mixed with oil or grease to make lapping mixture. The face of the lap becomes charged with abrasive particles. Laps may be operated by hands or by machine. Cylindrical work may be lapped by rotating the work in a lathe and reciprocating the lap over the work. Flat surfaces may be lapped by holding the work against a rotating disc. Special lapping machines like vertical lapping machine, centreless lapping machine and abrasive belt lapping machines are also widely used.

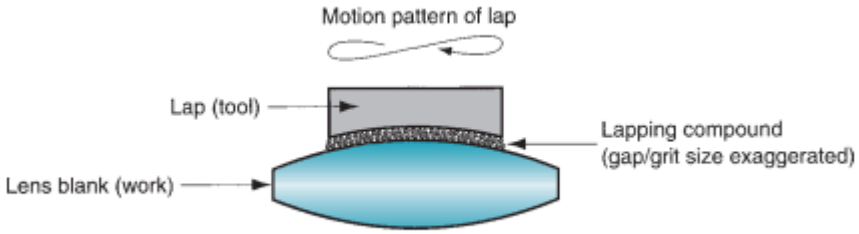


Figure 67.Lapping

C. Honing

Honing is the abrading process done mostly for finishing round holed produced by drilling, reaming or boring by means of bonded abrasive stones called 'hones'. Honing is a machining process and is used to remove metal upto 0.25 mm. The surface roughness value can be maintained between 0.025 and 0.4 microns. So honing is used to correct some out of roundness, tapers, tool marks and axial distortion.

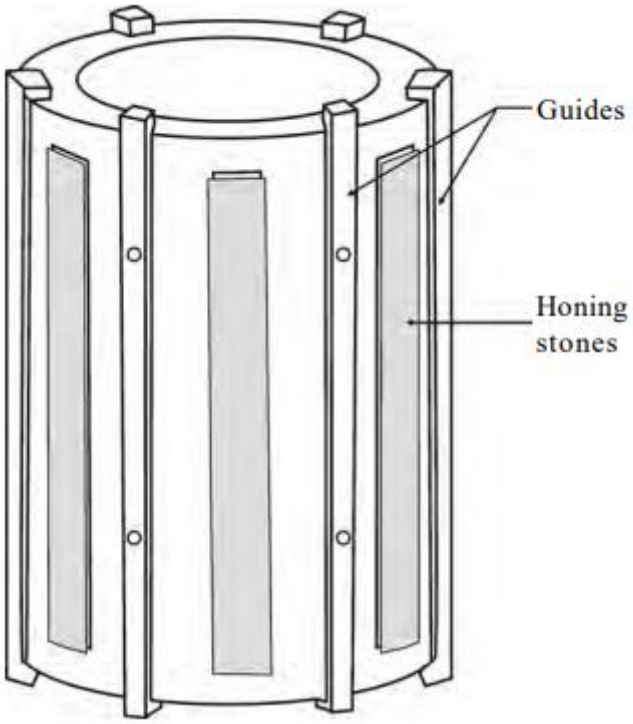


Figure 68.Honing

D. Super finishing

Superfinishing The process of superfinishing is an operation intended to produce an extremely high quality of surface finish. The surface roughness value can be maintained between 0.015 and 0.32 microns. A very thin layer of metal (0.005 mm to 0.02 mm) is removed by using very fine size of abrasives (Size of 400 to 600)in superfinishing. It can be done on both external and internal surfaces. The grinding stones are made to reciprocate and the workpiece is made to rotate or reciprocate. A

fine surface is obtained by admitting coolant mixed with kerosene. Using some special machines, superfinishing is performed on crankshaft, journal bearings and cam shafts. (JESUDOSS, 2011)

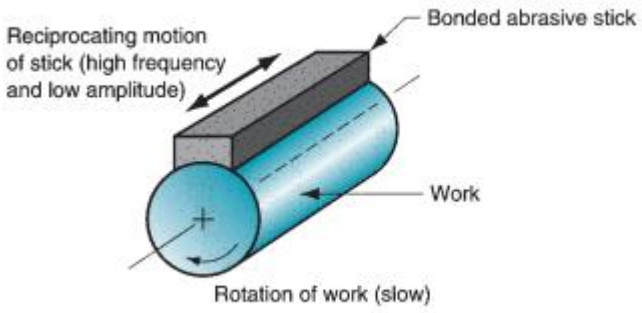


Figure 69. Super finishing

LO 3.3 – Select grinding wheel

- **Content/Topic 1 :Types of grinding wheel according to the shape**

A grinding wheel is an expendable wheel that carries an abrasive compound on its periphery. These wheels are used in grinding machines. The wheel is generally made from a matrix of coarse particles pressed and bonded together to form a solid, circular shape, various profiles and cross sections are available depending on the intended usage for the wheel. They may also be made from a solid steel or aluminium disc with particles bonded to the surface.

1. Straight wheel

To the left is an image of a **straight wheel**. These are by far the most common style of wheel and can be found on bench or pedestal grinders. They are used on the periphery only and therefore produce a slightly concave surface (*hollow ground*) on the part. This can be used to advantage on many tools such a chisels.

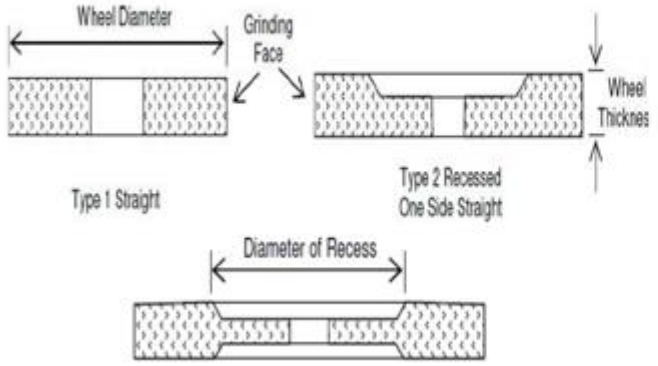


Figure 70.straight wheel

These are generally used for cylindrical internal, centreless and surface grinding operations. These wheels vary in size, diameter and width of the face

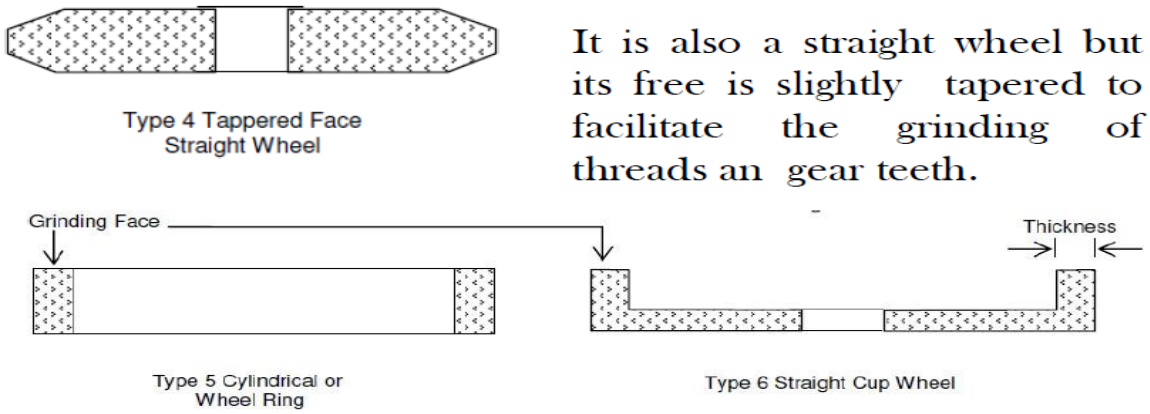


Figure 71.straight wheel

3. Cylinder wheel

Cylinder wheels provide a long, wide surface with no center mounting support (hollow). They can be very

- ✓ **Cylinder or wheel ring**

The proper mounting of a grinding wheel is very important. An improperly mounted wheel may become potentially dangerous at high speeds.

The specified wheel size for the particular grinding machine to be used should not be exceeded either in wheel diameter or in wheel width. Figure 5-12 illustrates a correctly mounted Grinding wheel :

- ✓ Cylinder
- ✓ Tapered
- ✓ Recessed one side
- ✓ Straight cup
- ✓ Recessed both sides
- ✓ Flaring cup
- ✓ Dish
- ✓ Saucer
- ✓ Mounted wheels

3. Tapered wheel

A straight wheel that tapers outward towards the center of the wheel. This arrangement is stronger than straight wheels and can accept higher lateral loads.

4. The dish cup type

A **cup wheel** as pictured to the right is predominantly used in Tool and Cutter grinders where orientation of the wheel and a slim profile are required. These wheels are used (and dressed) on the side face and have the advantage of producing a truly flat surface on the side of lathe tools. They are used in jig grinders to produce flat surfaces or counterbores

5. Diamond wheel

Diamond wheels are grinding wheels with industrial diamonds bonded to the periphery.

They are used for grinding extremely hard materials such as carbide tips, gemstones or concrete. The saw pictured to the right is a slitting saw and is designed for slicing hard materials, typically gemstones.

Figure 72.Diamond grinding wheel

- ✓ **Diamond dresser**

The diamond dresser is the most efficient for truing wheels for precision grinding, where accuracy and high finish are required. A dresser may have a single diamond or multiple diamonds mounted in the end of a round steel shank. Inspect the diamond point frequently for wear. It is the only usable part of the diamond, and is worn away it cannot dress the wheel properly. Slant the diamond 3° to 15° in the direction of rotation and 30° to the plane of the wheel as shown in Figure 5-14 to prevent chatter and gouging. Rotate the diamond slightly in its holder between dressing operations to keep it sharp. A dull diamond will force the abrasive grains into the bond pores and load the face of the wheel, reducing the wheel's cutting.

- ✓ **Saucer grinding wheel**

A special grinding profile that is used to grind milling cutters and twist drills. It is most common in non-machining areas, as sawfilers use saucer wheels in the maintenance of saw blades.

Figure 73.Saucer grinding wheel

- **Content/Topic 2: Specification of grinding wheel**

1. Abrasives

Most grinding wheels are made of silicon carbide or aluminium oxide, both of which are artificial (manufactured) abrasives. Silicon carbide is extremely hard but brittle. Aluminium oxide is slightly softer but is tougher than silicon carbide. It dulls more quickly, but it does not fracture easily therefore it is better suited for grinding materials of relatively high tensile strength.

Abrasives are used for grinding and polishing operations. It should have uniform physical properties of hardness, toughness and resistance to fracture. Abrasive may be classified into two principal groups.

1. Natural abrasives
2. Artificial abrasives

- **Natural abrasives**

The natural abrasives are obtained from the Earth's crust. They include sandstone, emery, corundum and diamond. Sandstone is used as abrasive to grind softer materials only. Emery is natural alumina. It contains aluminium oxide and iron oxide. Corundum is also a natural aluminium oxide. It contains greater percentage of aluminium oxide than emery. Both emery and corundum have a greater hardness and abrasive action than sandstone.

Diamond is the hardest available natural abrasive. It is used in making grinding wheels to grind cemented carbide tools.

- **Artificial abrasives**

Artificial abrasives are of two types.

1. Silicon carbide abrasives
2. Aluminium oxide abrasives

- **Silicon carbide**

Silicon carbide is manufactured from 56 parts of silica, 34 parts of powdered coke, 2 parts of salt and 12 parts of sawdust in a long rectangular electric furnace of the resistance type that is built of loose brick work. There are two types of silicon carbide abrasives - green grit and black grit.

Silicon carbide is next to diamond in the order of hardness. But it is not tough enough as aluminium oxide. It is used for grinding materials of low tensile strength such as cemented carbides, ceramic materials, grey brass, bronze, copper, aluminium, vulcanized rubber etc.

This is manufactured under trade names of carborundum. It is denoted by the letter 'S'.

- **Aluminium oxide**

Aluminium oxide is manufactured by heating mineral bauxite, silica, iron oxide, titanium oxide, etc., mixed with ground coke and iron borings in arc type electric furnace. Aluminium oxide is tough and not easily fractured, so it is better adapted to grinding materials of high tensile strength such as most steels, carbon steels, high speed steels, and tough bronzes. This is denoted by the letter 'A'.

2. Bond

The abrasive particles in a grinding wheel are held in place by the bonding agent. The percentage of bond in the wheel determines, to a great extent, the "hardness" or "grade" of the wheel. The greater the percentage and strength of the bond, the harder the grinding wheel will be. "Hard" wheels retain the cutting grains longer, while "soft" wheels release the grains quickly. If a grinding wheel is "too hard" for the job, it will glaze because the bond prevents dulled abrasive particles from being released so new grains can be exposed for cutting. Besides controlling hardness and holding the abrasive, the bond also provides the proper safety factor at running speed. It holds the wheel together while centrifugal force is trying to tear it apart. The most common bonds used in grinding wheels are vitrified, silicate, shellac, resinoid, and rubber

- ✓ **Types of bonds**

A bond is an adhesive substance that is employed to hold abrasive grains together in the form of grinding wheels. There are several types of bonds. Different grinding wheels are manufactured by mixing hard abrasives with suitable bonds. The table containing the types of wheels manufactured using different types of bonds and their symbols is given below

Type of bond	Symbol	Grinding wheel
1.vitrified	v	Vitrified wheel
2.silicate	s	silicate wheel
3.shellac	E	shellac wheel
4.resinoid	B	resinoid wheel
5.rubber	R	vulcanised wheel
6.oxychloride	O	oxychloride wheel

Figure 74Types of bonds

3. Grit

Grain size (Grit)

The grinding wheel is made up of thousands of abrasive grains. The grain size or grit number indicates the size of the abrasive grains used in making a wheel, or the size of the cutting teeth.

