RQF LEVEL 3

MATRO301

MANUFACTURING TECHNOLOGY

Rolling Operation

TRAINEE'S MANUAL

October, 2024

ROLLING OPERATION

KOICA
Korea International Cooperation Agency

TQUM
TVET Quality Management Project

2024

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ACRONYMS

CBA: Competency Based Assessment

CBT: Competency Based Training

PPE: Personal Protective Equipment

RP: Rwanda Polytechnic

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

TQUM Project: TVET Quality Management Project

TVET: Technical and Vocational Education and Training

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in manufacturing technology, specifically for the module of **"Rolling Operation".** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies. The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

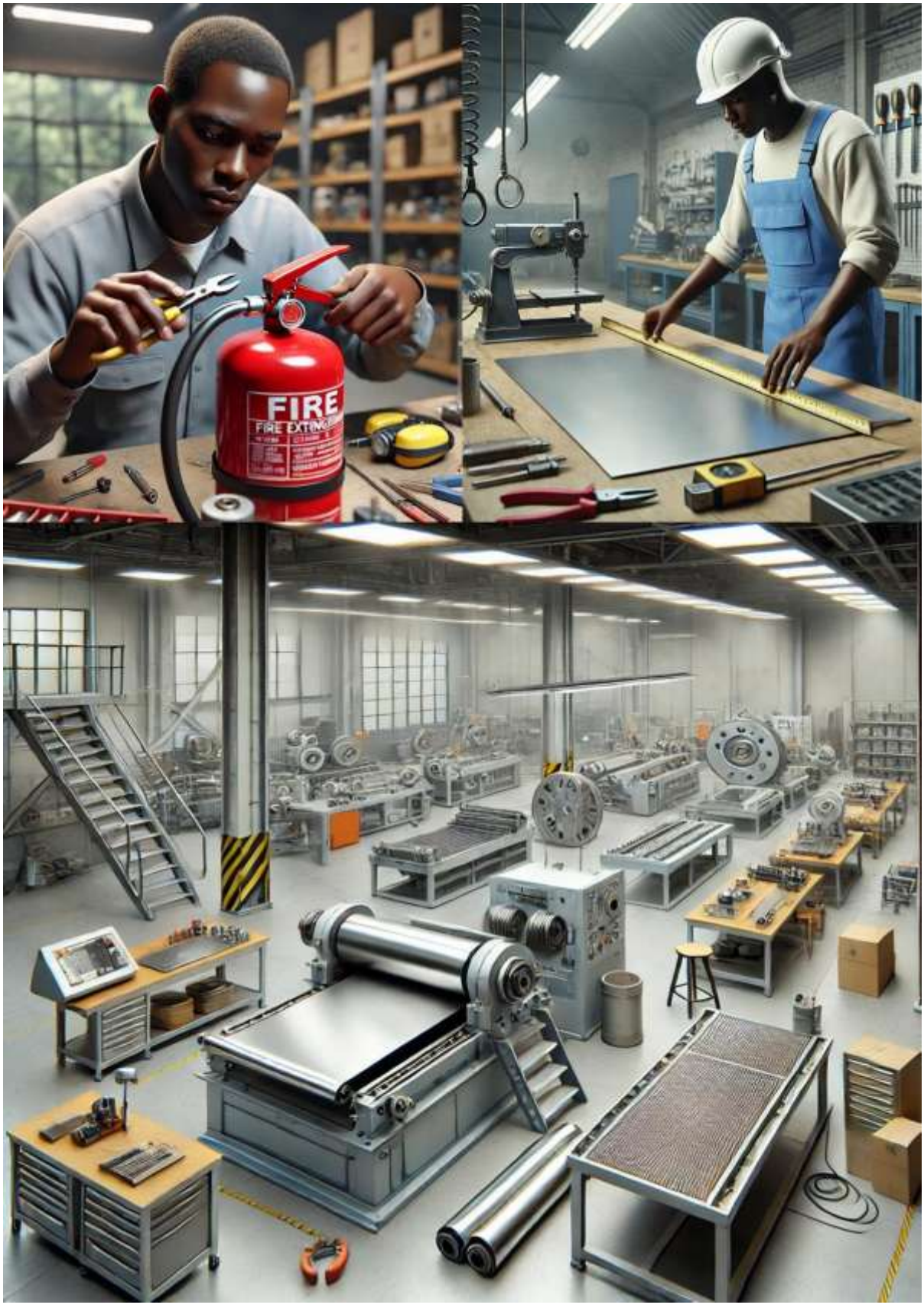
The trainee's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: MATRO301 ROLLING OPERATIONS

Learning Outcome 1: Prepare for rolling operation
Learning Outcome 2: Carry out rolling operation
Learning Outcome 3: Perform post-rolling operation activities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Indicative contents
1.1 Introduction to rolling operation
1.2 Safety rules and regulations
1.3 Selection of materials, tools and equipment
1.4 Identification of rolling process
1.5 Identification of rolling defects

Key Competencies for Learning Outcome 1: Prepare for Rolling Operation

Knowledge	Skills	Attitudes
• Description of rolling operation • Identification of Safety and security measure required in rolling operation • Description of materials, tools, and equipment used in rolling operation • Description of rolling process • Description of rolling defects	• Applying safety precautions required in rolling operation • Selecting, materials, tools and equipment used rolling operation	• Being a good communicator with team members, supervisors, and other departments while selecting rolling tools and equipment. • Being adaptable to new techniques of maintaining rolling tools and equipment.

Duration: 8 hrs

Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Define correctly key terms used in a manufacturing rolling operation
2. Explain clearly Working principle of rolling machine used in manufacturing
3. Identify correctly application of rolling operation used in manufacturing
4. Identify effectively advantages and disadvantages of rolling operation in manufacturing
5. Identify properly safety and regulations measures rolling operation applied in manufacturing
6. Describe correctly tools, materials and equipment for rolling operation used in manufacturing
7. Apply appropriately maintenance technics for rolling equipment used in manufacturing

Resources

Equipment	Tools	Materials
● PPE, ● Fire extinguishers, ● first aid kit ● Rolling machine ● Angle grinder ● Shear machine ● Cut-off machine	● Micrometre ● Tape measure ● Callipers ● Ruler ● Gauges ● Shears ● Cut-off saws ● Plasma cutter ● Marking pens and pencils ● Scribers ● Stencils and templates	● Oil ● Grease ● Sheet metals ● Steel bar

	● Wire brushes ● Abrasive pad ● Solvents and degreasers ● Wrenches ● Screwdriver ● Impact driver ● Grease gun ● Oil cans ● Lubrication pumps ● Inspections mirrors ● Magnifying glasses	

Indicative content 1.1: Introduction to Rolling Operation

Duration: 2 hrs

Theoretical Activity 1.1.1: Introduction to rolling operation

Tasks:

1. You are asked to answer the following questions:
   i. What do you understand by the following terms?
      a) Rolling process
      b) Ingot
      c) Billet
      d) Slab
      e) Bloom
      f) Strip
      g) Foil
      h) Bar
      i) Wire
   ii. Describe the working principle of rolling.
   iii. Explain the application of rolling.
   iv. Explain the advantages and disadvantages of rolling.

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard.

3. Present your findings/answers to the trainer and/or the whole class.

4. Pay attention to the trainer's clarification and ask questions where necessary.

5: For more clarification, read the key readings 1.1.1.

Key readings 1.1.1.: Definition of concepts related to rolling operation

- **Definition of rolling process**

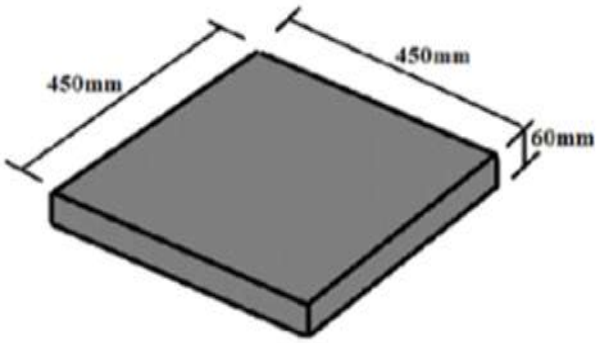
It is a deformation process in which metal(s) in its semi-finished or finished form is passed between the two opposing rollers, which reduces the metal's thickness through the compression process. The rollers roll around the metal as it squeezes in between them.

- **Stages of metal products created during the rolling process:**
  - ✓ **Ingot**

- It is the starting metal that is provided input to the rolling process.
- The Ingot is a forging terminology, where metal is taken out from the cast with various defects.
- Ingots serve as a primary form of semi-finished metal products and are used as raw material for various manufacturing processes in the metal industry.

  - ✓ **Bloom**

- It is the first rolled product of ingot, with a cross-section area of more than 230 cm2.
  - ✓ **Billet**
- The product is obtained by further rolling of Bloom, having an area of Cross-section greater than 1600 mm2.
  - ✓ **Slab**
- It is a hot Rolled Ingot, with a Cross-section area greater than 100 cm2 and width>=2*thickness.



  - ✓ **Plate**:
- I plate," are flat sheets of metal that are characterized by their rectangular or square shape and uniform thickness.
- These plates are typically made from a variety of metals, including steel, aluminium, brass, copper, and others t is the Mill product, with thickness more than 6 mm.

  - ✓ **Sheet**:
- It is a mill product, with thickness less than 6 mm, and width greater than 600mm.
  - ✓ **Strip**:
- It is a mill product with thickness less than 6 mm, and width less than 600 mm.

https://www.smetals.co.uk>shop

- ✓ **Foil**

- It is a thin strip, with a width of 300 mm, and a maximum thickness of 1.5 mm.