Grain size is denoted by a number indicating the number of meshes per linear inch of the screen through which the grains pass when they are graded. There are four different groups of the grain size namely coarse, medium, fine and very fine. If the grit number is large, the size of the abrasive is fine and a small grit number indicates a large grain of abrasive.

coarse	10	12	14	16	20	24	
medium	30	36	46	54	60		
fine	80	100	120	150	180		
Very fine	220	240	280	320	400	500	600

Figure 75.grain size

4. Grade

The grade of a grinding wheel refers to the hardness with which the wheel holds the abrasive grains in place. It does not refer to the hardness of the abrasive grains. The grade is indicated by a letter of the English alphabet. The term 'soft' or 'hard' refers to the resistance a bond offers to disruption of the abrasives. A wheel from which the abrasive grains can easily be dislodged is called soft whereas the one, which holds the grains more securely, is called hard. The grade of the bond can be classified in three categories.

soft	A	B	C	D	E	F	G	H	
medium	I	J	K	L	M	N	O	P	
hard	Q	R	S	T	U	U	X	Y	Z

Figure 76Grade

5. Structure

The relative spacing occupied by the abrasives and the bond is referred to as structure. It is denoted by the number and size of void spaces between grains. It may be 'dense' or 'open'. Open structured wheels are used to grind soft and ductile materials. Dense wheels are useful in grinding brittle materials.

dense	1	2	3	4	5	6	7	8
open	9	10	11	12	13	14	15	Or higher

6. Shape

Standard shapes of grinding wheel faces. The nature of the work dictates the shape of the face to be used. For instance, shape A is commonly used for straight cylindrical grinding and shape E for grinding threads.

7. Size

Abrasive grains are selected according to the mesh of a sieve through which they are sorted. For example, grain number 40 indicates that the abrasive grain passes through a sieve having approximately 40 meshes to the linear inch. A grinding wheel is designated coarse, medium, or fine according to the size of the individual abrasive grains making up the wheel

8. Grain Size

Grain size to be chosen when selecting a grinding wheel depends upon the factors described below. The softer and more ductile the material, the coarser the grain size. The larger the amount of stock to be removed, the coarser the grain size. The finer the finish desired, the finer the grain size.

Standard marking system of grinding wheels

The Indian standard marking system for grinding wheels has been prepared with a view of establishing a uniform system of marking of grinding wheels to designate their various characteristics.

Prefix Manufacturer's abrasive type symbol First element (letter) Type of abrasive

Second element (number) Size of abrasive Third element (letter) Grade of bond

Fourth element (number) Structure of the grinding wheel

Fifth element (letter) Type of bond

Suffix Manufacturer's symbol

The meaning of the given marking on grinding wheel

w	A 54 M 7 V 20	
	W-manufacture abrasive type symbol	
	A-type of abrasive	Aluminium oxide
	54-size of abrasive	medium
	M-grade of bond	medium
	7-structure of grinding wheel	dense
	V-type of bond	vitrified
	20-manufacture symbol	

Figure 77.

- **Content /Topic 3: Grinding wheel selection factors Constant factors**

Selection of Grinding Wheels:

The proper selection of grinding wheels is very important for getting good results (i.e. obtaining better finish and at the same time having more life of the wheel). In order to meet all these requirements, the various elements that influence the process must be considered.

Selection mainly depends upon the following factors:

a) Constant factors.

(b) Variable factors.

Constant factors include:

(i) Work material. It should be remembered that for grinding a soft material, hard wheel should be used and vice versa,

(ii) Amount and rate of stock removal,

(iii) Area of contact between work and wheel.

(iv) Condition of grinding machine. A softer grade of wheel is used on robust and heavy machine,

(v) Finish and accuracy required on the job.

Variable factors include:

(i) Wheel speed,

(ii) Work speed,

(iii) Condition of grinding machine (state of the wheel spindle bearing),

(iv) Skill of operator (personal factors).

From above it is obvious that several factors are to be considered for the proper selection of the right wheel. The different wheels are constituted by different combinations of abrasive materials, grain size, type of bond, hardness of bond, structure etc. Thus the difficulty in choosing right wheel for any particular job can be gauged from the fact that more than 10,000 different combinations are obtainable in one wheel.

Work Material:

It will influence the following elements:

(a) Abrasive material,

(b) Grain size of grit number (mesh number),

(c) Grade (strength of bond),

(d) Structure.

(a) Abrasive:

This choice of right abrasive is to some extent determined by the type of material only to be ground, which will decide whether the abrasive is Silicon Carbide (SiC) or Aluminium Oxide (Al_2O_3) as these

are most commonly used abrasives in different varieties. SiC is the best suited abrasive for brittle and hard materials like grey cast iron castings, chilled iron, tungsten carbide, hard steels, stone, porcelain and other ceramic substances.

SiC is also recommended for low tensile strength material such as non-ferrous metals, bronze, brass, copper, aluminium and plastic materials, $A1_2 0_3$ is better for tough materials having high tensile strength like mild steel, alloy steel, high speed annealed malleable iron, tough bronze, wrought iron, etc.

(b) Grain Size:

For softer materials, it is a general practice to use coarse grain size and for harder materials, fine grains. Coarser grain is used for high rate of stock removal. Fine grain is used if the work size or the work surface finish is important. Grain size is determined by the mesh number by which it is retained when passed through a series of meshes in a vibrating sieve.

(c) Grade:

The hard materials and materials having high strength offer more resistance to wheel while grinding operation is performed. Thus if hard grade of wheel is used then wheel will get blunt soon and the grinding will not be good. Therefore, for better results on such materials, the abrasive particles should break and fall quickly so that new sharp faces of the particles do the work and they never get blunt.

For softer materials, high or harder grade, i.e. good bond is used. The grading is done by capital alphabets, the first alphabets being used for softer grade and last ones for harder grade.

(d) Structure:

This represents the void between the abrasives and is influenced by the work material. In the case of harder materials the chips are of small size and also the rate of metal removal is low. Thus a small reservoir is needed to remove the chips from the hard material, and the dense structure is desirable for it.

For softer materials, the open structure is prescribed as the rate of metal removal is high and size of chips is also big. The structure is denoted by numbers from 1 to 15.

Amount and Rate of Stock Removal:

It does not influence the abrasive material but the

(a) Grain size,

(b) Grade,

(c) Structure.

For fast removal of metal, coarse gain size is required and vice versa. As regards grade, soft grade is used for fast removal of metal, of course at the cost of wheel life. With softer grade, the abrasive

particles fall off quickly and wheel keeps on sharpening, thus removing more quantity of material. Also in order that metal may be removed at faster rate, more space is required for chip removal and hence open structure is desirable for fast removal of metal and vice versa.

Area of Contact:

It mainly influences grade and to some extent grain size also. When the area of contact in grinding operation is large, total grinding pressure is distributed over a larger area and the pressure per unit area is less and hence a softer wheel is needed for it. Thus for internal grinding where arc of contact is more, softer wheel is used and for external grinding, harder wheel.

Condition of Grinding Machine:

Heavy rigid machines demand the softer grade of wheel than the light machines. If condition of grinding machine is such as to cause vibration, harder grade is used compared to one where complete freedom from vibrations is there.

Finish and Accuracy Required:

For high degree of accuracy and fine finish requirement, small sized grain wheels should be used.

Variable Factors:

i. Wheel Speed and Work Speed:

These are the most predominant factors and about 70% of the complaints can be improved by proper selection of work and wheel speed e.g. if one gets burnt surface then speed of the wheel may be reduced. If there is excess wheel wear, it indicates that either wheel is running too slow or the work too fast.

Wheel speed affects the grade to a considerable extent and for higher wheel speed, soft wheel (soft grade) should be used. Wheel speed depends upon type of grinding operation e.g. external or internal grinding or parting off operation. Work speed depends upon type of work, type of grinding and finish required. It also affects the grade, and for higher work speed it is desirable to use harder wheel and vice versa.

ii. Condition of Grinding:

(By condition of grinding we mean whether the grinding is done in wet conditions or dry conditions.) In dry conditions with hard wheel the heat generation is more and thus soft wheel is required and vice versa.

iii. Skill of Operator:

An unskilled worker can't handle soft wheels and he is likely to break them. Thus unskilled worker should be allowed to work only in those conditions which require a hard wheel. The factors influencing the type of abrasive for thread grinding wheels are the material of workpiece, its hardness, pitch and profile of the threads. Al_2O_3 wheel is preferred for most of the applications. For

grinding titanium, SiC wheel is used and for grinding carbide and ceramic materials, diamond wheel is used. Finer grit size is used for finer pitch.

If fine grit it used then harder wheel is employed. For high precision thread grinding, and where lead errors in pre-cut threads are to the corrected, vitrified bond wheels are used which are more rigid also. Resinoid bond wheels are very flexible and can remove stock rapidly. However, these can't correct the lead errors in pre-cut threads because of their flexibility.

For tool sharpening, Al_2O_3 wheels are used for H.S.S; silicon carbide wheels are used for carbide-tipped tools. The operation of lapping and fine finish is done by diamond wheel. CBN wheel is well suited for grinding a variety of difficult to machine tool steels. Other considerations are same as for general grinding applications.

Learning Unit 4 – Set the surface grinding machine

LO 4.1 – Mount grinding wheel

- **Content/Topic 1 Mounting grinding wheel methods**

1. Horizontal spindle and reciprocating table

Mounting a wheel on machine, balancing, truing and dressing

A grinding wheel is a delicate and fragile tool. Unless it is used properly, it may not give optimum service or may even result in accidents. In this respect correct mounting and balancing is of utmost importance. Balancing is needed as wheels revolve at many thousand r.p.m. and any unbalanced centrifugal forces may crack the wheel or spoil the bearing.

As soon as a fresh wheel has been fitted on a grinding machine spindle, it will be necessary to true its face and perhaps, its sides for a short distance down so that the wheel may become, square to the work piece.

Truing or dressing also become necessary after the wheel has been in use for sometimes, to correct for non uniform wear on its face or for opening up its face to obtain efficient cutting conditions.

The truing or dressing up of grinding wheels is done by a diamond tool. Being harder, it is able to cut through, the abrasive grains and the bond material.

Grinding wheel is an expendable wheel that carries an abrasive compound on its periphery. These wheels are used in grinding machines.

The wheel is generally made from a matrix of coarse particles pressed and bonded together to form a solid, circular shape, various profiles and cross sections are available depending on the intended usage for the wheel. They may also be made from a solid steel or aluminium disc with particles bonded to the surface.

2. Vertical spindle and reciprocating table

Cylinder wheels provide a long, wide surface with no center mounting support (hollow). They can be very large, up to 12" in width. They are used only in vertical or horizontal spindle grinders.

3. Horizontal spindle and rotary table

A straight wheel that tapers outward towards the center of the wheel. This arrangement is stronger than straight wheels and can accept higher lateral loads

4. Vertical spindle and rotary table

A very shallow cup-style grinding wheel. The thinness allows grinding in slots and crevaces. It is used primarily in cutter grinding and jig grinding.

General Mounting of a grinding wheel

Great care must be taken in mounting the grinding wheels on the spindle because of high cutting speeds. The following points are important in connection with mounting of grinding wheel. Fig

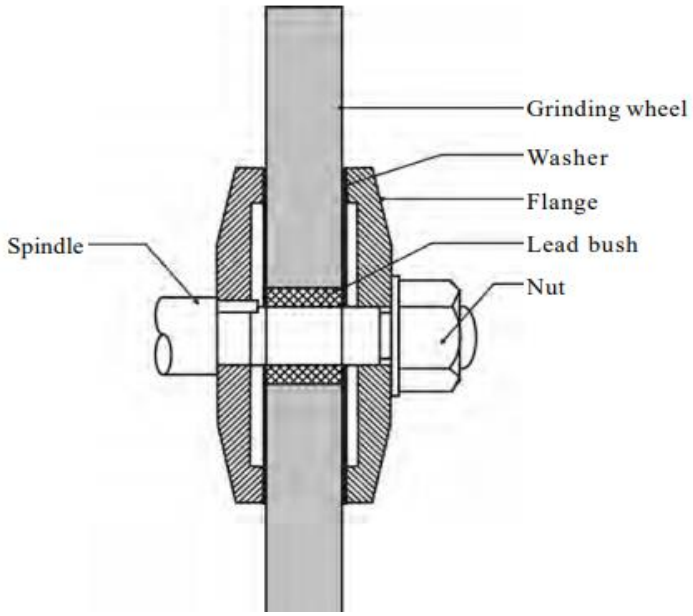


Figure 78.Mounting of a grinding

1. All wheels should be inspected before mounting to make sure that they have not been damaged. The wheel is put on an arbor and is subjected to slight hammer blows. A clear, ringing, vibrating sound must be heard.

2. The wheel should not be forced on and they should have an easy fit on the spindle.

3. The hole of grinding wheel is mostly lined with lead. The lead liner bushes should not project beyond the side of wheels.

4. There must be a flange on each side of the wheel. The flange must be large enough to hold the wheel properly, at least the flange diameter must be equal to the half of the grinding wheel diameter. Both the flanges should be of same diameter.

5. The sides of the wheel and the flanges should be flat. Flanges contact the wheel only with the annular clamping area.

6. Washers of compressible materials such as cardboard, leather, rubber etc., not over 1.5 mm thick should be fitted between the wheel and its flanges. The diameter of washers may be normally equal to the diameter of the flanges.

7. The inner flange should be keyed to the spindle, whereas the outer flange should have an easy sliding fit on the spindle so that it can adjust itself tightly to give a uniform bearing on the wheel and the compressible washers.

8. The nut should be tightened to hold the wheel firmly. Undue tightness is unnecessary and undesirable as excessive clamping strain is liable to damage the wheel.

9. The wheel guard should be placed and tightened before the machine is started.

10. After mounting the wheel, the machine is started. The grinding wheel should be allowed to idle for a period of about 10 to 15 minutes. Grinding wheels must be dressed and trued before any work can be started.

LO 4.2 – Mount work piece

- **Content/Topic 1: Methods of mounting a work piece**

1. Mounting work piece for cylindrical grinding

Cylindrical grinding may be done with the work piece setup between centers, held in the chuck and supported by a center rest, or clamped to the faceplate as in lathe setups. Use the following methods when mounting the work piece between centers: Use a dead center in the tailstock spindle. This method is preferred because it eliminates any error caused by wear in the machine's spindle bearings. Before grinding check the accuracy and alignment of centers and correct if necessary.

After the centers are accurate, align the centers by one of the methods prescribed for aligning lathe centers. Position the work piece between the centers, and use a lathe dog to revolve the work piece.
Use the following methods and procedures when mounting the work piece for concial grinding.
Work pieces for conical grinding can be set up in a chuck or between centers.
To set up a work piece for grinding between centers proceed as follows:

1) Ensure that the centers in the/work head and foot stock and the center holes in the work piece are in good condition.
2) Clamp a driving dog onto the work piece.'
3) Position the work head and foot stock and set 'the traverse stop dogs so that when the work piece is in place, the table will traverse (longitudinally) the proper distance to grind the surface.
4) Ensure that the work head swivel, the taper table attachment, and the wheel head

2. Work mounting on magnetic chuck

- **Magnetic Chucks**

The top of a magnetic chuck (see fig. 13-4) is a series of magnetic poles separated by non -magnetic materials. The magnetism of the chuck may be induced by permanent magnets or by electricity. In a permanent type magnetic chuck, the chuck control lever positions a series of small magnets inside the chuck to hold the work. In an electromagnetic chuck, electric current induces magnetism in the chuck; the
Control lever is an electric switch. Work will not be ground when it is replaced to ensure that it is parallel with the grinder table. To grind the table, use a soft grade wheel with a grit size of about 46. Feed the chuck slowly with a depth of cut not to exceed 0.001 or 0.002 inch. Use ample coolant to

help reduce heat and flush away the grinding chips. Remain in place unless it is in contact with at least two poles of the chuck.

Work held in a magnetic chuck may become magnetized during the grinding operation. This is not usually desirable and the work should be demagnetized. Most modern magnetic chucks are equipped with demagnetizers.

Magnetic chuck will become worn and scratched after repeated use and will not produce the accurate results normally required of a grinder. The removal of small burrs by hand stoning with a fine grade oil stone is needed. But regrinding of the chuck to remove low spots from wear and deep scratches also necessary. If the chuck is ever removed from the grinder.

3. **Work mounting on vice**

- **Universal Vise**

4. The universal vise (fig.) can be used for setting up work, such as lathe tools, so that the surface to be ground can be positioned at any angle. The swivels can be rotated through 360°.The base swivel (A of fig.) can be rotated.

5. **Work mounting directly on the table**

The sliding table of the cylindrical grinder is mounted directly on longitudinal ways on the base of the grinder. This table moves back and forth to traverse the work longitudinally along the width of the grinding wheel.

An adjustable taper table, located on top of the sliding table, s used for grinding long (small angle) tapers on the work piece. The taper table is adjusted like the taper attachment on a lathe. Work holding devices are clamped on top of the taper table.

The motor-driven work head is mounted on the taper table. This component holds and rotates the work during the grinding cut. Variable speed drive motors or step pulleys are provided for changing the rate of rotating speed of the work piece to meet the requirements of the job.

A chuck, a center, or a face plate can be used in mounting work on the work head. Center rests and steady rests are also used in conjunction with the work head for mounting long work pieces for cylindrical grinding.

On most cylindrical grinders used by the Navy, the work head is mounted on a swivel base. The same center holes are then used for the grinding setup. Center rests or steady rests (as applicable) are used to support long work or overhanging ends. Short work pieces can be held, in chucks. For internal grinding (on machines that have an internal grinding spindle), the work is held in a chuck; steady rests are used/ if necessary, for support

LO 4.3 – 4.3: Set machine parameters

- **Content/Topic 1 :Surface grinding machine setting parameters**

1. Cutting Speed

In cylindrical grinding, it is difficult to recommend any work speeds since these are dependent upon whether the material is rigid enough to hold its shape, whether the diameter of the work piece is large or small, and so forth.

Listed below are areas to consider when performing cylindrical grinding:

The larger the diameter of the work piece, the greater is its arc of contact with the wheel. The cutting speed suitable for one diameter of work piece might be unsuitable for another.

The highest work speed that the machine and wheel will stand should be used for roughing.

The following cylindrical work speeds are only typical: steel shafts, 50 to 55 FPM; hard steel rolls, 80 to 85 FPM; chilled iron rolls, 80 to 200 FPM; cast iron pistons, 150 to 400 FPM; crankshaft bearings, 45 to 50 FPM; and crankshaft pins, 35 to 40 FPM.

Higher work speeds increase the cutting action of the wheel and may 'indicate that a harder wheel and a smaller depth of cut be used to reduce wheel wear.

work speed for surface grinding

Surface grinding machines usually have fixed work speeds of approximately 50 SFPM or have variable work speed ranges between 0 and 80 SFPM. As with cylindrical grinding, the higher work speeds mean that more material is being cut per surface foot of wheel rotation and therefore more wear is liable to occur on the wheel.

Calculating wheel size or speeds

Both cutting speeds in SFPM and rotational speed in RPM must be known to determine the size wheel to be used on a fixed-speed grinding machine. To determine the grinding wheel size, use the following formula:

D = 12 x SDFPM/ RPM

Where SFPM = Cutting speed of wheel (In surface feet per minute).

RPM = Revolutions per minute of wheel.

D = the calculated wheel diameter (in inches).

To obtain the cutting speed in SFPM when the wheel diameter and RPM are given, use the same formula in a modified form:

SFPM = D x RPM/12

To obtain the rotational speed in RPM when the wheel diameter and desired cutting speed are known use the formula in another modified form:

RPM = 12 SFPM/D

2. Feeds

The feed of the grinding wheel is the distance the wheel moves laterally across the work piece for each revolution of the piece in cylindrical grinding or in each pass of the piece in surface grinding. The following methods are recommended Calculate the table traverse feed using this formula.

TT = (WW X FF X WRPM) + 12

Where TT = Table travel in feet per minute

WW = Width of wheel

FF = Fraction of finish

WRPM = Revolutions per minute of work piece

12 = Constant (inches per foot)

The fraction of finish for annealed steels is 1/2 for rough grinding and 1/6 for finishing; for hardened steels, the rate is 1/4 for rough grinding and 1/8 for finishing. For example, a l-inch-wide wheel is used to rough grind a hardened steel cylinder with a work RPM of 300.

Table travel =(1 x 1/4 x 300) ÷ 12 = (75) ÷ 12 = 6.25 FPM After the calculations have been completed, set the machine for the proper traverse rate, turn on the table traverse power feed, and grind the work piece.

3. Depth of Cut

Methods for determining depth of cuts are recommended for determining feeds.

In roughing, the cut should be as deep as the grinding wheel will stand, without crowding or springing the work.

The depth of cut also depends on the hardness of the material. In cylindrical grinding, in addition to these Factors, the cut depends on the diameter of the work. In any case, experience is the best guide. Generally, a cut of 0.001 to 0.003 inch in depth is used, depending on the size and condition of the grinding machine.

For finishing, the depth of cut is always slight, generally from 0.0005 inch to as little

Learning Unit 5 – Operate surface grinding machine

LO 5.1 – Perform surface grinding machine operations

- **Content/Topic 1 :Perform surface grinding machine operations**

1. Polishing

Polishing is an abrading process in which small amounts of metal are removed to produce a smooth or glossy surface by application of cushion wheels impregnated or coated with abrasives. Polishing may be used for reduction or smoothing of the surface to a common level for high finish where accuracy is not important or it may be employed for removing relatively large amounts of material from parts of irregular contour. Rough polishing is performed on a dry wheel using abrasives of No. 60 grain (60 grains per linear inch) or coarser. Dry finish polishing is a similar process where No 70. Grain to No. 120 grain abrasives is used. Oiling is the term applied to polishing with abrasive finer than No.120 grain. In this process, the abrasive is usually greased.

2. Buffing

Buffing is a smoothing operation which is accomplished more by plastic flow of the metal than by abrading. The abrasives are generally finer than those used in polishing and instead of being firmly cemented to the wheel are merely held by a "grease cake" or similar substance. Buffing is used to produce a high luster or color without any particular regard to accuracy of dimension or plane. Cut down buffing produces a rapid smoothing action with fast-cutting abrasives and relatively hard buffing wheels. It is accomplished with high speeds and heavy pressures to allow a combined plastic flow and abrading action to occur. Color buffing is the imparting of a high luster finish on the work piece by use of soft abrasives and soft buffing wheels.

3. Lapping

Lapping, like polishing, is an abrading process in which small amounts of material are removed. Unlike polishing, however, lapping is intended to produce very smooth, accurate surfaces, and is never used instead of polishing or buffing when clearance is the only consideration. Lapping is accomplished by charging metal forms called laps with flour fine abrasives and then rubbing the work piece with the lap.The lap may be of any shape and may be designed to fit into most power machine tools. The only requirements of the lap are that it be of softer material than the material being lapped, and that it be sufficiently porous to accept the imbedded abrasive grain. Common materials for laps are soft cast iron, copper, brass, and lead. Some laps are flat and others are cylindrical to fit on steel arbors for internal lapping of bores. A cutting oil is recommended for most lapping operations.

4. Super finishing

Super finishing is another abrasive process which utilises either bonded abrasive like honing for cylindrical surfaces or a cup wheel for flat surfaces produces a high wear resistant surface on any object which is symmetrical Surfaces are: Cylindrical, conical, spherical and flat. The contact surface is large and tool maintains a rotary contact with work piece while oscillating.

LO 5.2 – Check work piece dimensions

- **Content/Topic 1 :Types of measuring tools**

1. Non precision measuring tools

- **Steel Rule**

It is the simplest measuring tool just like a scale used in fitting shop. A six inch semi flexible rule is shown in Fig. 19.15 Other types of rules are described in the chapter on carpentry shop. Most of the dimensions are measured by the steel rule in workshops.

Steel rule is generally employed for purpose of measuring rough dimensions and laying out them. It is always advisable to start measuring from 1 cm mark because the end of the rule is generally worn out.

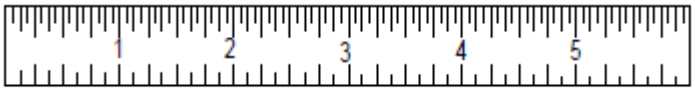


Figure 79.Steel Rule

- **Tape measure**

A measuring tape is a flexible form of ruler. It consists of a ribbon of cloth, plastic, or metal strip with linear measurement markings. It is a common measuring tool. Its flexibility allows for a measure of great length to be easily carried in pocket or toolkit and permits one to measure around curves or corners.

- **Protractor**

Bever Protractor

The bevel protector (Fig.) is an instrument used for testing and measuring angles within the limits of five minutes accuracy. The common components of this instrument are base, disc which is fitted with a pivot at the centre and carries a datum line. On this pivot of the protector, the dial is allowed to rotate when the clamping nut is released. The other unit clamps the blade rigidly to the dial. The blade can be moved lengthwise.

Vernier scale is also provided on the disc to take reading for accurate measurement. Dial is graduated in degrees over an arc.

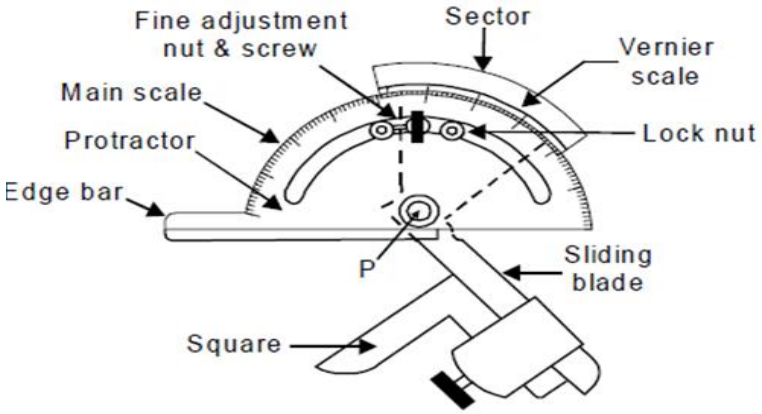


Figure 80. Bever Protractor

- **Combination set**

Combination set is an important instrument which has the combination of instruments namely square head, a centre head, and a bevel protractor and sprit level as depicted in Fig.

It is a very useful instrument frequently utilized in the bench work and machine shop measurements. The three portions of the combination set are used separately being held in at any desired position by nuts which engage in a slot machined on the whole length of the beam at its back.