- ✓ **Bar**

- It is a Uniform circular cross-section Object, in the form of a Cylinder.

- ✓ **Wire**

- It is a bar with a small area of cross-section, which may go up to 9.5 mm.

- **Working principle of rolling**

Most metal rolling operations are similar in that the work material is plastically deformed by compressive forces between two constantly spinning rolls. These forces act to reduce the thickness of the metal and affect its grain structure.

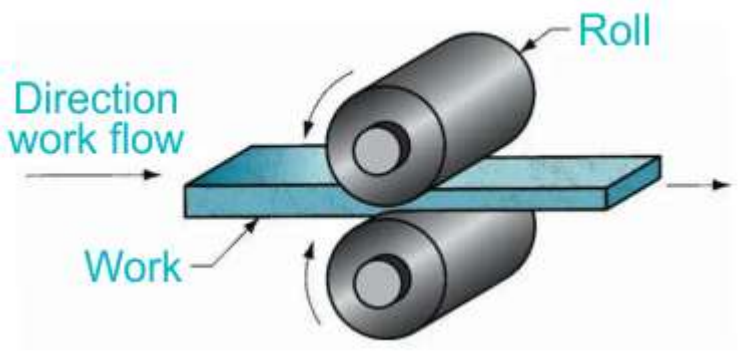
The Rolling Process consists of two opposing rollers and a metal squeezing in between them. The basic consideration is that the thickness between the rollers should be less than the Metal's (Ingot) Initial Thickness. This consideration will help metal's forward motion as it passes through the gap between the Rollers. Rolling Process decreases the Thickness of Metal and Increases its Length and Breadth, Keeping Overall Volume Constant.

The Working principle of Rolling might be clear from its basic definition. It is a Manufacturing Process consist of Rollers that are present at a distance from each Other. The Metal in its Semi-finished or finished form is squeezed through the Rollers gap, sliding at the ends.

- **Three stages of rolling process**

✓ **Primary Rolling**:

- It is the Primary stage of Thickness reduction, in which Ingot is changed into simple stock members like bloom and slab.
- This process refines the structure, improves the mechanical properties, and removes Internal defects.

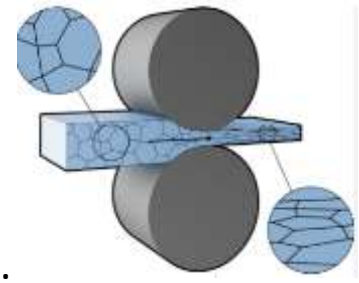


✓ **Hot Rolling**:

- Blooms and Slabs Obtained by Primary rolling are converted into plates, sheets, rods, and Other secondary members through Hot Rolling.
- Hot rolling is a metalworking process in which metal is heated above the recrystallization temperature to plastically deform it in the working or rolling operation.
- This process is used to create shapes with the desired geometrical dimensions and material properties while maintaining the same volume of metal.

✓ **Cold Rolling**:

- This is a final finishing process, in which the final products obtained are given good surface finish, tolerances, and enhancing their mechanical properties



- Cold rolling is a process by which metal is passed through rollers at temperatures below its recrystallization temperatures.
- The metal is compressed and squeezed, increasing the yield strength and hardness of the metal.

- Cold rolling of metal strip is a special segment within the metalworking industry.

- **Applications of rolling**

✓ **Steel industry**

- Hot Rolling is used to process large steel billets, blooms, or slabs into products like plates, strips, and structural sections.
- The metal is heated above its recrystallization temperature to improve its ductility and reduce the force required for deformation.
- Products examples: Hot-rolled sheets, plates, structural beams, and rails.
- Cold Rolling is used to produce thin sheets and foils with improved surface finish and dimensional accuracy.
- The metal is rolled at room temperature, which increases strength through strain hardening.
- Products examples: Cold-rolled sheets, coils, and precision strips used in automotive, appliance, and consumer goods industries.

✓ **Aluminium Industry**

- Production of aluminium sheets, foils, and plates for various applications, including packaging, automotive parts, and construction.
- Aluminium is rolled at both hot and cold stages to achieve the desired thickness and properties.
- Products examples: aluminium foil, beverage cans, aluminium roofing sheets, and heat exchangers.

✓ **Automotive Industry**

- Rolling is used to produce sheet metal for car body panels, including doors, hoods, and roofs.
- Cold rolling improves surface quality and strength, which is crucial for forming intricate shapes and providing durability.
- Product example: Automotive sheet metal parts.

✓ **Construction Industry**

- Rolling produces structural steel sections used in building frameworks, bridges, and other infrastructure projects.
- Hot rolling creates I-beams, H-beams, channels, and angles for load-bearing applications.
- Products example: Building columns, beams, and girders.

✓ **Oil & Gas Industry**

- Rolling is used to manufacture large-diameter steel pipes for transporting oil, gas, and other fluids.
- Hot rolling is utilized to produce pipes with the necessary strength and size.
- Product example: Pipeline sections for transportation networks.
- Rolling produces the cylindrical shells and plates used in pressure vessels and reactors.
- Both hot and cold rolling are used to achieve specific mechanical properties and dimensions.
- Products example: Pressure vessel shells, reactor components.

✓ **Manufacturing and Aerospace**

- Precision rolling processes produce lightweight, high-strength aluminium and titanium components for aircraft.
- Cold rolling enhances material properties and precision for critical components.
- Products examples: Aircraft fuselage panels, wing structures.
- Rolling is used to create various tool steels and alloys with specific properties for cutting and forming tools.
- Controlled rolling processes enhance mechanical properties and ensure uniformity.
- Products example: Tool steel bars, rolls, and dies.

✓ **Consumer Goods**

- Rolling produces thin aluminium foils used for packaging food, pharmaceuticals, and other products.
- Cold rolling is used to achieve the required thickness and surface finish.
- Products examples: Food wrappers, blister packs.
- Rolling is used to manufacture parts for household appliances, including refrigerators, ovens, and washing machines.
- Cold rolling enhances the finish and formability of metal sheets used in these applications.
- Products examples: Appliance casings, internal components.

- **Advantage of rolling**

✓ **High production efficiency**:

- Rolling machines are known for their high production efficiency.
- They can continuously and rapidly shape metal into the desired profiles or shapes, resulting in a faster and more efficient manufacturing process.
- These machines can operate at high speeds, allowing to produce a large volume of metal components or products in a relatively short time, which can significantly re duce production costs.

✓ **Improved material properties**

- The rolling process can improve the mechanical properties of the material.
- For example, it can increase the strength and hardness of the metal by working it a t high pressures and temperatures, such as in hot rolling.
- Cold rolling can enhance the material's surface finish and dimensional accuracy, m aking it suitable for applications requiring tight tolerances and excellent surface qu ality.

✓ **Wide range of shapes**

- Rolling machines can be configured to produce a wide variety of shapes, fro m simple profiles to complex cross-sectional geometries.
- These shapes can include angles, channels, tubes, and custom profiles.
- The versatility of rolling machines allows manufacturers to adapt to the spe cific requirements of different industries and applications.

✓ **Good surface finish**

- Rolling machines can achieve a high-quality surface finish on the metal products th ey produce. Cold rolling can provide a smooth, polished surface.
- The ability to obtain a good surface finish reduces the need for additional surface t reatments and saves time and costs in post-processing

- **Disadvantages of rolling**

✓ **High initial equipment cost**

- One of the significant disadvantages of rolling is the high initial cost associated wit h the purchase and installation of rolling mills and machinery.
- Setting up a rolling mill can be capital-intensive, especially for small or medium-siz ed manufacturing operations.

✓ **Material wastage**

- Although rolling is generally more material-efficient compared to some other meta lworking processes, there is still some material wastage involved.
- This can occur due to the need for trimming and removing the ends of rolled produ cts, which may not meet the desired quality or dimensional specifications.

✓ **Energy intensive**

- Rolling can be an energy-intensive process, particularly in hot rolling, where the m etal is heated to high temperatures.
- The energy required for heating and maintaining the rolling mills can contribute to operational costs and environmental concerns.

✓ **Limited to metals**

- Rolling is primarily limited to the processing of metals and metal alloys.
- It is not a suitable method for working with non-metallic materials like plastics, cer amics, or composites.
- This limitation may require the use of other manufacturing processes for non-meta llic materials.

✓ **Tooling and maintenance costs**

Rolling mills and machinery require regular maintenance, including the replacement of roll s and other consumable components. These maintenance and tooling costs can add to the overall operating expenses.

✓ **Size limitations**

- Rolling mills are often designed for specific size limitations, both in terms of the wi dth and thickness of the metal that can be processed.
- This means that very large or extremely thin materials may be beyond the capabilit ies of some rolling mills

Points to Remember

- Always keep in mind these key terms related to rolling operation: ingot, bloom, billet, slab, plate, sheet, strip and wire.
- Rolling is widely used in the following main applications: sstructural shapes, wire and wire products, tubes and pipes sheet metal, plates, bars and rods.
- Even if rolling has different advantages, it has also drawbacks like; high initial equipment cost, material wastage and limited to metals.

Application of learning 1.1.

Conduct a study visit to any manufacturing workshop/workplace located in your surroundings. The workshop/workplace should be specialized in production of rolled products using metallic materials. Observe how they produce different shapes by using rolling machines. By referring to the key readings 1.1 .1, prepare a report about:

i. The working principle of rolling machines

ii. Applications of rolling

iii. Advantages and disadvantages rolling.

Indicative content 1.2: Safety Rules and Regulations

Duration: 1 hr

Theoretical Activity 1.2.1: Description of safety rules and regulations applied in rolling operation

Tasks:

1: You are requested to answer the following questions:

i. What do you understand about the term" hazard"?

ii. Describe the types of potential hazards in the rolling workplace.

iii. Identify safety signs and symbols applied in the workshops.

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard.

3. Present your findings/answers to the trainer and/or the whole class.

4. Pay attention to the trainer's clarification and ask questions where necessary.

5: For more clarification, read the key readings 1.2.1.

Key readings 1.2.1. Description of safety rules and regulations applied in rolling operation

- **Definition of hazards**

  A hazard is a potential source of harm or adverse effect on something or someone. For example, a fire hazard is something that can cause a fire, such as a faulty electrical wire or a flammable material.

- **Types of hazards**

  The words 'risk' and 'hazard' are often used interchangeably. However, if you are responsible for managing the health and safety in your workplace, it's important that you understand the difference between them. The rest of this article focuses on hazards, including where they might be found in different workplaces. We also provide you with a range of further resources to make your risk assessment process as smooth as possible.

  Six main categories of hazards:

- Biological: Biological hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts. For example, mould, blood and other bodily fluids, harmful plants, sewage, dust and vermin.
- Chemical: Chemical hazards are hazardous substances that can cause harm. These hazards can result in both health and physical impacts, such as skin irritation, respiratory system irritation, blindness, corrosion and explosions.
- Physical: Physical hazards are environmental factors that can harm an employee without necessarily touching them, including heights, noise, radiation and pressure.
- Safety: These are hazards that create unsafe working conditions. For example, exposed wires or a damaged carpet might result in a tripping hazard. These are sometimes included under the category of physical hazards.
- Ergonomic: Ergonomic hazards are a result of physical factors that can result in musculoskeletal injuries. For example, a poor workstation setup in an office, poor posture and manual handling.
- Psychosocial: Psychosocial hazards include those that can have an adverse effect on an employee's mental health or wellbeing. For example, sexual harassment, victimisation, stress and workplace violence.

- **Safety precautions**

  This kind of machine operation needs professional operators, who must be familiar with the performance of the machine and operating procedures, in case of some safety problems.

  The following are safety precautions that operators must take for metal roll forming machine equipment:

✓ **Install emergency control devices**

To prevent any accidents, keep running and emergency stop controls must be installed on the winder.

✓ **Skilled and experienced operator**

As with any other sheet metal forming process, sheet metal rolling must be performed by experienced and certified personnel. Because he knew the right way to handle the machine and was very aware of its dangers.

✓ **Carry out regular maintenance and repair**

There are many moving mechanical parts in a metal mill that are easily worn out after a certain period. Maintenance and repair can be carried out to improve performance, however, it can also help prevent accidents. Therefore, the repair and maintenance here is a preventive measure.

✓ **Operators must wear personal protective equipment**

- PPE include workshop aprons, gloves, protective headbands and heat-resistant and flame-resistant glasses.
- Proper clothing is essential as loose clothing can get stuck in rollers or can be exposed to heat.
- Operators must avoid wearing any loose or fancy jewellery when using such equipment and sheet metal.
- Loose jewellery can get trapped in the device or even melt as temperatures rise, causing accidents.

✓ **Safe working distance**

- Operators must operate at a safe distance on sheet metal rollers, especially when inserting metal sheets between hot rollers.
- As the machine consists of many moving mechanical parts, the operator must not touch any moving parts.
- Non-operators are forbidden to enter the work area and keep more than 2 meters from the equipment.

✓ **Environmental safety**

- The environment near the sheet metal rolling equipment must be well maintained.
- No temperature reaction objects, or chemical reaction materials should be near to prevent accidents.
- After the work, the equipment should be shut down and the surrounding area cleaned.

- **Safety signs and symbols**

- Wherever necessary (but not as a substitute for elimination by design or the use of safeguards), the designer usually adds warning signs and devices.

- Visual signals, such as flashing lights and audible signals (e.g., siren, horn, etc.) are to be used to warn of an impending hazardous event such as equipment start-up or over-speed.

- Markings, signs, and written warnings are to be readily understandable and unambiguous.
- These signs concerning the specific function(s) of the equipment, as they are related to readily understandable signs (pictograms), are to be used in preference to be written warn.

Practical Activity 1.2.2: Applying safety rules and regulations in rolling operation

Task:

1: Referring to the activity 1.2.1, you are requested to go at workplace and apply safety rules and regulations by positioning hazard symbols, fire safety signs, mandatory signs, prohibition signs, warning signs.
2: Wear the PPE
3: Referring to trainer's demonstration and instructions, apply the safety rules and regulations.
4: Read key reading 1.2.2 and ask clarification where necessary.
5: Perform the task provided in application of learning 1.2

Key readings 1.2.2.: Application of safety rules and regulations

Types of health and safety signs are:	**Categories of safety signs:**	**Hazard Symbols**	
• Prohibition Signs. • Mandatory Signs.	- Mandatory, - Prohibition, 	• Explosive (Symbol: exploding bomb)	
		• Flammable (Symbol: flame)	

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Warning Signs.

Safe Condition Signs.
Fire Equipment Signs.

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<td>
- Warning,
- Danger,
- Fire Fitting,
- Emergency information ,
- Restriction.
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Oxidizing (Symbol: flame over circle)

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Corrosive (Symbol: corrosion

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Acute toxicity (Symbol: skull and crossbones)

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Hazardous to the environment (Symbol: environment)

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Health hazard/Hazardous to the ozone layer (Symbol: exclamation mark)

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Serious health hazard (Symbol: health hazard)

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Gas under pressure (Symbol: gas cylinder)

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Points to Remember

- While describing safety rules and regulations applied in rolling operation you must consider mainly types of hazards and safety signs and symbols used in rolling operation.
- While applying safety precautions in rolling operation you should focus mainly on the following elements: install emergency control devices, skilled and experienced operator, carry out regular maintenance and repair, use personal protective equipment, safe working distance, environmental safety.
- While preventing hazards at a rolling workplace you should consider risk assessment, safety training, safety equipment, emergency plans, and regular inspections.

Application of learning 1.2.

Suppose that there is a manufacturing workshop that is requesting your school a support of training its workers about the appropriate application of safety and security measures in the manufacturing workshop. You are asked to train them to:

a) Use PPEs for metal cutting
b) Allocate and use fire extinguisher
c) Allocate safety signs and symbols in the workshop
d) Identify first aid kit
e) Control hazards

Indicative content 1.3: Selection of Materials, Tools and Equipment

Duration: 3 hrs

Theoretical Activity 1.3.1: Description of materials, tools and equipment used in rolling

Tasks:

1: You are requested to provide answers to the following questions:

i. What do you understand by?
   a. Materials
   b. Tools
   c. Equipment

ii. Identify (with examples) the types of materials, tools, and equipment used in rolling operations

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard.

3. Present your findings/answers to the trainer and/or the whole class.

4. Pay attention to the trainer's clarification and ask questions where necessary.

5: For more clarification, read the key readings 1.3.1.

Key readings 1.3.1.: Description of materials, tools and equipment used in rolling operation

- **Materials**

  Materials are the matter or substance that objects are made from. Engineering materials are basically classified into two groups namely metals and non-metals, and their sub classification is given below.

- **Types of materials**

  Each stand in the roll forming process has a specific job in the fabrication of the piece, and every stage involves minor changes in the configuration of the metal.
  The size of the stands used depends on the metal's type, thickness, and formability. The types of metals used in roll forming manufacturer categorizes into two groups: ferrous metals and non-ferrous metals

✓ **Ferrous Metals**

Ferrous metals are any metals that feature a bivalent iron compound. Most ferrous metals have magnetic properties and are primarily used for their strength and durability. Most ferrous metals use protective coatings to prevent rust and corrosion.

- **Steel**

It is made up primarily of iron and malleable below its melting point by at least one temperature range without requiring special heat treatment.

Steel for roll forming is usually free from slag and between 0.05 and two percent of its weight is carbon.

Steel can also contain small amounts of silicon and manganese, as well as trace quantities of sulfur and phosphorus.

- **Stainless Steel**

It contains a high percentage of chromium, which lends it high staining and corrosion resistance. This form of steel is also resistant to weak mineral acids, oxidation, organic acids, and other caustic materials.

- **Galvanized sheet steel**

sheet steel that has been coated on both sides with zinc and immediately heat treated so the surface of the metal features a bonded coating

✓ **Non-Ferrous Metals**

Non-ferrous metals are more malleable and light weight than ferrous metals. Because they do not contain iron, they are more resistant to rust and corrosion.

- **Aluminium:**

It is a soft, malleable, and lightweight metal with excellent resistance to corrosion. When exposed to air, it forms a thin layer of aluminium oxide to protect it from of zinc-iron alloy

- **Brass:**

It is a copper and zinc alloy featuring a bright, gold-like colour and a high resistance to corrosion.

There are several different types of brass, including bronze, an alloy of copper and tin.

Brass is very malleable and is used in a variety of applications.

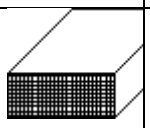
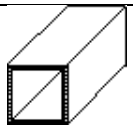
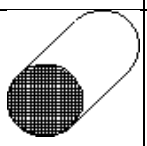
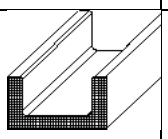
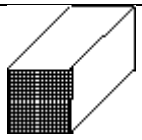
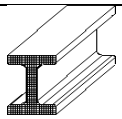
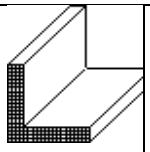
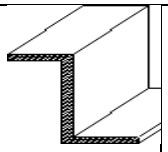
- **Copper**:

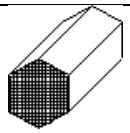
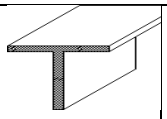
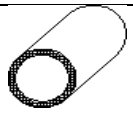
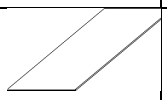
a ductile metal noted for its electrical conductivity.