The beam of the instrument acts as a rule, which is marked in inches or centimetres or in both for measuring the length and height as and when required. The square head possesses one edge square to the rule, giving a right angle, where as the other edge form an angle of 45°. It is provided with a spirit level. The scale on the protractor may be divided into degrees or a vernier attached whereby the angle can be measured in degrees and minutes. It is also fitted with a spirit level to help in levelling the work of setting it at an angle.

The centre head with the rule fastened to it is called a centre square. It has two arms at right angles to one another and is so set on the rule that this angle is exactly divided in two by the edge of the rule. It may be used to find the centre of a round bar or shaft.

Spirit level is commonly used for checking levels and other measurement. It is designed to handle measurements, layout and checking of angles. The square head is used for checking 90° angle or as a square as shown in Fig. The protractor head may be utilized with a rule to measure angles or to measure the slope of a surface as shown in

Fig.

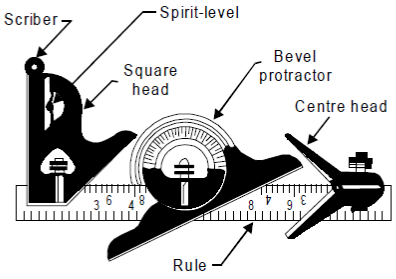


Fig. 19.24 A combination set

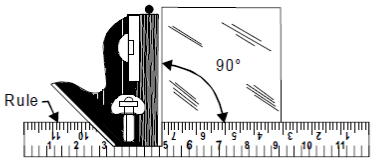


Fig. 19.25 Checking 90° angle using combination set

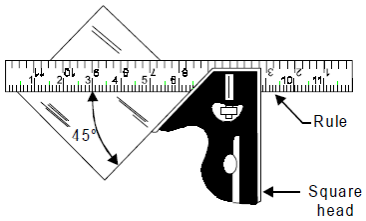


Figure 81.Checking 45° angle using combination set

- **Callipers**

Callipers are generally of two types inside and outside to make internal or external measurements. They do not have direct scale reading. They transfer the measurement from jobs to scale or vice versa. Fig. shows a simple outside calliper. The calliper is held in a rule as shown in Fig. to read the size. It is used to make external measurement such as thickness of plates, diameter of sphere and cylinders. Fig. shows the standard spring joint outside calliper.

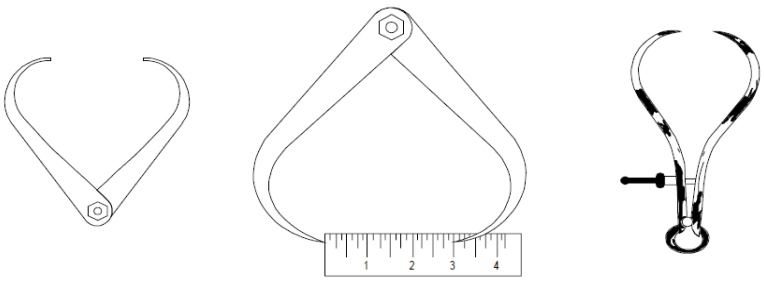


Figure 82.calliper.

2. Precision measuring tools

- **Vernier calliper**

Fig. shows the vernier calliper, which is commonly used to measure accurately

(1) Outside diameters of shafts,

(2) Thicknesses of various parts,

(3) Diameters of holes or rings and

(4) Internal dimensions of hollow jobs or articles.

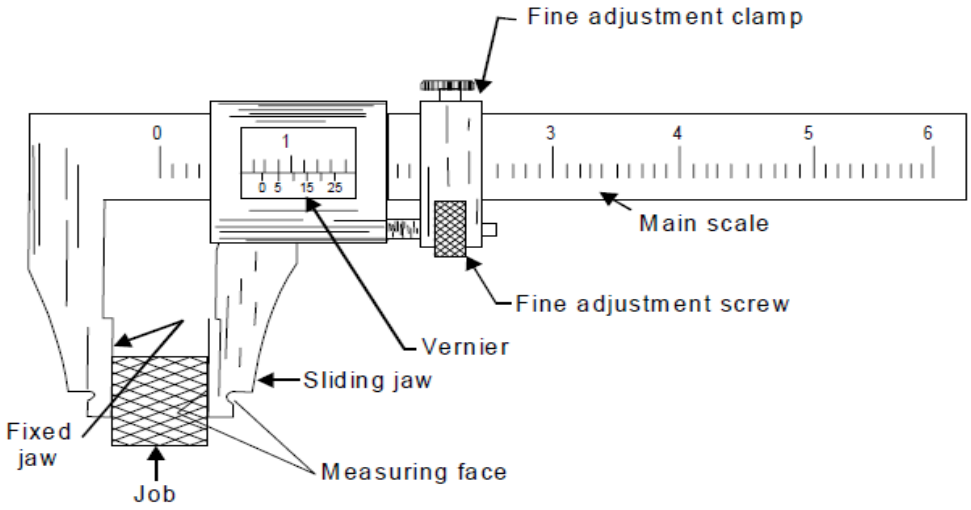


Figure 83.Vernier calliper

It works on the principle of vernier and can measure the dimensions to an accuracy of 0.02 mm. For making a measurement of external dimensions, the job is placed between the fixed and the movable jaws. The movable or the sliding jaw is moved until it almost contacts the job kept against the fixed jaw. The sliding jaw assembly of the vernier calliper that carries the fine adjustment screw should be clamped to the graduated beam with the help of adjustment clamp. The two jaws are then brought into contact with the job by moving the sliding jaw with the help of fine adjustment screw. The jaws should make now definite contact with the job but should not be tight. The main slide assembly is then locked to the beam with help of clamp. The calliper is then carefully removed from the job to prevent springing the jaws and the reading is taken. For making a measurement of internal dimensions, the job is placed outward between the fixed and the movable jaws meant for measuring inner dimension.

- **Micrometer**

The micrometers are commonly employed for measuring small dimensions with extreme accuracy of 0.01 mm. They may be of the three kinds:

(*a*) External micrometer for measuring external dimensions,

(*b*) Internal micrometer for measuring internal dimensions, and

(*c*) Depth micrometer for measuring depths.

For measuring a dimension in external micrometer, the work piece is held between the fixed anvil face and the spindle face of the micrometer. The spindle of the micrometer is allowed to move linearly towards the work by rotating thimble. When the spindle will touch the work piece properly, the ratchet will give its sound. The small locking lever is then rotated to clamp the spindle so that reading can be taken more accurately. Outside micrometers are used for measuring the outside dimensions of jobs, such as diameter of a bar, rod and thickness of plate.

Generally, until and unless they are provided with the vernier attachment, the former can read up to 1/1000 or 0.001 inch and the latter up to 0.01 mm. The former are known as inches micrometers and the latter metric micrometers, which are gradually replacing the former due to the introduction or adopting of metric system. Inside micrometers are commonly used for measuring inside dimensions of the objects, such as inside dia. of a hole, width of a slot or cavity, etc.

The outside micrometers are the most extensively used in industrial applications. All the micrometers, irrespective of the fact as to whether they carry graduations in inches or millimetres, are similar in construction. An outside micrometer is discussed as under.

- **OUTSIDE MICROMETER**

This shows an outside micrometer. It consists of the following main parts.

1. Metallic frame
2. Axial graduated sleeve
3. Circumferential screwed spindle
4. Hardened steel anvil
5. Thimble
6. Ratchet stop screw
7. Lock nut

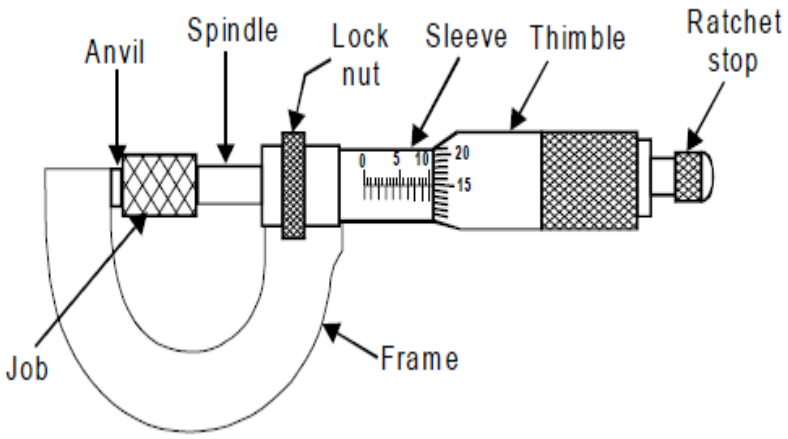


Figure 84.Micrometer

Micrometer works commonly on the principle of nut and bolt assembly. The sleeve carries inside threads at the end, which forms the nut, and the screwed part of the spindle passes through it. The spindle and the thimble are secured to each other such that by rotating

COMMON PARTS OF OUTSIDE MICROMETER

- **Frame:** The U frame of micrometer is made of steel, cast steel, malleable cast iron or light alloy.

- **Hardened anvil:** It protrudes from the frame for a distance of at least 3 mm for holding and supporting the jobs for measurement.
- **Screwed spindle:** It does the actual measuring and possesses threads of 0.5 mm pitch.
- **Barrel or Sleeve:** It has datum or fiducially line and fixed graduations.
- **Thimble:** This is a tubular cover fastened with the spindle and moves with the spindle. The bevelled edge of the thimble is divided into 50 equal parts, every fifth being numbered.
- **Ratchet:** This part is commonly recognized as friction stop of the micrometer, which acts as a precautionary measure also. It is a small extension to the thimble in which the ratchet slips when the pressure on the screw exceeds a certain amount. This produces uniform reading and prevents any damage or distortion of the instrument.
- **Spindle clamp:** It is used to lock the instrument at any desired setting or at any particular reading.

➢ **Dial gauge indicator**

Dial Indicators

The dial indicators are also known as dial gauges and are shown in Fig. (a, b). They are generally used for testing flatness of surfaces and parallelism of bars and rods. They are also used for testing the machine tools. They are available in both metric as well as in inches' units. Inches dial indicator of 0.001" measuring accuracy is in commonly used but they are also available up to an accuracy of 0.0001". The commonly used metric dial indicator has an accuracy of 0.01 mm. Those having 0.001 mm accuracy are also available; however, they are used in highly precision measurement work.

Figure 85,Dial Indicators

- **Content/Topic 2: Use measuring tools to**

✓ **Use measuring tools to Check length**

The universal standard of length is the metre, and the definition of this in terms of wavelength of light was agreed by all countries in 1960. The metre was defined at this time as 1 650 763.73 wavelengths of the orange radiation of the krypton-86 isotope in vacuo.

At the same time the yard was defined as 0.9144 m, which gives an exact conversion of 1 inch = 25.4 mm.

It was also in 1960 that the first laser was constructed and by the mid-1970s lasers were being used as length standards. In 1983 the krypton-86 definition was replaced and the metre was defined as 'the length of the path travelled by light in a vacuum during a time interval of 1/299 792 458 of a second' and this is done at NTL by an iodine-stabilised helium–neon laser with an uncertainty of 3 parts in 10 (to the power 11).

✓ **Use measuring tools to cCheck angle**

The measurement of angles can be simply carried out using a protractor, but the level of accuracy obtained is, at best, 5 minutes using a vernier instrument. Greater accuracy can be obtained by using angle gauge blocks or by using a sine bar in conjunction with gauge blocks.

✓ **Use measuring tools to check squareness**

Two surfaces are square when they are at right angles to each other. Thus the determination of squareness is one of angular measurement. There is no absolute standard for angular measurement in the same way as there is for linear measurement, since the requirement is simply to divide a circle into a number of equal parts.

The checking of right angles is a common requirement, and the workshop standard against which they are compared is the engineer's square, of which there are a number of types. BS 939: 2007 specifies the requirements for engineer's try-squares ,cylindrical squares.

✓ **Use measuring tools to check Flatness**

The workshop standard against which the flatness of a surface is compared is the surface plate or table. The error in flatness of a feature may be stated as the distance separating two parallel planes between which the surface of the feature will just lie. Thus flatness is concerned with the complete area of a surface, whereas straightness is concerned with a line at a position on a surface; e.g. lines AB, BC, CD and DA in Fig. may be straight but the surface is not flat, it is twisted.

For high-precision work, such as precision tooling and gauge work, toolmaker's flats and high-precision surface plates are available and are covered by BS 869: 1978. This standard recommends four sizes of toolmaker's flat – 63,100, 160 and 200 mm diameter – made from high-quality steel, hardened and stabilised.

LO 5.3 – Apply coolant

- **Content/Topic 1: Cooling technics**

❖ **Air cooling**

One of the most critical factors in achieving a good finish is the Grinding Fluid or Coolant. Grinding fluids are used to lubricate, reduce and dissipate the heat generated during a grinding operation.