It also features prominently in building materials and as a primary component in other non-ferrous alloys.

- **Sizes and shapes of rolled metals**

Manufacturing companies use metal bending and rolling equipment to create different finished metals for commercial applications.
The dimensions of a metal rolling machine vary greatly and may be custom manufactured for your specific production requirements

Material Shape	**Size specification**		**Material shape**	**Size specification**
	**Flat-bar:** Thickness × Width × Length			**Square-tubing:** Thickness × Width × Length
	**Round-bar:** Diameter × Length			**Channel-Bar:** Width × Height × Length
	**Square-bar:** Width × Length			**I-Beam:** Length × Thickness × pounds
	**Angle-bar:** Thickness × Width × Length			**Z-Bar:** Width × Length

	**Hexagon-bar:** Diameter × Length		**T-Bar:** Width × Length
	**Pipe:** Diameter × Schedule × Length x 20 is thinner than x 40		**Metal Sheet:** Gauge × Width× Length

Mechanical properties of metals:

- **Strength:** Ability of a material to resist loads without failure.
- **Tensile Strength:** Ability of a material in tension to withstand stress without failure.
- **Shear Strength:** Ability of a material to withstand transverse loads without fracture.
- **Elasticity:** Property of material which enables it to regain its original shape after deformation within the elastic limit.
- **Stiffness:** Property of material which enables it to resist deformation.
- **Plasticity:** Ability of material to be deformed permanently without fracture even after removal of force.
- **Ductility:** Ability of a material to deform plastically without rupture under tensile load.
- **Malleability:** Property which enables the metal to withstand deformation by a compressive load without fracture.
- **Hardness:** Property of the material which enables it to resist abrasion, indentation, machining and scratching.
- **Toughness:** Ability of material to absorb maximum energy up to fracture takes place.
- **Weldability:** Ability of a material to be joined by welding

- **Tools**

✓ **Measuring tools**

- **Steel Rules**

Steel rules are the most common linear measuring tools and are available in the metric or inch system. Metric rules are graduated in both millimetres and half millimetres. Some rules are available with both inch and millimetre graduation.

- **Steel tape ruler**

Steel tape rules have often a small sheet-metal angle which makes it easy to apply it at the workpiece edge (fig. below).

Steel tape rule applied to a work-piece edge

- **Vernier Calliper**

- Vernier callipers are precision measuring instruments used to make internal, external and depth measurements. Both systems metric and inch are available, and some styles of vernier calliper provide metric readings on one side and inch readings on the other side.
- The common size of verniers for machine shops are 200 mm, 250 mm and 300 mm. The precision depends on the vernier scale. Common types provide an accuracy of either 0.05 mm or 0.02 mm. The example below shows an accuracy of 0.05 mm.

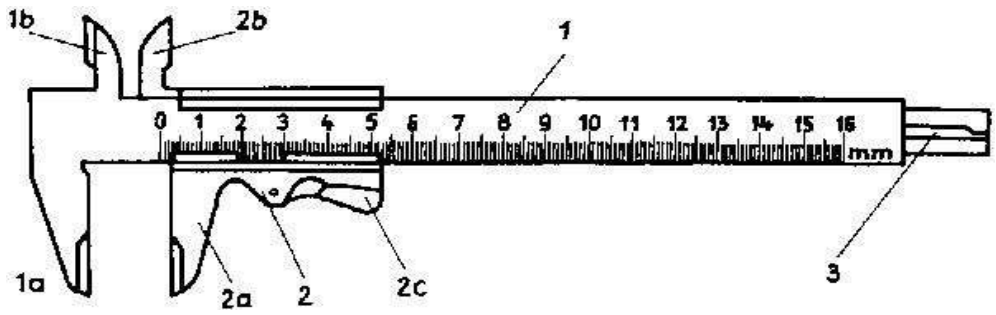
How to read a Metric Vernier Calliper (accuracy 0.05 mm):

- The last numbered division on the bar to the left of the zero on the vernier scale represents the number of millimetres. In the example above the #2 (20 mm) is th e last number left of the zero on the vernier scale.
- Count the graduations between the last number (#2) and the zero on the vernier scale. In the example above there are 8 (8 mm) graduations between the #2 and t he zero on the vernier scale.
- Locate the line on the vernier scale that aligns with a bar line. Divide the number below the line by 10. In the example above it is the line with #7 (7/10=0.7 mm).
- The measurement in the example above is 20 mm + 8 mm + 0.7 mm = 28.7 mm M easuring with the vernier calliper:
- While steel rule, folding rule and steel tape rule belong to the non-adjustable measuring tools, the vernier calliper is an adjustable measuring tool.

Calliper

- It is a device used to measure the distance between two symmetrically opposing sides. A calliper can be as simple as a compass with inward or outward facing points. The tips of the calliper are adjusted to fit across the points to be measured, the calliper is then removed, and the distance read by measuring between the tips with a measuring tool, such as a ruler.
- The Vernier Calliper is a precision instrument that can be used to measure internal and external distances extremely accurately.
- It allows a precise measurement of 0.1 mm. Its measuring range amounts either to 160 mm or to 320 mm. The vernier calliper is used when dimensions on relatively small workpieces shall be determined as precisely as possible
- The vernier calliper consists of a beam with fixed jaw and a sliding member with sliding jaw. A clamping screw or clip serves to clamp the sliding member. The jaws, for example, allow to measure the diameter of a bolt (external measurement). The upper parts of the jaws are shaped as measuring edges. By using them, for example, the diameter of a hole can be determined (internal measurement). At the back end of the beam, the depth gauge is provided which allows the measurement of the depth of a hole (depth measurement).
- The graduation on the beam of the vernier calliper is given in millimetres (mm) (main graduation). Another graduation is on the sliding member which is designated as vernier. The vernier has 10 parts over a length of 9 mm. Thus, it is

possible to read off the tenth of a millimetre. When both jaws touch each other, the zero mark of the vernier and the zero mark of the main graduation are exactly one upon the other. When the zero mark of the vernier coincides with a mark of the main graduation, the zero mark of the vernier indicates the precise dimension in whole millimetres.



✓ **Marking tools**

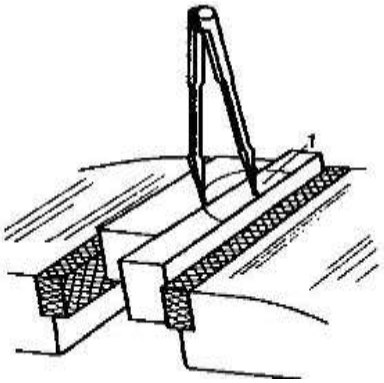
Scribed lines are produced by tools which are either slightly notching the surface of the workpiece or leaving a thin line by wearing themselves,

Steel scriber

Widely used scribing tool with hardened or carbide points which are straight or angular. It is used for rough or rough-machined steel parts and leaves a fine notch.

Dividers

Scribing tool for scribing circular arcs and curvatures. The use of dividers always necessitates a punch mark for the guiding point. It leaves a fine notch!



Scribing with toolmakers' dividers using an insert (1)

- **The Engineers Try-Square**

Engineer's square (figure below) is made of hardened tool steel. It is used for checking the straightness and the squareness of a workpiece. It can also be used for marking perpendicular lines onto a workpiece.

- **Engineers Try Square**

The engineers try-square is composed of two parts, the stock and the blade. They are usually made from bright mild steel with the blade being hardened and tempered so that it resists damage.

It is normally used during engineering / metalworking projects

A typical use of an engineer's try-square is to mark out material for cutting/shaping. The try square is pushed against a straight side of the material (eg. steel). An engineer's scriber is then used to scratch a line onto the surface of the metal. Sometimes engineers blue (a dye/ink) is wiped onto the surface first so that the scratched line can be seen easily. The material is then cut down to this straight line.

- **Centre punch Punching**

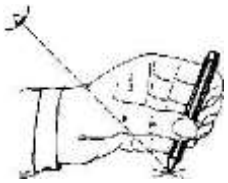
To be able to recognize clearly a scribed line up to the end of working, prick punch marks are set on the scribed line. This is carried out by means of a prick punch which intrudes with its tip into the workpiece metal after a light hammer blow. The punch marks are put in larger distances on straight lines than on curved scribed

lines. Crossings and transitions of straight lines to curves are always punched.

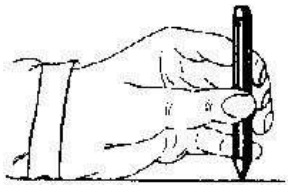
Punch marks are not only made to mark the scribed lines but also to determine insertion points for the dividers and hole centres.

Punching serves to mark scribed lines, insertion points of dividers and hole centres.

Manipulation of the centre punch

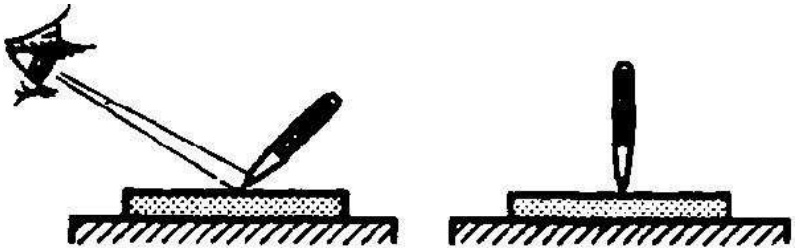


Application of the centre punch



Erection of the centre punch for the blow centre punch procedure:

- Make sure that the point of the punch is sharp before starting.
- Hold the punch at a 45-degree angle and place the point carefully on the layout li ne.
- Tilt the punch to a vertical position and strike it gently with a light hammer.
- If the punch mark is not in the proper position, correct it as necessary



✓ **Cutting tools**

Hand file

- The file is a cutting tool to work materials. It has many cutting edges which are like

small chisels (file teeth) and are harder than the material being worked upon. For cutting metals normally Cross-Cut files are used. These files have an overcut, and an upcut. When using a file, several cutting wedges always act at the same time.

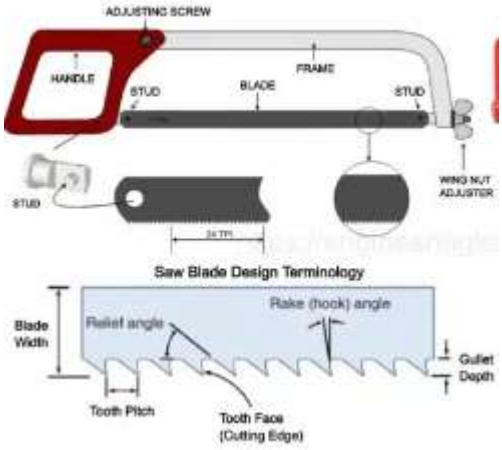
- To file different materials there are various courses available, such as smooth-c ut, second cut,
  and bastard cut.
- The length of the file body normally used is between 100 mm and 350 mm.
- The file handle is either from wood or from plastic

File Handling

- Clamp the workpiece as close as possible to the jaws of the vies. Use protective ja ws (Aluminium) to protect the workpiece.
- Start with a rough file for removing more material then take a smooth file to reach a good surface.
- Forward stroke with pressure; Return stroke without pressure.
- Move with the file crosswise to control the area of filing.
- Clean the file from time to time (especially smooth files) with a wire brush to prevent messy finishes.
- Never work with a file without a file grip.
- Make sure that the file grip is properly attached, that it has the right dimension a nd that it is not splitted.

Hand Hacksaw

- A hand hacksaw mainly serves to separate materials and to produce grooves and slits. It is generally used for cutting a metal into pieces.
- It consists of a frame and a saw blade as shown below. It is a "U" shaped steel frame with a pistol handgrip and a saw blade as shown below. The frame may be of fixed type to take only one length of blade, or adjustable to take different blade lengths. It has a wing nut to adjust the tension of the blade.



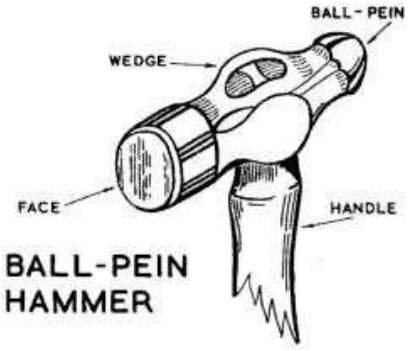
- **Chisel**

In chiselling the cutting edge of a chisel is driven into a workpiece by impact. A chisel must be harder than the piece being worked. Most chisels are made of alloyed tool steels.

Wedge angle for soft materials 30 to 50 degree; for mild steel 60 to 70 degree; for alloyed steels 70 to 80 degree

- **Hammers**

The type most used is the ball pein hammer, which has a flat striking face and a ball-shaped end (call the pein). Hammer heads are made from medium carbon steel. The two ends must be hardened and tempered, the centre of the head with the eye being left soft. It is specified according to its weight.



A hammer is used nearly in every operation related to metal works:

- They are made of cast steel or carbon steel.
- It mainly consists of a face, peen and body. The face and the peen are hardened a nd tempered but the rest of the body is kept soft. A wooden handle is fitted in the eyehole of the hammer with the help of a wedge. The wedge spreads the handle and fixes it inside the hole.
- Hammers are made in the size range of 25 Gram to 10 Kg.
- There are different types of hammers available: Fitters hammer, Ball pane hamme r, Rubber mallet, Plastic hammer, Wood hammer, Sledgehammer, Claw hammer, Aluminium hammer, copper etc.,

  Safety and Care of Hammer

- The hammer head is firmly fixed to the shaft by a wedge.
- The striking face of the hammer head does not wear.
- The handle of a hammer should be dry and not greasy
- The surface of a handle should be smooth
- The face of a hammer should not be spotted, if it so then makes it smooth by grin ding
- Hold the hammer handle always nearer to its tail end.

Bench Vice

A bench vice is the device for holding the workpiece where most hand processes to be carried out. The body of the vice is made of cast iron while the two clamping jaws are made of hardened tool steel. Some bench vice has a swivel base, which can set the workpiece at an angle to the table. The vice height should be correct ergonomically. Vice clamps, made of copper are fitted over the vice jaws when holding finished work to avoid damage to the finish surfaces.

- The base of a bench vice is normally made of cast iron. The jaws are hardened . Clamping soft work pieces requires covering the jaws with an aluminium sheet cover.
- The size of the bench vice is measured by the width of the jaws and the ma ximum opening between the jaws.
- There are different types of bench vices available: With or without an anvil pla te, with a pipe clamping device, machine vise for drill press, and adjustable in an y position within 360 degrees. Care of Vices
- Do not direct impact the vice body by the hammer.
- Light hammering can be done on and only on the anvil of the vice.
- To avoid over clamping, the handle of the vice should be tightened by hand only

- **Rolling equipment**

✓ **Types of rolling machine:**

There are different types of bending machines available based on their different fields of utilization.

Mechanical:

The mechanical three-roller type bending machine is classified as symmetrical an d asymmetrical

Mechanical three-roller symmetry:

The structure of this machine is a three-roller symmetrical type structure. The up per roller of this machine moves vertically at the center at a symmetrical position of the two lower rollers. This configuration is obtained by the assistance of trans mission of the screw nut and the worm.

The rotational motion transmitted in the machine through the output gear of the reducer meshing with the lower roller gear provides the required amount of tor que for the rolled metal plastic sheet.

The biggest disadvantage that the mechanical bending machine suffers from is t he need of pre bending of the end of the sheet metal plate (with the help of othe r equipment).

Mechanical three-roll asymmetrical:

The structure of this machine is a three-roll asymmetrical type in which the upper roller functions as the main drive, and the lower roller moves vertically in order to clamp the plate firmly and mesh with the upper roller gear through the lower roller gear.

- **Hydraulic**:

The biggest benefit of hydraulic three-roller symmetrical plate rolling/bending machine is that the upper roller of this rolling machine can be very easily vertically elevated and lowered down. The vertical lifting hydraulic transmission of this rolling machine is obtained by the utilization of hydraulic oil in the hydraulic cylinders functioning on the piston rod. The lower roller inside the machine is driven in rotational motion, and the output gear meshes through the machine's reducer.

To provide the necessary torque required for the coil, an idler is present under the lower roller, which can be manually adjusted. The upper roller of this machine is shaped quite like the design of a drum, which enhances the straightness of the product being made and is suitable for manufacturing of ultra long tanks with various large cross-sectional shapes.

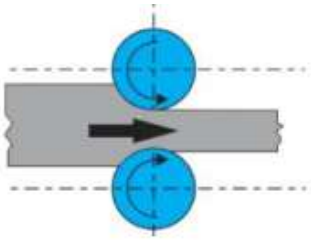
As this rolling machine is an upward adjusting symmetrical three-roller plate rolling machine, it can effortlessly roll and form metal sheets into circular, arc-shaped, and conical workpieces as required according to demands within a certain range. One of the two lower rollers present in this model is the driving rollers and the other roller is the driven roller.

- **Rolling Mills:**

Rolling mills consist of set-up that rotates the roller and helps in initiating and completing the rolling process. It consists of one or more roller stands, reducing gear, the main drive motor, stand pinion, flywheel, and coupling gear between the units. These components equipped together to help in the completion of the rolling process. Rolling mills are classified based on the number and arrangement of rolls in a stand. Theare commonly six types of Rolling mills that are used, they are as follows:

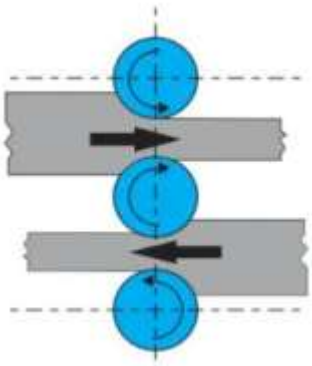
- **Two-High Rolling Mill:**

It Consists of two High stands, and two rolls placed exactly one over the Other. In this type of rolling mill, the rollers rotate in opposite direction and their direction changes after each Metal pass. The metal (ingot) is passed continuously and approximately 25-30 passes are required to convert ingot to bloom.