Other functions of the coolant are as follows:

1. Dissipation of the heat generated during grinding thus keeping the work and wheel cool and reducing work distortion due to heat.
2. As a lubricant, it reduces the amount of friction between the cutting tool and the chip.
3. Influences the form of chip.
4. Reduces the diamond dressing tool while dressing.
5. Reduces loading to improve finish.
6. Assists in keeping work area clean

➢ **Selection of Coolants**

Coolant type selection is based on the following factors:

- Application type & severity of operation, e.g. stock removal
- Nature of machine operation (cutting method)
- Water quality (Soft, Hard, Chloride, Sulphate, Bi-carbonate %)
- Material to be machined
- Surface finish
- Filtration system in the machine tool

Coolant or lubrication is essential in metal-cutting operation to reduce the heat and friction created by the deformation of metal and the chip sliding along the chip-tool.

interface. This heat and friction cause metal to adhere to the tool's cutting edge and causing the wheel to break down. The finishing results will poor and inaccurate work

The application of coolants to the grinding process is important. Coolants reduce grinding machine power requirements, maintain work quality, stabilize part dimensions, and insure longer wheel life. Coolants are emulsions, synthetic lubricants or special grinding oils. Coolants are applied by either flooding the work area or by high pressure jet streams. The coolant used in this project is cutting oil.

❖ **fluid**

usually oil or water-glycol – flows through a cooler. A fan draws air and drives it through the cooling element. Thus, there is a temperature difference and heat exchange takes place. Of this results an increase in air temperature which is then released into the environment.

This process reduces the average temperature of the fluid up to a few Celsius degrees over the actual environmental temperature. It is possible to install an air cooler in almost every situation, with a minimum impact on the existing lay out.

The operating costs are correspondingly low and their further reduction is possible by using a speed-controlled fan. With new designs using special, low noise fans. A wide range of coolers is available, with either axial and radial fan designs. AC, DC electric drives, and hydraulic motors ensure versatility in catering to a variety of applications and ambient conditions.

- **Use of Coolants**

Coolants play a decisive role in machining. Appropriate application of coolants results in enhanced process stability, better work piece quality and tool life. Apart from heat dissipation i.e. cooling, the other main function of a coolant is lubrication which is achieved by reduction of friction at the chip-tool interface and tool-finished surface interface. Carrying away swarfs away from the contact zone is another important function of the coolant. The combined effect of lubrication and cooling reduces tool wear and improves surface quality and dimensional accuracy of the work piece.

- **Content/Topic 2: Types of coolants**

1. **Water soluble oils**

Water is the cheapest cooling medium, but it is unsuitable by itself, mainly because it rusts ferrous metals. In soluble oils, or more correctly emulsifiable oils, the excellent cooling property of water is combined with the lubricating and protective qualities of mineral oil.

Oil is, of course, not soluble in water, but with the aid of an agent known as an emulsifier it can be broken down and dispersed as fine particles throughout the water to form an emulsion. These are often referred to as ‘suds’ or coolant. Other ingredients are mixed with the oil to give better protection against corrosion, resistance to foaming and attack by bacteria, and prevention of skin irritations. Under severe cutting conditions

2. **Synthetic oil**

Sometimes called chemical solutions, these fluids contain no oil but are a mixture of chemicals dissolved in water to give lubricating and anticorrosion properties. They form a clear transparent solution with water, and are sometimes artificially coloured. They are very useful in grinding operations, where, being non-oily, they minimise clogging of the grinding wheel and are used at

dilutions up to 1 in 80. As they are transparent, the operator can see the work, which is also important during grinding operations.

3. **Petroleum-based oils**

The name **petroleum** covers both naturally occurring unprocessed crude **oil** and **petroleum** products that are made up of refined crude **oil**.

Petroleum-based oils *are:*

a) Oils (including lubricants or fluids but not greases) derived from petroleum and their synthetic equivalents

b) Oils (including lubricants, fluids and greases) derived from petroleum and their synthetic equivalents, if recycled for use as oils. Petroleum-based oil describes a broad range of natural hydrocarbon-based substances and refined petroleum products, each having a different chemical composition. As a result, each type of crude oil and refined product has distinct physical properties. These properties affect the way oil spreads and breaks down, the hazard it may pose to marine and human life, and the likelihood that it will pose a threat to natural and man-made resources.The rate at which an oil spill spreads will determine its effect on the environment. Most oils tend to spread horizontally into a smooth and slippery surface, called a *slick*, on top of the water. Factors which affect the ability of oil spill to spread

Viscosity: the measure of a liquid's resistance to flow. The higher the viscosity of the oil, the greater the tendency for it to stay in one place.

- **Content /Topic 3 : Factors influencing selection of coolant**

1. **Work piece material**

Materials like SKD11, copper, mild steel and titanium alloy have these properties, and these are the **material** highly machined in this. For this reason we have considered the **work piece materials** for the experimentation are: copper, mild steel and titanium alloy.

Most researchers have also communicated that specific physical, metallurgical, and electrical properties of the work piece material also influence the process.

These properties include how well the metal is polished, its magnetic condition, and how the metal was removed from the heat treatment process when it was produced. One must also consider the phenomenon of expansion and contraction, according to the temperature of the material.

2. Cutting tool material

The material from which the work piece is made is not usually your choice. The operation to be carried out decides which machine you will use. This narrows the problem – knowing the operation and the machine, you can select the type of cutting tool; knowing the work piece material you can decide the cutting-tool material, the cutting angles, the speeds at which to run the work piece or cutting tool and whether to use a cutting fluid. Finally, you must be able to maintain the cutting tools in good condition as the need arises, and this requires knowledge of regrinding the tool usually by hand, known as off-hand grinding

Properties of cutting materials

To be effective, the material from which a cutting tool is made must possess certain properties,

It is obvious that a cutting tool must be harder than the material being cut, otherwise it will not cut. It is equally important that the cutting tool remains hard even when cutting at high temperatures. The ability of a cutting tool to retain its hardness at high cutting temperatures is known as red hardness. Current practice often uses, the term 'hot hardness'.

Properties of cutting materials are:

- ***Abrasion resistance:*** When cutting, the edge of a cutting tool operates under intense pressure and will wear due to abrasion by the material being cut. Basically, the harder the cutting-tool material the better its resistance to abrasion.
- ***Toughness:*** *A* cutting-tool material which is extremely hard is unfortunately also brittle. This means that a cutting edge will chip on impact if, e.g. the component being machined has a series of slots and the cut is therefore intermittent. To prevent the cutting edge from chipping under such conditions
- **High-speed steels (HSS):**High-speed tool steels consist of iron and carbon with differing amounts of alloying elements such as tungsten, chromium, vanadium and cobalt. When hardened, these steels are brittle and the cutting edge will chip on impact or with rough handling. They have a high resistance to abrasion but are not tough enough to withstand high shock loads. These steels will cut at high speeds and will retain their hardness even when the cutting edge is operating at temperatures around 600 °C. The range of cutting tool materials from the toughest to the hardest is:
  - ✓ Uncoated tungsten carbide;
  - ✓ Coated tungsten carbide;
  - ✓ cermet;
  - ✓ Ceramic;
  - ✓ Cubic boron nitride;

- ✓ Diamond.

3. Cutting tools

- **Clearance**

All cutting tools, whether held by hand or in a machine, must possess certain angles in order to cut efficiently. The first essential is a clearance angle, which is the angle between the cutting edge and the surface of the material being cut. This prevents any part of the cutting tool other than the cutting edge from coming in contact with the work, and so eliminates rubbing.

- **Rake**

For effective cutting, a second angle known as the rake angle is required. This is the angle between the tool face and a line at right angles to the surface of the material being cut.

The face upon which this angle is ground is the face along which the chip slides as it is being removed from the work. This angle therefore varies with the material being cut, since some from the work.

- **Cutting fluids**

During metal cutting, the metal immediately ahead of the cutting tool is severely compressed, which results in heat being generated. The metal then slides along the tool face, friction between the two surfaces generating additional heat. Any rubbing between the tool and the cut surface, which would occur with tool wear when the clearance angle is reduced, also produces heat.

This heat is usually detrimental, especially to high-speed-steel cutting tools. Some metals, as they are cut, have a tendency to produce a chip which sticks or welds to the tool face, due chiefly to the high pressure between the metal and the tool.

LO 6.1 – Clean machines, tools and equipment

- **Content/Topic 1: Cleaning materials and** products

1. Soft brushes

Ideal for light duty household, kitchen scrubbing and routine cleaning. It is also great for upholstery and vinyl. Easy to hold handle and firm bristles make this brush ideal for getting into tight cracks and crevices

Firm plastic bristles are arranged in a v-shape for easy cleaning of the grout between tiles on shower walls and floors. Threaded base allows you to add a standard threaded handle. Brushes are made in different sizes and styles. Choose one that has a strong handle and can reach all areas. There is always a need of keeping the toilet brush separated from other cleaning tools and cloths and replaces it regularly for hygiene reasons.

The one pictured is a Turks Head brush. Note the bristles on the top. These are designed specifically to clean under the rim of the toilet which is the dirtiest

2. Solvent

Solvents are contained within many detergents in small quantities for general cleaning. Used individually, solvents are one of the most dangerous categories of chemicals that may be used for specific cleaning purposes.

Solvents include:

- White spirit-used for dry cleaning
- Mineral Turpentine - used for removal of oil based paint Perchlorethylene - used as a dry cleaning fluid
- Methylated spirits - used as a quick drying agent in window cleaners
- Acetone. This is used in nail polish remover and may be necessary to use when nail polish has been spilt as in guest rooms.

The use of solvents in every day cleaning should be limited. Always ventilate an area well if used and handle with great care.

Solvents are contained within many detergents in small quantities for general cleaning. Used individually, solvents are one of the most dangerous categories of chemicals that may be used for specific cleaning purposes.

3. Brooms

Brooms and Brushes

Brooms are available in different widths and with different bristle types. Soft bristle brooms are usually better on indoor hard floors and hard bristles better on outdoor areas. The wider the broom, the larger the areas that can be swept in one pass. Brushes and brooms are used for: General sweeping.

- **Toilet cleaning**

Toilet brushes

Toilet brushes are made in different sizes and styles. Choose one that has a strong handle and can reach all areas. You MUST always keep the toilet brush separate from other cleaning tools and cloths and you should replace it regularly for hygiene reasons.

The one pictured is a Turks Head brush. Note the bristles on the top. These are designed specifically to clean under the rim of the toilet which is the dirtiest part of a toilet bowl.

- ✓ **Cobweb removal**

The current document is directed to automated, electromechanical methods and devices that clean dirt, moisture, and spider webs from the lenses of surveillance cameras. In one implementation, a camera-cleaning device comprises a cleaning unit, a freely rotating L-shaped hinge, a geared electric motor, a motor-control circuit for controlling the forward and backward motion of the device, and a time-control circuit for controlling the start, finish and run time of cleaning cycles. The cleaning unit includes a cleaning head and a propeller blade that spins to lift the cleaning unit up from a rest position to a cleaning position and subsequently clean the front of the camera lens

Clear away dust and cobwebs with one simple sweep using the Unger cobweb duster brush! This bundle of split-tipped soft poly fibres dust surfaces without scratching, creating electrostatic energy to attract and trap dust

This cobweb duster can be used as a handheld duster or attached to a telescopic pole, making it great for cleaning hard-to-reach areas like ceiling fans and light fixtures! Plus, when you're done, it simple rinses clean with water.

In our professional house cleaning company we run into this task on a daily basis. Our cleaners are equipped with the right tools for cobweb removal. Below here are some of the tools and tips we use to get rid of cobwebs in our clients homes.

Vacuum up the cobwebs using an attachment nozzle. Make sure to use an extension for your vacuum cleaner so that you can reach those hard to reach places where the cobwebs are. Make sure to attack the corners of your home because that is mainly where they are hiding, and especially around your windows and doors as well. web removal, you can benefit from:

- ✓ **A cleaner home.** Some webs can be intricate and interesting to look at, but that doesn't keep them from messing up your home's appeal. Let our team remove those unsightly webs so you can go back to enjoying your clean and clear home.
- ✓ **Fewer pests.** Without a place to make a web, most spiders will just move along. If you've got an arachnid issue in your living space, our experts can give a helping hand by totally eradicating the nests and webs around your space.
- ✓ **A safe service.** Most spiders are fairly innocuous, but the Mid-Atlantic area has quite a few species that can cause some pretty serious harm. By letting our team handle things, you can stay safe and bite-free.

- ✓ **Dishwashing**

Dishwasher is a mechanical device for cleaning eating-utensils and dishes .Dishwashers can be found in private homes and hotels. Unlike manual dishwashing's, which depend largely on physical scrubbing to remove soiling, the mechanical dishwasher cleans by the brush and by spraying water, at the dishes.

A mix of water and detergent is circulated by a pump. Water is pumped to one or more rotating sprays arms, which blast the dishes with the cleaning mixture. Once the wash is finished, the water is drained. After the rinse cycle finishes and the water is drained, and the dishes are left in the atmosphere for drying he function of the dishwasher is to provide the mechanical action necessary to distribute and direct the detergent solution and rinse waters over, under and around the dishes to loosen and remove soil. The dishwasher must also remove soil-laden waters from the machine after. Each phase of the cycle and provide for the drying of dishes after the cleaning process has been completed.

- ✓ **Hard floor scrubbing**

The head is densely filled and the handle is thick walled and epoxy coated with a convenient hanger cap. Wire bound, nailed to hardwood handles and made using only premium quality corn. They are designed for long life and durability.

Fine sweep brooms are made of horse hair, and are suitable for smooth floor sweeping. Medium sweep brooms are made of Tampico, and work best in areas with tile, wood and sealed concrete industrial/commercial floors. Course sweep brooms are made of polystyrene, and are suitable for cleaning the heaviest soils in wet or dry environments.