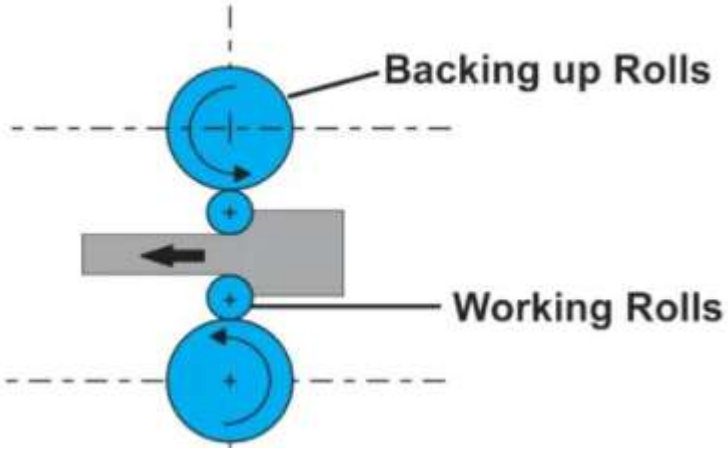
- **Three-High Rolling Mill:**

It consists of three high stands and three Rollers present in the same vertical plan e. The Top and bottom roller rotate in the same direction, and the middle roller r otates in the Opposite Direction. In this type of Rolling mill, the Direction of the d rive is not changed after each pass. It is more Productive and easier with respect to the two-High Rolling Mill.



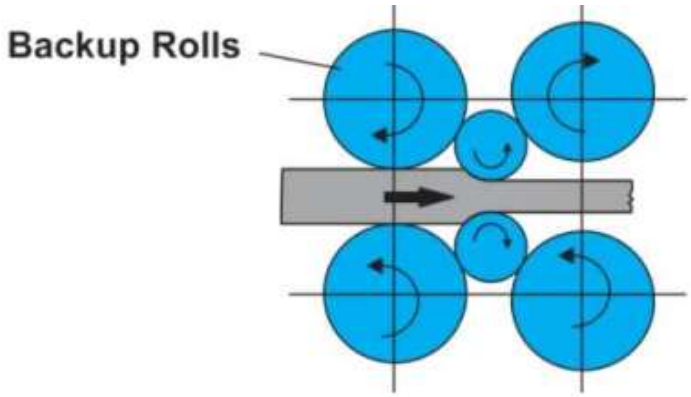
- **Four-High Rolling Mill:**

It Consists of two backup rollers and two Working rollers, arranged One over the Other in the same Vertical Plane. The Diameter of Backup rollers is always greate r than the Working rollers. This type of rollers is mainly used in Sheet Rolling. The Two Working Rollers of small diameters are used to reduce the power demands, but it increases the chance of bending of working rollers, and as a result, non-Uni form compression of sheets. This is the reason we use Backup rollers for reducing the bending of Working rollers.



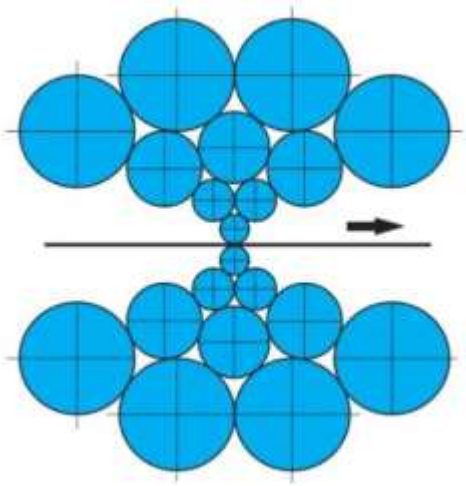
- **Cluster Mill:**

  It consists of Two Working rollers and two or more backup rollers. The number of Backup rollers depends upon the amount of support required for working. It is mostly used in Cold rolling Operations.



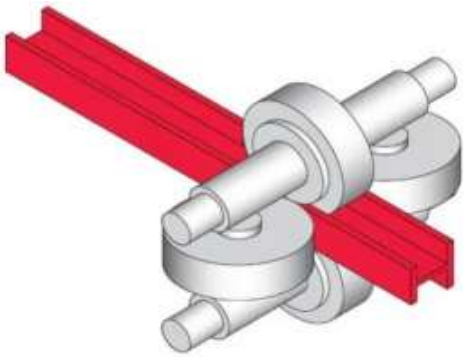
- **Multi-High Roll Mill:**

  It consists of two small diameters of working rollers and an intermediate row of driving rolls, and a row of Backup rollers. The arrangement is made in such a way that the whole system achieves exceptional rigidity. Multi-High Rolling mills are used for making a sheet of minimal thickness.



Universal Rolling Mill:

It consists of two vertical rollers and two Horizontal rollers. The Vertical rollers ar e arranged between the bearing of horizontal rollers in the vertical plane. It is wi dely used to produce blooms from Ingot, and for rolling wide flange H-Section be ams.



Points to Remember

- While selecting tools materials, and equipment to be used in rolling operation you must consider mainly on: Functionality, life span, ease use, cost.

Practical Activity 1.3.2: Selecting cutting tool, material and equipment for rolling operation

Task:

1: Referring to the previous activity 1.3.1, you are requested to go in manufacturing workshop for selecting tools, materials and equipment as required for producing 20 chimneys in construction of GS TSS kitchens.
2: based on trainer's demonstration, select and wear appropriate PPE related to the task.
3: Select tools, materials and equipment according to the trainer's demonstration.
5: Present your work to the trainer and your classmates.
6: Read the key reading 1.3.1. and 1.3.2
7: Perform the task provided in application of learning 1.3:

Key readings 1.2.2.: Practical Activity 1.3.2: Selecting cutting tool, material and equipment for rolling operation

- **Selection criteria to consider while selecting tools used in rolling operations**

  - ✓ Material compatibility
  - ✓ Tool geometry
  - ✓ Operational Specifications
  - ✓ Tool material
  - ✓ Machine compatibility
  - ✓ Cost and economic factors
  - ✓ Performance Characteristics
  - ✓ Manufacturer reputation
  - ✓ Environmental considerations

- **Selection criteria to consider while selecting materials to be rolled**

  - ✓ Material type
  - ✓ Mechanical properties
  - ✓ Thickness and size
  - ✓ Thermal properties
  - ✓ Microstructure
  - ✓ Surface condition
  - ✓ Formability
  - ✓ Cost and availability
  - ✓ End-use requirements
  - ✓ Regulatory and environmental considerations

- **Important factors to consider when selecting rolling equipment:**

- ✓ Type of rolling process
- ✓ Material compatibility
- ✓ Capacity and size
- ✓ Design of rolls
- ✓ Operational speed
- ✓ Automation and control systems
- ✓ Energy efficiency
- ✓ Maintenance requirements
- ✓ Manufacturer reputation and support
- ✓ Cost of equipment

Points to Remember

- While describing types of materials used rolling ng operation you must consider focus mainly on: Ferrous and Nonferrous
- While selecting tools materials, and equipment to be used in rolling operation, you should consider their functionality, life span, ease use, and cost.

Application of learning 1.3. Selection of materials, tools

Suppose that your school has organised a study visit to one of the manufacturing workshops located in your home district. The workshop wishes to produce metallic doors and windows. By referring to the key readings 1.3.1, You are asked to accomplish the following tasks:

i. Select tools
ii. Select materials
iii. Select equipment

Indicative content 1.4: Identification of Rolling Process

Duration: 1 hr

Theoretical Activity 1.4.1: I Description of rolling process.

Tasks:

1: You are requested to provide answers to the following question:
Describe the rolling processes?
2. Write your findings/answers on paper, flipchart, blackboard or whiteboard.

3. Present your findings/answers to the trainer and/or the whole class.

4. Pay attention to the trainer's clarification and ask questions where necessary.

5: For more clarification, read the key readings 1.4.1.

Key readings 1.4.1.: Identification of rolling process

- **Steps of rolling process:**

Step1: Material preparation:

- In this step, raw materials, typically in the form of metal billets or blooms, are prep ared.
- These materials may be heated to a suitable temperature to make them more mall eable for the rolling process.

Step2: Rolling mill setup:

- Rolling mills are set up with the required rolls, guides, and other components to sh ape the material.
- The rolls can be flat or shaped to create specific profiles, depending on the desired product.

Step3: Passing through rolls:

- The prepared material is fed into the rolling mill.
- The rolls exert pressure on the material to reduce its thickness or change its shape.
- The material passes through a series of rolling stands, which progressively reduce it s thickness.

Step4: Reduction in thickness:

- The primary purpose of rolling is to reduce the thickness of the material.
- This is achieved through repeated passes between the rolls, with each pass causing a slight reduction in thickness.

- The degree of thickness reduction is controlled by the roll gap and roll speed.

Step5: Cooling and lubrication:

- To prevent overheating and maintain the material's properties, cooling and lubricat ion systems are often used.
- Water or other coolants are applied to the material during the rolling process to dis sipate heat, and lubricants are used to reduce friction between the rolls and the ma terial.

Step6: Shape and dimensional changes:

- Rolling can also be used to change the shape and dimensions of the material.
- Depending on the roll design and setup, the material may undergo various shaping and dimensional changes, including width reduction, thickness reduction, and the c reation of specific profiles.

Step7: Final inspection:

- After the material has been rolled to the desired thickness and shape, it undergoes a final inspection to ensure that it meets the specified quality and dimensional req uirements.
- This step may involve measurements, visual inspection, and non-destructive testin g.

Step8: Coiling or cutting:

- Once the material has been rolled to the desired specifications, it is either coiled in to rolls (e.g., for steel strips) or cut into specific lengths (e.g., for steel sheets or bar s).
- The choice between coiling and cutting depends on the final product's intended us e.

Points to Remember

- While describing rolling process you must consider the following elements: Material preparation, rolling mill setup, passing through rolls, reduction in thickness, cooling and lubrication, shape and dimensional changes, final inspection, coiling or cutting.