4. Mops

Always choose the right type of mop for the task you will be doing. There are cotton mops, cotton/polyester blends, sponge mops, dust mops and microfiber mops. Cotton and cotton polyester blends come in different weights. Female staff may use a lighter one than a male. Cotton mops are used for mopping as they are more absorbent and cotton/polyester ones are used for applying polishes to hard floor because they are lint free and so do not leave particles. Microfiber mops do not require the use of any chemicals. Sponge mops are not recommended for commercial heavy cleaning as they disintegrate quickly.

Ideal when frequently applying floor finish. Heavy duty poly coated headband mesh withstands harsh Chemicals and laundering for the life of the mop. Designed for high absorbency while allowing for quick Release of floor finish. Available in narrow or wide band.

Wet mopping will remove any surface dirt and stains.

Half fill a mop bucket with hand hot water and add the correct amount of the selected detergent

Select the correct mop

Erect correct signage at both ends of the area you are about to mop

Wheel the bucket to the area and position it where it will not be knocked over or present as a hazard to others Start at the furthest point away from the exit door so you do not walk over the wet floor.

5. Clothes

White microfibre cloths utilize microscopic micro-fibers that remove virtually everything from a surface including biological contaminants. Use them damp or dry, with or without cleaning chemicals.

Using microfibre cleaning cloths

When cleaning, it is important not to decontaminate the area with a dirty cloth. A new cloth surface should be used on each new area. You can accomplish this by folding your cloth into quarters (see right), providing you with eight separate sides to clean with. Just turn and refold as necessary to reveal a clean “side.” When the eight sides are used, change to a fresh cloth. For surfaces with a higher soil or bacteria load (e.g. toilets), microfiber should not be used. Rather, use paper wiper towels and dispose after each surface cleaned.

Cloths should also be colour coordinated to the area they are meant to be used in so as to prevent cross-contamination.

- **Content/Topic 2: Types of cleaning**

1. Cleaning with cloth lugs

An important aspect of the cleaning process is the design of the cleaning machine. Mechanical methods, including moving the parts that are being cleaned, pumping the cleaning solution around them and spraying, high pressure, pressure flooding, brushing, ultrasound and electrolytic processes, can remove the laminar boundary layer on the surface of the work piece, significantly reduce the diffusion time and, therefore, accelerate the cleaning process considerably.

- ✓ **Air pressure cleaning**

Compressed air used for cleaning in the workplace can be very dangerous if the necessary precautions are not taken.

The Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.242 (b) requires that the nozzle pressure of an air gun used for cleaning purposes remain below 30 pounds per square inch (psi) for all static conditions.

In the workplace, pressure to air guns can range from 55 to 160 psi.

Working safely when cleaning with compressed air

High-pressure injection of particles or liquids may damage eyes or skin.

Compressed air entering the bloodstream through a break in the skin or through a body opening can create an air bubble (embolism), which is a dangerous (and potentially deadly) medical condition.

Excessive noise may cause hearing loss and rupture eardrums.

Dangling hoses can present a trip hazard.

- ✓ **Cleaning with cloth lugs**

Use of Cable Cleaning Wipes & Solvents

Cable wipes have been adopted by UK and international power utilities for cleaning polymeric and bitumized coated cable sheaths and the removal of greases – once the LV HV cables are effectively cleaned an excellent bonding and sealing surface is secured for resin, **Cold Shrink** or heat shrink jointing systems to adhere to. The cable wipes are pre-impregnated with cleaner avoiding the requirement for solvents to be dispensed from containers – this eliminates the risk of unnecessary, wasteful and potentially harmful effects of exposure to spillage and splashes of the cable cleaner.

Cleaning applications

- Maintenance of cables, switchgear and network equipment LV HV
- Low and high voltage electrical equipment cleaning and degreasing
- Removes oils, soils, tar and bitumen residues from transformers and cables
- High voltage approved cleaning solvent and cable wipes
- High strength, low lint cable jointing and terminating cleaning wipes
- Substation cleaning and maintenance
- Low toxicity and odour cable cleaning wipes

LO 6.2 – Clean the workplace

- **Content/Topic 1 : Oil removal techniques**

1. **Using solvent**

Cleaners work in all industry sectors and workplaces, from hotels to hospitals and factories to farms. They work inside and outdoors, including in public areas. Often working at night or in the early morning, sometimes alone, cleaners are found in every setting and the work.

2. **Hot water**

Hot Water, High-Pressure Washing

Using hot water, high-pressure washing is the most widely accepted method of cleaning invasive mussels from surfaces. The combination of lethal temperature water (at least 140 °F), combined with the mechanical action of high pressure is most effective. PPE use required. The following measures are recommended:

Use a power washer unit that is capable of applying a flow rate of at least 4 gallons per minute with a nozzle pressure of 3,000 psi, and that is able to supply water at 140 °F or hotter at the surface point of contact.

To begin the cleaning process, reduce the nozzle water pressure by adjusting the power washer or using reduced pressure attachments. Do not attempt to remove or detach mussels from the surface using high water pressure at this point in the cleaning process. The goal is to kill adult mussels with hot water while they remain attached to the surface.

Rinse the entire surface to be treated with heated water for at least 30 seconds'exposure time at 140 °F to effectively kill all mussel life stages. To achieve this surface temperature, the operator may have to spray the surface for 1-3 minutes, depending on the size of the working area and the material composition of the surface.

Hot water extraction

This method of carpet cleaning is designed to deep clean the carpet.

Erect signage and barriers Wear rubber boots

Fill the solution tank with water and add the selected detergent at the correct dilution rate

Attach the hose and carpet cleaning tools to the machine Switch on both motors

Plan the cleaning so that you do not walk on the wet carpet Pre-spot any obvious stains

Press the injection trigger to release the solution on to the carpet and pass the wand several times over one small area when clean, use the suction and pick up the cleaning solution Move to the next section overlap each pass so that no section of carpet is missed. Failure to do this will result in a streaky finish caused by having stripes of dirty carpet Work back towards the exit door

Ventilate the area and leave the carpet to dry naturally Leave signage until the carpet is dry.

- **Content/Topic 2 : Clean and dry floors to prevent slips and falls**

  ✓ **Slips, trips and falls**

Slips, trips and falls can happen in any workplace. They can occur at the entry of a building, in the kitchen, in cold rooms, on loading docks and even as you walk outside the building.

More serious slips or trips together with the resulting falls may result in:

- Sprains or strains
- Broken bones when trying to break the fall
- A back injury due to the sudden and forceful impact during a fall
- Burns if it occurs near hot surfaces or if the person is handling hot fluids
- Cuts if it occurs near sharp objects.

✓ **Causes of slip, trips and falls**

There are various factors that contribute to the risk of slips and trips. Slips usually occur when there is a loss of grip between the shoe and the floor. This commonly occurs when there is a contaminant between the shoe and the floor. Trips occur when a person's foot hits a low obstacle in the person's path, causing a loss of balance. Often, the obstacle is not easily visible or noticed.

The following factors can contribute to the risk of slips and trips. It is usually a combination of these factors that create the risk of a slip or trip.

Cleaning: cleaning affects every workplace and everyone in the workplace. Besides regular cleaning programs, everyone has a role keeping the work area clear and taking responsibility for their own spills.

Floors need to be cleaned properly to ensure that:

- Contaminants are effectively removed
- A build up of cleaning product residue is avoided
- The floor does not become too slippery
- Floors maintain slip resistant properties (of non-slip flooring)

Prompt attention to spills is also important in order to prevent slips.

Obstacles and other trip hazards: Trips most often occur because of uneven flooring or cluttered walkways with low obstacles which are not easily visible or noticed. Common examples of low obstacles include trailing cables, uneven edges to flooring, gratings or covers, loose mats or carpet tiles and changes of floor surface level.

Trips can be prevented by:

- Good housekeeping practices
- Ensuring the floor surface is in good order such as being free from holes, uneven surfaces, curled
- Up linoleum or carpet edges
- Avoiding any changes in floor surface level, or if this is not possible, highlighting these changes
- Providing adequate storage facilities.

LO 6.3 – Manage of waste material

- **Content/Topic 1: Disposal of waste and recyclable materials**

1. Recyclable materials

Mechanical Recycling Mechanical recycling is regarded as the best technology for recycling of conventional plastic waste materials into new raw materials without the basic structure been changed. The mechanical recycling involves crushing, washing and sorting operations and it is use for all types of plastic waste materials. This process involves the assembly of mechanical products which includes driven electrical motor, pulley, cutter and others. The collected, sorted and clean plastic waste materials are put in the shredder or chipper to grind into the smaller pieces called flakes. The flakes are then feed to the extruder machine through the hopper. The extruder is incorporated with rotating single or double screw in heating barrel

Feedstock or chemical recycling Here the plastic waste materials are broken down into smaller chemical form by chemical process and reuse to produce raw material for manufacturing plastic products or different kinds of products. The feedstock recycling is done by decomposition of the

plastic waste materials aided by the presence of heat, chemical agents and other catalysts in order to turn the plastic waste materials as source of hydrocarbon chemicals or fuels.

A simple and economic solution for recycling your used abrasive wheels.

Do you have a stock of used grinding wheels that you wish to dispose of? **Valour has the ideal recycling solution for you and your needs.**

- **All types of Bonded Abrasive Wheels:** All dimensions and sizes, with or without inserts.
- **All types of grain:** Corundum, Alumina, Zirconium Oxide, Ceramic.
- **All quantities:** Upwards of 1 Ton.
- **All types of packaging:** Bulk, Big-Bags, Crates…
- **Logistics:** We offer two types of logistical solutions: Valor boxes for small quantities, or 10m3 skips.
- **Simplicity :** We will empty the containers at your request

2.Non-recyclable materials

- ✓ Garbage.
- ✓ Food waste.
- ✓ Food-tainted items (such as: used paper plates or boxes, paper towels, or paper napkins)
- ✓ Ceramics and kitchenware.
- ✓ Windows and mirrors.
- ✓ Plastic wrap.
- ✓ Packing peanuts and bubble wrap.
- ✓ Wax boxes.

Non–recyclable plastic consumer items - some food storage containers, dishware, vinyl, disposable diapers, toys, Formica™, fiber glass, foam materials, and plastics attached to other materials such as kitchenware or auto parts. **Non–recyclable** glass – window glass, mirrors, light bulbs, and cookware. Some materials are not readily recyclable and are appropriate for disposal *today*. But with research and advancements in technology they could become resources tomorrow.

Non–recyclable paper: wrapping paper that is laminated or contains foreign materials such as foil-coatings or glitter, photographic film, microwave containers, hardcover books, frozen food boxes, thermal fax paper, carbon paper, blueprints, aluminium foil boxes and binders.

Treated or contaminated wood: wood treated with preservatives or attached to other materials like sheetrock or window glass. Highty percent of materials thrown away are resources – not waste.

Non–recyclable plastic consumer items :some food storage containers, dishware, vinyl, disposable diapers, toys, Formica™, fiberglass, foam materials, and plastics attached to other materials such as kitchenware or auto parts

Non–recyclable glass : window glass, mirrors, light bulbs, and cookware

Other waste : ashes, soil, animal feces and carcasses, dirt, furniture, mattresses, and insulation

For now, it's important to buy carefully, use and reuse, and find ways to reduce waste wherever possible.

Learning Unit 7 – Handle the work done

LO 7.1 – Proper labelling of the work piece

- **Content/Topic 1 : Labelling importance**

1. Provide information

The role of **packaging and labelling** has become quite significant as it helps to grab the attention of the audience. **Labelling** and **packaging** can be used by marketers to encourage potential buyers to purchase the product. **Packaging** is also used for convenience and information transmission.

- **Standard:** Labels, as defined in the HCS, are an appropriate group of written, printed or graphic informational elements concerning a hazardous chemical that are affixed to, printed on, or attached to the immediate container of a hazardous chemical, or to the outside packaging.
- **Composition:** The label provides information to the workers on the specific hazardous chemical. While labels provide important information for anyone who handles, uses, stores, and transports hazardous chemicals, they are limited by design in the amount of information they can provide. Safety Data Sheets (SDSs), which must accompany hazardous chemicals, are the more complete resource for details regarding hazardous chemicals.
- **Labels for a hazardous chemical must contain:**
  - ✓ Name, Address and Telephone Number
  - ✓ Product Identifier
  - ✓ Signal Word
  - ✓ Hazard Statement(s)
  - ✓ Precautionary Statement(s)

- **Brand creation**

- Name
- **Product Identifier** is how the hazardous chemical is identified. This can be (but is not limited to) the chemical name, code number or batch number. The manufacturer, importer or distributor can decide the appropriate product identifier. The same product identifier must be both on the label

- **Logo**

label producer may provide additional instructions or information that it deems helpful. It may also list any hazards not otherwise classified under this portion of the label. This section must also identify the percentage of ingredient(s) of unknown acute toxicity when it is present in a concentration of ≥1% (and the classification is not based on testing the mixture as a whole). If an

employer decides to include additional information regarding the chemical that is above and beyond what the standard requires, it may list this information under what is considered "supplementary information." There is also no required format for how a workplace label must look and no particular format an employer has to use; however, it cannot contradict or detract from the required information.

- **Legal**

Employers are responsible for maintaining the labels on the containers, including, but not limited to, tanks, totes, and drums. This means that labels must be maintained on chemicals in a manner which continues to be legible and the pertinent information (such as the hazards and directions for use) does not get defaced (i.e., fade, get washed off) or removed in any way.

- **Stand out**

To **stand out** is to attract attention, either for the way **you** look or behave, or because **you** perform better at something than other people do.