Indicative content 1.5: Identification of Rolling Defects

Duration: 1 hr

Theoretical Activity 1.5.1: Identification of rolling defects

Tasks:

1: You are requested to provide answers to the following questions:

i. What do you understand about “defect” in rolling operation?
ii. State the types of rolling defect
iii. Explain the causes and prevention of rolling defect

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard

3. Present your findings/answers to the trainer and/or the whole class

4. Pay attention to the trainer’s clarification and ask questions where necessary

5: For more clarification, read the key readings 1.5.1.

Key readings 1.5.1.: Description rolling defects

- **Types rolling defects**

Several defects are arising in the rolling process. These defects are as follows:

✓ **Edge Cracking:**

This Occurs due to limited ductility of the material, or uneven deformation, mainly at the edges. This type of deformation Occurs mostly in Ingots, plates, or slabs.

Edge cracking is a common defect that occurs during various manufacturing proces ses, including metal forming, rolling, and heat treatment. It is essential to understa nd the causes of edge cracking in order to implement effective remedies. Here are some common causes and remedies for edge cracking:

- **Causes of Edge Cracking:**

  Material Properties:

  High Hardness: Materials with high hardness are more prone to edge cracking. This is especially true for brittle materials.

  Process Parameters:

  Rolling Parameters: Inappropriate rolling parameters such as excessive rolling speed, improper roll gap, or incorrect rolling temperature can contribute to edge cracking.

  Insufficient Lubrication: Inadequate lubrication between the rolls and the material can lead to increased friction and heat, resulting in edge cracking.

  Material Defects:

  Inclusions: The presence of non-metallic inclusions in the material can act as stress concentrators, promoting edge cracking.

  Design Factors:

  Inadequate Edge Radii: Sharp edges on the material can act as stress concentrators, making the material more susceptible to cracking.

- **Remedies for Edge Cracking:**

  Material Selection:

  Choose materials with suitable properties for the intended application, considering factors like hardness and toughness.

  Optimize Process Parameters:

  Adjust rolling parameters such as speed, temperature, and roll gap to values that minimize stress concentrations and reduce the likelihood of edge cracking.

  Ensure proper cooling and lubrication during the rolling process.

  Surface Treatment:

  Apply surface treatments to enhance the material's resistance to cracking. This may include shot peening, case hardening, or other relevant processes.

  Proper Edge Radii:

  Design the product with appropriate edge radii to reduce stress concentrations at the edges.

Quality Control:

Implement stringent quality control measures to detect and remove materials with defects like inclusions before they enter the manufacturing process.

Heat Treatment:

Employ appropriate heat treatment processes to improve the material's toughness and reduce its susceptibility to cracking.

Process Monitoring:

Implement real-time process monitoring systems to detect deviations from optimal conditions, allowing for immediate corrective actions.

Roll Maintenance:

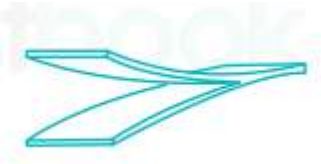
Regularly inspect and maintain rolling equipment to ensure that it is in good workin g condition. Worn or damaged rolls can contribute to edge cracking.

Material Handling:

Handle materials with care during various stages of manufacturing to prevent surfa ce damage that could lead to edge cracking.

- ✓ **Alligatoring:**

In this type of defect, the Metal tears down into 2 Pieces in the Horizontal Plane. It mainly Occurred with slabs and occurs when slab thickness to the length of Contact falls
between 1.4 to 1.65.



Alligatoring, also known as alligator cracking or crocodile cracking, is a defect that appears as a pattern of interconnected cracks on the surface of a material, often resembling the scales of an alligator or crocodile. This defect is commonly observed in materials such as asphalt, concrete, and certain types of coatings. Here are some common causes and remedies for alligatoring:

- **Causes of alligatoring:**

Fatigue loading:

Repeated traffic loads or cyclic loading can lead to fatigue failure, resulting in the development of alligator cracks over time.

Aging and weathering:

Exposure to environmental factors such as sunlight, rain, and freeze-thaw cycles can contribute to the aging and deterioration of materials, causing the development of cracks.

Inadequate pavement design:

Poor design or inadequate structural support for the pavement can result in excessive stress, leading to the formation of alligator cracks.

Insufficient thickness:

Pavements or coatings that are too thin may not withstand the applied loads, leading to cracking.

Poor quality materials:

Low-quality materials or improper mix designs in the case of asphalt or concrete can result in reduced durability and increased susceptibility to cracking.

Improper Installation:

Incorrect installation practices, such as inadequate compaction or improper curing, can contribute to the development of alligator cracks.

- **Remedies for alligatoring:**

Overlay or Resurfacing:

Applying an overlay or resurfacing the affected area with a new layer of material can provide additional support and improve the structural integrity of the surface.

Structural Rehabilitation:

Implementing structural rehabilitation measures, such as strengthening the pavement base or subgrade, can address underlying issues contributing to alligatoring.

Crack Sealing:

Performing crack sealing by filling the cracks with suitable materials can help prevent water infiltration and further deterioration.

Proper Maintenance:

Regularly inspect and maintain pavements or surfaces to address minor cracks before

they escalate into extensive alligatoring.

Improved Drainage:

Enhancing drainage systems to prevent the accumulation of water can reduce the impact of environmental factors on the material.

Corrective Action Based on Severity:

Depending on the severity of the alligatoring, the appropriate corrective action may range from localized repairs to complete reconstruction.

Use of High-Quality Materials:

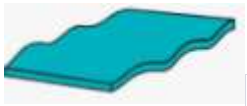
Ensure the use of high-quality materials with suitable mix designs to improve the durability and longevity of the pavement or coating.

Proper Construction Practices:

Follow best practices during the construction phase, including proper compaction, curing, and thickness design.

- ✓ **Wavy edge** "

is a type of defect that can occur during the metal rolling process. It is also known as " wave crack " or "wavy edge defect." This defect is typically associated with the edges of the rolled metal material, such as sheets or strips.



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A wavy edge, also known as waviness or edge distortion, is a rolling defect characterized by irregularities or deformations along the edges of a rolled material. This defect can be caused by various factors related to the rolling process. Here are some common causes and remedies for wavy edge defects:

- **Causes of Wavy Edge:**

Uneven Roll Pressure:

Inconsistent or uneven pressure applied by the rolls during the rolling process can result in material deformation and the formation of a wavy edge.

Uneven Material Thickness:

Variations in material thickness across the width of the sheet or strip can lead to uneven deformation and the development of a wavy edge.

Misalignment of Rolls: Incorrect alignment of the rolls can cause uneven

deformation, leading to wavy edges.

Uneven Temperature Distribution:

Inconsistent temperature distribution across the width of the material can result in uneven deformation during rolling.

Roll Deflections:

Excessive deflections or deformations in the rolls themselves can contribute to uneven pressure distribution and wavy edge formation.

Inadequate Lubrication:

Poor lubrication between the material and rolls can increase friction and uneven deformation, leading to wavy edges.

Material Properties:

Variations in material properties, such as hardness or composition, can contribute to uneven deformation during rolling.

- **Remedies for Wavy Edge:**

Optimize Roll Pressure:

Ensure that the rolls apply consistent and evenly distributed pressure across the width of the material.

Check Roll Alignment:

Regularly inspect and adjust the alignment of rolls to prevent uneven deformation.

Monitor and Control Material Thickness:

Implement controls to ensure uniform material thickness across the width of the material being rolled.

Maintain Proper Temperature:

Control and maintain uniform temperature distribution across the material to prevent uneven deformation.

Minimize Roll Deflections:

Inspect rolls for wear and damage and replace or repair any rolls with excessive deflections.

Improve Lubrication:

Ensure effective and consistent lubrication between the rolls and the material to

reduce friction and promote even deformation.

Use Homogeneous Materials:

Select materials with consistent properties to minimize variations that can contribute to wavy edge defects.

Implement Roll Profile Monitoring:

Utilize advanced monitoring systems to track and control the profile of the rolls during the rolling process.

Roll Maintenance:

Regularly inspect and maintain rolls to ensure they are in good condition and free from defects that could contribute to wavy edges.

Process Control and Automation:

Implement process control systems and automation to maintain optimal rolling parameters and minimize variations that lead to wavy edges

Points to Remember

- While describing rolling defects, you should consider edge cracking, alligator, and wavy edge**.**

Learning outcome 1 end assessment

Written assessment

Question 1. Define the following terms:

a) Rolling process

b) Sheet

C) A lubricant

Question 2. Where rolling operation is applicable? (at least six).

Question 3. State at least five advantages of rolling operation.

Question 4. Differentiate ferrous metals and non- ferrous metals and state two examples for each**.**

Question 5. What is the principal aims of rolling operation ¬?

Question 6. Choose the letter corresponding to the right answer. Measuring instrument are

a) Tape measure, Steel rule, Square, Protractor., Vernier caliper.

b) Tape measure, chisel, Square, Vernier caliper, Protractor.

c) Vernier caliper, Tape measure, Steel rule, Square, Scriber.

d) a, b and c are measuring instrument.

Question 7. Read the following statement and answer by True if the statement is correct or False if it is wrong:

Surface defects, such as scale and cracks, are common rolling defects.

Question 8. Match the stimuli of column A with their corresponding response in column B in the provided place for column of response using the letter corresponding to the correct answer

Column A	**Column B**
1. Primary function of a rolling mill in the rolling operation	a. Material Properties
2.Is crucial in determining the success of a rolling operation	b. Heat Treatment (Annealing)
3.Metalworking process that uses a rolling mill to reduce thickness and change shape	c. Rolling Mill
4.used to remove internal stresses and improve the material's ductility	d. Rolling
	e. Drawing

Practical assessment

DUFATANYE company located in Nyamasheke District needs to replace the damaged gutter which is fixed on their store house. The manager of the company wants to hire a technician to roll another gutter made in mild steel sheet metal with the following dimensions 1.5mm thick, the width of 18mm, front side of 18mm, length of 4m and the back side of 14mm respectively. You are asked to perform the following tasks for making that gutter in 4 hours:

a) Apply safety rules and regulations
b) Select materials, tools and equipment

all resources are available DUFATANYE store.