- **Shelves**

A **shelf** is a raised, horizontal surface used for storing things. The word **shelve** is a verb that means to decide not to move forward with something or to put things on a **shelf**. The two words are never interchangeable, although **shelves** is both the plural form of **shelf** and a possible conjugation of **shelve**

- **Batch**

2. Batch production: Here the orders are for small quantity only but orders are repeated again after an interval of time. Machinery and plant used is general purpose type only, but greater use of jigs and fixtures is made to reduce cycle-time and ensure accuracy of parts. Some common examples of this type of production is printing of books, production of machine tools, pumps, compressors

- **Content/Topic 2 : Describe the work**

Types of material

Materials are generally split into four main groups: metals, polymers, ceramics, and composites. These four categories are useful ways to sort different materials. Metals, polymers and.... Some materials rust (a type of oxidation reaction).

Product batch

Batch number or lot number is a mark of identification, usually generated by the manufacturer, which allows a small sample **of product to be uniquely identified. A batch number may** relate to the date of production, the source of raw materials or the machines used

Dimension

The dimension of work is the dimension of energy is the dimension of mass. We measure quantities in units, and some units can be expressed in terms of length and time. Thus area can be thought of as length squared volume as length cubed, velocity as length over distance, and so on.

- **Content /Topic 3: Labeling methods**

  - **Punching**

Punching is a separating technique, mainly used to process holes into flat materials like paper, plastic film or sheet metals. Normally, the punching equipment consists of two tool parts – one support for the punches and one for the dies. While the punches enter the dies, the material is being shear cut.

Punching is mainly used to process round or profile holes into flat material, but it is also suitable for applications where waste removal can cause problems.

The following materials can be processed: Thin metal or plastic films and paper, but also thicker materials like packing materials, compounds, leather and metal sheets used in the packaging, food, hygienic, medical and pharmaceutical industry.

Over the last years, punching also became very important for the processing of metal foils for technically sophisticating products, e.g. for aerospace or electronics industry.

  - **Stamping**

Stamping is to obliterate the stamp mark and the underlying structure requires determination. For a criminal, over-stamping with a cold chisel appears to make the imprinted letter unreadable, but the chisel damage is much more localised and a letter may still be recovered. This is due to the localised deformation caused by the chisel in comparison with the die stamping and distorting the crystal structure is shown with specimens of Charpy samples that had aligned grain structures. Etching with Fry's reagent revealed the aligned grain structure and how this is re-orientated at the stamp mark. Figure indicates the realignment of the grains at the stamp mark.

❖ **Coding**

Coding of a Grinding Wheel

IndianStandardCodingsystemofgrindingwheelisIS:551 1954.It provides uniform system of coding of grinding wheels to designate their various characteristics. It gives a general indication of the hardness and grit size of any wheel as compared with another. Coding of a grinding wheel consists of six symbols as described below.

W: Symbol for manufacturer's Abrasive type (prefixed)

C: Name of Abrasive

30: Grain size

L: Grade

5: structure type

R: Bond type

17: Manufacturer symbol for record

❖ **Printed labels**

The model uses three different experimental results & observations as an input, which is average grit height, average grit number and pullout percentage. Then, the model makes the calculations using geometrical properties of grits and obtains the -*Ra*- of the grinding wheel.

There are many different surface roughness parameters, but the arithmetic average of the absolute values -*Ra*- is the most commonly used one to determine surface quality. In this chapter, the modelling of the surface roughness -*Ra*- of the electroplated CBN grinding wheel is presented for the first time. Since the model is based on experimental results, its application to the other single layer grinding tools, such as brazed wheels is possible. This model can be used not only for CBN abrasive, but also for other types of

Abrasives such as diamond, aluminum oxide modelling of the surface roughness of the work piece

❖ **Modelling of the grinding wheel**

There are some assumptions in the presented model:

- After a geometric shape is selected, all the grits are assumed to be the same (identical). For example, if the spherical model is selected, all the other grits are assumed to be spherical on the tool as well.
- In the production of the electroplated CBN grinding tools, half of the grits are buried under the plate that is why the same concept was used in the model.
- After the pullout occurs, it leaves a flat surface behind.

- Since the grits have a 3D shape, the probe tip may miss the valley tip. It can be assumed that averagely *70%* of the grits' heights were scanned while the probe is passing over the grit

LO 7.2 – Protect the product

- **Content/Topic 1 Methods of protection**

1. Methods of protection

Mechanical protection is protection against mechanical damage such as being knocked or bashed. Mechanical-protection would surely be protection by a machine or something mechanical.
Protection against scratches

Scratching is the term used to describe the resistance of a solid body to penetration by an edge or protuberance on a second body that is traveling along its surface, and is typically equated with a singular incidence on the specimen surface. Comparatively, marring is defined as relatively fine, shallow surface scratches spread over a larger area, usually resulting in the appearance of the material or coating surface being spoiled.

Scratch Resistant Provides superior screen protection against scratches

Scratch tester equipment to study scratch adhesion, scratch hardness, scratch resistance at nano, micro and macro scale. Inline integrated 3D profiler allows to create 3D stitched images to comprehensively and conclusively characterize the coating failures. Advanced capacitive sensors allows to measure penetration depth with resolution needed to differentiate coatings that have similar properties cratch adhesion testing, ASTM C1624-05, covers the determination of the adhesion strength and failure modes of hard thin ceramic coatings on metal or ceramic substrates. Developed based on the Revetest RSX machine, the standard explains the principles of the scratch test in detail, along with the limitations of the test, applicability to different coatings, terminology, test methodology, specimen requirements, apparatus requirements, calibration, test procedure, calculations, and requirements for repeatability and reproducibility. Overall, the standard provides a complete and accurate document for helping coating manufacturers develop an in-house quality control scratch test that can screen coated components and evaluate their adhesion.

Mechanical impact

Typically, although laboratory techniques are not able to fully reproduce the mechanics observed in real life, a controlled test permits the researcher to undertake an approximation of field conditions and subsequent evaluation of materials utilizing the same set of criteria. This strategy can yield substantial insight into the multiple variables that influence a material's performance; starting at its point of manufacture to after it is placed into service. This is particularly relevant when there are so many opportunities for damage to take place.

During a laboratory scratch test, a stylus with a defined geometry is drawn across a specimen surface with a known force and at a known speed. Mar tests may use a counter-faced material, such as steel wool, which generates damage over a greater area. The goals of most scratch and mar resistance lab evaluations comprise the determination of the behaviour of the material under particular test conditions; the establishment of a relative ranking of related materials; and/or the determination of the failure limit of the material or surface coating. The overarching objective is to reproduce the damage that may transpire during everyday use and handling, shipping or assembly processes

Scratch Damage

The amount of scratch damage on a material surface can be affected by the test variables and demands a suitable methodology to ensure these influences are minimized. To many, it should be clear that different scratch traces can be produced in relation to the individual composition and geometry of the scratching instrument. By way of example, utilizing any of the following scratch indenter geometries can cause divergent mechanical deformations: conical diamond; cube corner; 1mm spherical ball (hardened stainless or tungsten steel); cylinder sectioned at 45° to the axis; pyramidal; 0.8 mm diameter helix; the radius edge of a paperclip

- **Chemical protection**
- **Oiling**

Introduction

The substance of which the film is composed is a lubricant, and to apply it is to lubricate. These are not new concepts, nor, in their essence, particularly involved ones. Farmers lubricated the axles of their ox carts with animal fat centuries ago. But modern machinery has become many times more complicated since the days of the ox cart, and the demands placed upon the lubricant have become proportionally more exacting. Though the basic principle still prevails the prevention of metal-to-metal contact by means of an intervening layer of fluid or fluid-like material chemical compounds added to lubricating oils to impart specific properties to the finished oils. Some additives impart new and useful properties to the lubricant; some enhance properties already present, while some act to reduce the rate at which undesirable changes take place in the product during its service life. Additives, in improving the performance characteristics of lubricating oils, have aided significantly in the development of improved prime movers and industrial machinery.

Lubricating Oil Additives products already formed in the bulk lubricant. Oxidation inhibitors intercept the oxidation mechanism, and dispersants and detergents perform the suspending part (Kyunghyun, 2010).

Detergents are metal salts of organic acids that frequently contain associated excess base, usually in the form of carbonate. Dispersants are metal-free and are of higher molecular weights than detergents. The two types of additives work in conjunction with each other.

The final products of combustion and lubricant decomposition include organic and inorganic acids, aldehydes, ketones, and other oxygenated materials. The acids have the propensity to attack metal surfaces and cause corrosive wear. Detergents, especially basic detergents, contain reserve base that will neutralize the acids to form salts. While this decreases the corrosive tendency of the acids, the solubility of the salts in the bulk lubricant is still low.

The organic portion of the detergent, commonly called “soap”, has the ability to associate with the salts to keep them suspended in the bulk lubricant. However, in this regard, detergents are not as effective as dispersants because of their lower molecular weight.

Greasing function of grease

The function of grease is to remain in contact with and lubricate moving surfaces without leaking out under gravity or centrifugal action. Grease should retain its properties under shear at all temperatures that it is subjected to during use. Grease must be able to flow into the bearing through grease guns to all parts of the lubricated machinery as needed, but must not add significantly to powerrequirements.

Grease characteristics

Cartridges improve storage (they prevent the grease from oozing out in high temperature conditions).

Store cartridges upright in a cool, dry place. The operating instructions of the vehicle, machinery and Aggregate manufacturers must be observed! For further information see the technical information leaflet

Application:

For the lubrication and care of machines, plain bearings and anti-friction bearings, for long term lubrication in wet rooms and areas as well as in critical areas in the food, pharmaceutical, printing and paper industries. For lubricating points on commercial vehicles subject to medium or high loads, such as wheel bearings (axle bearings), driveshaft bearings, axle drives, trailer couplings, loading tailgates, wheel hubs, universal joints, steering knuckles, wheel suspensions, lifting gear, hand brake linkage, tipper bearings, semi-trailers, etc

Painting

The study of artists' techniques in general and the study of an individual artist's techniques in particular are important for several reasons:

(a) Art historians can use detailed knowledge of an artist's technique and its developmental evolution throughout the artist's career in the authentication process. This information can also aid in the establishment of a proper chronology for the known works of a given artist.

PAINT AS FOLLOWS. Water-based paint should be applied With a brush that has synthetic filaments. Oil-based and alkyd paint should be applied with brushes with natural or mixed bristles. If the door is to remain on its hinges while being painted, start with the frame and the edges of the actual door. Wipe off any excess paint. When painting an inside door, it is worth removing it from its hinges and placing it on stable blocks so that it be easier to paint the frame. You have best control with a pen grip. Spread and work the paint in over a small surface. Finish with light strokes in the transverse direction to the surface you have painted. One cannot see where you have lifted the brush – but one can see where you put the brush down in wet paint.

ROLL QUICKLY. Flat doors are painted most simply with a felt roller or micro-fibre roller, which both give a fine surface. When using a felt roller, smooth the paint with a wide brush or pad. When using latex paint, a fine surface must be obtained before it hardens.

HOLDING THE BRUSH. Use a relatively thin brush when you paint borders. For water-based paint, use a brush with synthetic filaments. Water-based paint must be worked quickly. Apply over several decimetres and finish with a light movement in the opposite direction to that already painted. One cannot see where you have lifted the brush on the painted surface – but it can be seen where you put the brush down in wet paint. Oil and alkyd paint do not dry as fast as water-based paint, and can therefore be applied over a longer period of time.

BRUSH CLEAN. Plaster and concrete have open surfaces that hide a lot of dirt. Start by scraping away any loose paint. A two-handed scraper with a durable tungsten carbide blade is best for larger areas. Clean with a stiff brush and paint cleanser

LO 7.3 – Store the work piece, grinding wheels and attachment

- **Content/Topic 1 : Product storage defects**

- **Effect of scratch**

Scratch behaviours of metallic and ceramic materials have been widely explore since the 1950's .However, fundamental scratch behaviour of polymeric materials has not been the focus of significant research until about a few years ago .Owing to the widespread uses of plastics in durable goods applications, and especially due to their soft surface nature, the scratch behaviour of plastics has drawn significant attention in recent years.

The effects of nano-additives on the scratch properties of epoxy(DER-332) have been examined. Scratch parameters such as critical load for onset of macro-crack formation, scratch coefficient of friction were utilized in this study while optical and electron microscopy was used to determine failure and fracture patterns caused by the scratch.

When subjected to scratch can depend on various factors. One of the most important of these factors is the physical and mechanical nature of the material, which itself can determine whether the surface damage will exhibit cracking, material removal, tearing, ductile drawing or etc. or even a combination of more than one feature. Therefore, when examining polymeric systems which do not exactly fall into either categories of ductile or brittle at testing temperatures, caution should be carried out especially while examining the damage type and extent and scale of occurrence.

Effect of Heat and cold on finished product

Depletion of fossil resources in addition to their negative impact on the environment has accelerated the shift toward sustainable energy sources. Renewable energies such as solar radiation, ocean waves, wind, and biogas have been playing a major role in reforming the natural balance and providing the needs of the growing population demand. However, due to the climatic vagaries, the means of storing these types of renewable energy has become urgent. This has lead to a need to develop efficient and sustainable methods of storing energy.

Classification and Characteristics of Storage Systems

Due to intermittency in availability and constant variation in solar radiation, TES found its place in thermodynamic systems. TES not only reduces the discrepancy between the demand and supply by conserving energy, but also improves the performance and thermal reliability of the system. Therefore, designing efficient and economical TES systems is of high importance. However, few solar thermal plants in the world have employed TES at a large scale. Energy storage system can be described in terms of the following characteristics:

- Capacity defines the energy stored in the system and depends on the storage process, the medium, and the size of the system;
- Power defines how fast the energy stored in the system can be discharged (and charged);
- Efficiency is the ratio of the energy provided to the user to the energy needed to charge the storage system. It accounts for the energy loss during the storage period and the charging/discharging cycle;
- Storage period defines how long the energy is stored and lasts hours to months (i.e., hours, days, weeks, and months for seasonal storage);
- Charge and discharge time defines how much time is needed to charge/discharge the system; and
- Cost refers to either capacity (/kWh) or power (/kW) of the storage system and depends on the capital and operation costs of the storage equipment and its lifetime (i.e., the number of cycles).

The computational fluid dynamic approach is also a vastly used method to save money, where fluent software seems to be successfully used for different engineering applications.

The main types of thermal energy storage of solar energy are presented in Figure 1. An energy storage system can be described in terms of the following characteristics:

- **Capacity** defines the energy stored in the system and depends on the storage process, the medium, and the size of the system;
- **Power** defines how fast the energy stored in the system can be discharged (and charged);
- **Efficiency** is the ratio of the energy provided to the user to the energy needed to charge the storage system. It accounts for the energy loss during the storage period and the charging/discharging cycle;
- **Storage period** defines how long the energy is stored and lasts hours to months (i.e., hours,

Deformation

Deformation is elongation or compressive, and we need to extend our concept of strain to include “shearing,” or “distortional,” effects. To illustrate the nature of shearing distortions, first consider a square grid inscribed on a tensile specimen as depicted in Fig. Upon uniaxial loading, the grid would be deformed so as to increase the length of the lines in the tensile loading direction and contract the lines perpendicular to the loading direction. However, the lines remain perpendicular to one another. These are termed normal strains, since planes normal to the loading.

- **Content/Topic 2: Introduction to storage**

Storage goals and objectives

Goals of material handling:

- Reduce unit costs of production
- Maintain or improve product quality, reduce damages, and provide for protection of materials
- Promote safety and improve working conditions
- Promote productivity
- Promote increased use of facilities
- Control inventor

Objectives of Materials Handling:

As we know that with the rise of factory system, men continued to develop handling equipment to perform jobs where human or animal muscles were insufficient in either capacity or speed. Later on it becomes important to reduce materials handling labour in order to reduce production cost.

Therefore main objective of materials handling engineer is to reduce product cost the one overall goal. Materials handling equipment is not production machinery, but is auxiliary equipment that improves the flow of material which in turn reduces stoppages in production machines and thus increases their production

Objectives of a proper materials handling system are:

1. Reduced costs
2. Increased capacity,
3. Improved working conditions,

Material handling

Definition of Materials Handling:

There is no hard and fast definition of materials handling, however attempts have been made to define this term. Materials handling is the science and art involving the moving, packing and storing of substance in any form, and includes the preparation, placing and positioning the material to facilitate their movement or storage

All material handling should be the result of a deliberate plan where the needs, performance objectives and functional specification of the proposed methods

- Are completely defined at the outset.
- Storage and handling methods

To better expose you to the big world of warehouse storage systems, we've compiled a list of the 6 most common types:

- Static Shelving
- Mobile Shelving

- Pallet Racking
- Multi-tier Racking
- Mezzanine Flooring
- Wire Partition

1. **Static Shelving**

As the name suggests, static shelves are storage mechanisms that are designed to stay in one place. For the most part, they are meant to hold inventory that is fairly lightweight (a few hundred pounds per shelf). It's commonly used for storing inventory that needs continuous replenishment.

Because they're not compatible with forklifts, static shelving is generally used with inventory that must be manually picked, placed, and/or organized. For your larger inventory, invest in a wide-span shelving system, which can hold more weight and can be used in higher-elevation configurations.

2. **Mobile Shelving**

Similar to static shelving, mobile shelving is a completely adjustable solution that is meant to hold your manually-picked items, but the difference here is that many of these systems are designed to hold more items in less space. With mobile shelving, shelves or cabinets are mounted on carriage and rail systems, eliminating fixed aisles and increasing productivity by making inventory more accessible, even when space is tight.

Mobile shelving designs typically include level tracks that can either be manual or mechanized. Some even come equipped with locking systems to control access to inventory.

3. **Pallet Racking**

For the busiest and largest warehouses, pallet racking systems are usually treated as the center piece of the operation. Typically, pallet racking systems are made out of wood, metal, or plastic and hold inventory that is received in large boxes. Depending on the height, the boxes are placed on the pallet racking system with the help of a forklift or an automated mechanism.

There are a variety of sub-categories of pallet racking systems, including carton-flow racking, cantilever racking, coil racking, double-deep racking, drive-in racking, drive-through racking, high-bay racking, mobile racking, narrow aisle racking, pallet live racking, push back racking, shuttle racking, and vertical racking. Most often, warehouses will choose systems based on weight limits, flexibility, and whether or not the system demands a change in infrastructure.

4. **Multi-Tier Racking**

A great choice for large stocks of items that have small unit sizes, multi-tier racking is a system that is designed to capitalize on vertical space. Because no warehouse is one-size-fits-all, many multi-tier racking options are flexible, with the ability to add or remove tiers depending on your current needs.

Mostly, multi-tier racking concerns relatively lightweight items that are picked and organized manually. To get the most out of this warehouse storage system, organize each tier strategically and pack items as densely as possible, while at the same time paying attention to weight limits and ceiling-to-rack height compliance guidelines.

5. Mezzanine Flooring

If you have the budget and your strategic warehouse layout allows for it, mezzanine flooring is an effective and space-saving storage option. Essentially, mezzanine flooring is a second (or third, or fourth) floor that is constructed above the main warehouse floor.

Because of the intrusive nature of the build, this is likely one of the more expensive options that a warehouse can choose, but it also has the most potential for customized features, such as lighting, lift-systems, and conveyors.

6. Wire Partitions

While mezzanine flooring is one of the more high-tech options, wire partitions are on the other end of the spectrum. Wire partitions are, effectively, strategically-placed wire cages that are meant to be installed and torn down quickly and easily.

Order picking is the process of finding and extracting products from a warehouse to fulfil customer orders. Since the order picking process involves significant cost and can affect customer satisfaction levels, there has been an increasing number of improvements proposed to help companies with this supply chain issues. Four types of methods:

- Picker to Part
- Part to Picker
- Sorting System
- Pick to Box

✓ **Picker to Part**: The picker-to-part method is commonly found in many warehouses. The process involves a storage area, a picking area, and a material handling system that refills the picking locations from the storage area. The handling system can be forklift-based or more specialized, such as gravity flow racks.

✓ **Part to Picker:** The part-to-picker method uses the same elements as the picker-to-part method: storage area, picking area, and a material handling system. The difference is that the picking area for this method is made up of a series of picking bays.

Products are moved from the storage area and delivered to the picking bays. Each bay receives the items for one or more orders. The picking operator then collects the products after they're delivered to their bay and fulfils the customer orders.

- ✓ **Sorting System:** The sorting system method uses an automatic material handling system consisting of multiple conveyors and a number of sorting devices. The items are placed on a conveyor in the storage area, and they're sorted for each particular order. The operator in the picking area collects the items that have been sorted for a customer order and processes that order.
- ✓ **Pick to Box:** The pick-to-box method is similar to the sorting system because it uses the same elements: a picking area, a storage area, replenishment of the picking area, and a sorter.

- **Content /Topic 3 : Housekeeping basics**

✓ **Overall cleanliness**

To ensure a good bond between the sprayed` coating and the base material to which it is applied, be sure the areas to be coated and the jacent areas are free from oil, grease, water. At, and other foreign matter which may contaminate the coating.

Adequate space and proper layout

✓ **Layout of Work Place**

The following should be observed at all times during workshop practice:

Generally, the workplace should be designed for maximum comfort, convenience, efficiency and safety of the users. The space should be free from unnecessary obstructions and allow free movement of the number of individuals who will occupy it. The space should be properly ventilated with, if necessary, provision for extraction of fumes and collection of dust. An adequate level of lighting should be provided.Workbenches and machines should be positioned with attention to the purposes and frequency of use.

They should consider both efficiency and safety. For example, a machine that is frequently used, such as a bench drill press, should be conveniently placed in relation to workbenches so as to avoid unnecessary movement by the operator Similarly, a machine that is potentially dangerous, such as a router, should have adequate space around it, both for the operator and others who may be passing from one part of the workshop to the other.

Workbenches should normally be between about 1.5 and 2 m long and about 0.6 and 0.8m wide.

To prevent the worker from having his back bent continuously while performing an operation, the height of the working surface should be about 0.9 m. Safety devices, such as electric cut-out switches, should be clearly marked, visible and easily reached. The workshop should be kept clean and tidy, with materials and tools properly stored.

✓ **Correct storage and materials handling**

All abrasive wheels should be stored in a dry area in rooms not subject to extreme temperature changes since some bonds may be affected by excessive humidity, dampness and extreme temperature differentials

Storage

- Suitable racks, bins, drawers or boxes shall be provided to store the various types of wheels used. (See Figure)
- Exception: Pallets should only be stacked in accordance with wheel manufacturers' recommendation. Wheels shall not be stored subject to:
  - Exposure to water or other solvents
  - Any temperature or humidity condition that causes condensation on the wheels
  - Freezing temperatures.
- Special care should be taken to prevent problems with wheel support and environmental conditions for wheels stored in mobile storage areas, such as:

(a) Rescue Squad trucks

(b) Field contractors

(c) Barges and boats

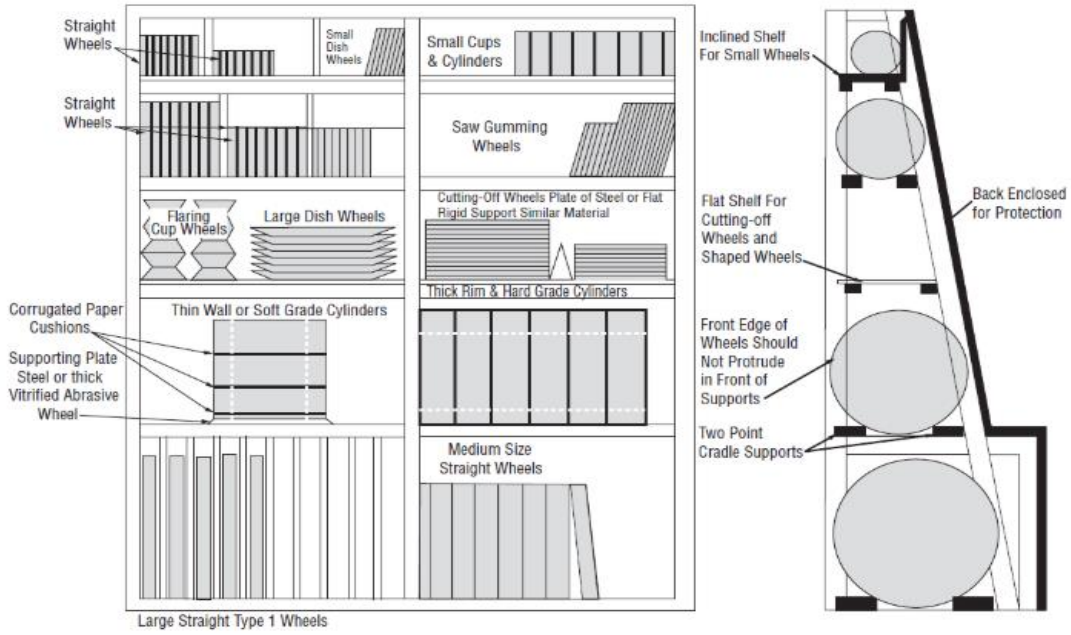


Figure 86.wheel storage

Abrasive wheel storage racks should be designed, constructed and located to fit the needs of the user. The following factors should be considered:

1) Location

All abrasive wheels should be stored in a dry area in rooms not subject to extreme temperature changes since some bonds may be affected by excessive humidity, dampness and extreme temperature differentials. Racks should be located as near as practical to the grinding location, but never where there is danger of damage from passing trucks, crane handling or excessive vibration.

2) Storage Methods

The racks, bins or drawers should be constructed so that each of the various types of wheels can be stored in an orderly and safe manner. Wheel selection should be possible with a minimum of handling. The selection of racks, bins, boxes, or drawers for storage depends on the size and type of wheels. The following suggestions should be considered.

- Thin organic bonded wheels, such as those used for cutting off, should be laid flat on a flat surface of steel or similarly rigid material away from excessive heat, moisture and other liquids to prevent war page. Loose blotters should not be placed between stacked thin wheels. If thin wheels are supplied with blotters attached, suitable separators should be used to preserve flatness
- Large diameter wheels (Types 1, 5, 7, 20, 21, 22, 23, 24, 25, and 26) of appreciable thickness are best supported in racks. The racks should provide cushioned two-point cradle support to prevent the wheels from rolling. Partitions are helpful in facilitating wheel selection with a minimum of handling.
- Flaring cup wheels (Type 11) are best stored as illustrated in Figure 1 to prevent chipping of edges.
- Small wheels (approximately 4 inches or less in diameter), except flaring cup wheels (Type

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