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END

Indicative contents
2.1 Interpretation of drawing
2.2 Setting up rolling machine
2.3 Application of rolling operations
2.4 Checking rolled products

Key Competencies for Learning Outcome 2: Carry out Rolling Operation

Knowledge	Skills	Attitudes
• Description of cutting • list elements • Description of procedures for setting up the rolling machine • Identification of criteria for checking rolled product	• Interpreting drawing • Setting up machine • Mounting work piece • Performing rolling operation • Checking the rolled • Product	• Being able to identify and troubleshoot issues related to rolling operations • Having a deep understanding of rolling principles and techniques

Duration: 15 hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly elements of cutting list used on Interpretation of drawing
2. Interpret correctly the drawing according to the work specifications
3. Set correctly rolling machine according to the distance between rollers to be used.
4. Set properly rolling machine according to Guides, meters and stops required
5. Set properly rolling machine according to the speed of roller required
6. Differentiate correctly rolling operations according to their application
7. Perform properly rolling operation according to the shape and application required.
8. Checking out clearly of rolled products on rolling operation

Resources

Equipment	Tools	Materials
• PPEs • Fire extinguishers • First aid kit • Bench • Anvil • Shear machine • Cut-off machine • Material handling equipment • Bending machine • Rolling machine	• Micrometre • Taper Measure • Callipers • Ruler • Gauges • Shears • Cut-off saws • Plasma Cutter • Marking pens and pencils • Scribers • Stencils and templates	• Metals. • Oil • Grease

• Air compressor	• Wire brushes • Abrasive pad • Rulers • Files • Reamers • Hammers • Screwdriver • Pliers • Spanners • Cloths rags • Wire brushes • Spray gun	

Indicative content 2.1: Interpretation of Drawing

Duration: 2 hrs

Theoretical Activity 2.1.1: Description of cutting list elements

Tasks:

1: You are requested to provide answers to the following questions:

i. What do you understand about "cutting list"

ii. State the elements of the cutting list

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard

3. Present your findings/answers to the trainer and/or the whole class

4. Pay attention to the trainer's clarification and ask questions where necessary

5: For more clarification, read the key readings 2.1.1.

Key readings 2.1.1.: Description of cutting list elements

- **Definition of cutting list**

  A cutting list, also known as a cut list or materials list, is a document used in construction, woodworking, and manufacturing to specify the dimensions and quantities of materials that need to be cut, shaped, or fabricated for a project

- **Elements of cutting list**

✓ **Serial Number:**

- A unique serial number assigned to each part or component in the cutting list. This number serves as an identifier for easy reference and tracking.
- Including serial numbers in a cutting list can be particularly useful in projects where there are numerous components, variations, or the need for precise inventory management.
- Each serial number corresponds to a specific item, allowing for easy cross-referencing with other project documents, such as assembly instructions, drawings, and inventory records.
- It helps streamline the manufacturing or construction process and reduces the likelihood of errors or confusion when managing many parts

- ✓ **Material:**
  - A description of the type of material required, including its specifications, such as type of wood, metal, or other materials
- ✓ **Specifications**
  - They are detailed descriptions of the requirements and characteristics of a product, system, or project.
  - They serve as a set of standards and guidelines that outline what needs to be accomplished, the quality standards to be met, and any other relevant details.

Key elements typically found in specifications:

- **Title:** The title of the specification document, which provides an overview of its purpose and scope.
- **Scope:** A clear and concise description of what the specification covers. It defines the boundaries of the project or product and what is excluded.
- **Objective:** The purpose or goal of the project or product, which helps stakeholders understand the intended outcome.
- **Applicable Standards:** References to industry standards, regulations, or codes that the project or product must adhere to. This ensures compliance with established guidelines.
- **Materials and Components:** Detailed information about the materials, components, or software elements that will be used, including their specifications, properties, and sources.
- **Technical Requirements:** Specific technical details, including dimensions, tolerances, performance criteria, and any other relevant data.
- **Quality Standards:** Requirements related to the quality of the product, such as acceptable levels of defects, tolerances, and performance benchmarks.
- **Design and Layout:** Information about the design, layout, and arrangement of components or elements in the project or product.
- **Testing and Inspection:** Procedures and criteria for testing and inspecting the product or project to ensure it meets the specified requirements.
- **Safety and Regulatory Compliance:** Safety guidelines and regulatory requirements that must be adhered to, along with any necessary certifications or approvals.

- **Environmental Considerations:** Information about how the project or product affects the environment and any necessary environmental compliance measures.

✓ **Units**

- In the context of a cutting list or materials list, the term "unit" typically refers to the quantity of a specific item or part that needs to be cut or fabricated for a project.
- It specifies how many identical pieces of a particular component are required.

For example, if you are creating a cutting list for constructing a set of wooden chairs, one of the elements in the list might be:

Chair Backrest:

- Material: Wood
- Dimensions: 18" x 24" x 1"
- Quantity: 6 units

In this case, "6 units" means that you need to cut six identical chair backrests from wood, and each one should have the specified dimensions.

- The term "unit" simply denotes that these are individual, identical components that make up the overall project.
- The "unit" can be any relevant quantity, depending on the project's requirements.
- It might refer to single pieces, pairs, sets, or any other quantity that accurately reflects the project's design and specifications

✓ **Quantity**

- In the context of a cutting list, the term "quantity" refers to the number of identical components or parts needed for a particular project.
- It specifies how many pieces of a specific item are required for construction, fabrication, or assembly

Points to Remember

- While interpreting a drawing, take into consideration cutting list elements mainly material and specification.

Indicative content 2.2: Setting up Rolling Machine

Duration: 3 hrs

Theoretical Activity 2.2.1: Description of setting up rolling machines

Tasks:

1: You are requested to answer the following questions:

i. What do you think about distance between rollers?
ii. Differentiate guide and meter.
iii. How can the speed of rolling machine be controlled?

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard

3. Present your findings/answers to the trainer and/or the whole class

4. Pay attention to the trainer's clarification and ask questions where necessary

5: For more clarification, read the key readings 2.2.1.

Key readings 2.2.1. Setting up rolling machines

- **Setting distance between rollers**

  Distance between rollers is a critical parameter in various rolling operations, whe re materials are passed through a set of rollers to be shaped, reduced in thicknes s, or processed in some way. The distance between rollers, also known as the roll gap, is a fundamental factor that influences the outcome of the rolling process.

- **Description of guides, meters and stop**

  Metal rolling machines, especially in industrial settings like rolling mills, guides, m eters, and stops are essential components used to ensure precise and consistent metal rolling.

  These elements help control the thickness, width, and shape of the rolled metal p roducts. Here's a brief overview of each:

✓ **Guides:**

- Guides in a metal rolling machine are devices or components that help direct and control the position and alignment of the metal as it passes through the rolling p rocess.

- They ensure that the metal stays on the desired path and doesn't deviate from th e correct alignment.
- Guides are often adjustable to accommodate various sizes and shapes of metal p roducts.

✓ **Meters (or Measuring Systems):**

- Meters or measuring systems in a metal rolling machine are used to monitor and measure key parameters during the rolling process.
- Common measurements include thickness, width, and sometimes length. These measurements are crucial to ensuring that the final product meets the desired sp ecifications.
- Advanced rolling machines may have automated measuring systems that provide real-time feedback to control the rolling process more precisely.

Guide on how to set the distance in meters on a rolling machine:

- **Consult the Manual:**
  Refer to the manufacturer's manual for the rolling machine. The manual should provide specific instructions on how to set the roller distance and may indicate whether the measurement is in millimeters or inches.
- **Understand Material Requirements:**
  Consider the type and thickness of the material you are rolling. Different materials
  may require different roller settings. Check the material specifications and any guidelines provided by the manufacturer**.**
- **Locate Adjustment Controls:**
  Identify the controls or mechanisms on the rolling machine that allow you to adjust the distance between rollers. These may be manual adjustments or controlled electronically depending on the machine type.
- **Use Measurement Tools:**
  Utilize measurement tools, such as calipers or a thickness gauge, to accurately set the distance between the rollers. Measure the initial thickness of the material and determine the desired final thickness.
- **Adjust Gradually:**
  Make gradual adjustments to the roller distance. It's often recommended to make small changes and test the results with scrap material before proceeding to full production.
- **Perform Test Runs:**
  Run test pieces through the rolling machine to check if the thickness meets the desired specifications. Adjust the distance as needed and repeat the test runs until the correct thickness is achieved.

- **Secure the Setting:**
  Once you have achieved the desired roller distance, secure the settings to prevent unintentional changes during regular operation. Follow the locking procedures outlined in the manual

✓ **Stops:**

- Stops in a metal rolling machine are physical barriers or devices that limit the mo vement of the metal as it passes through the rolls.
- They are used to control the length of the metal product being rolled. By setting t he position of the stops, you can control the final length of the rolled product.
- Stops are particularly important in ensuring consistent dimensions and preventin g over-rolling or under-rolling of the material.

- **Set the speed of rollers**

- Roller speed plays a major role in determining the quality of the rolled product. There are several works done to find the effect of the rolling speed on other parameters of rolling.
- Strain rate, flow stress, heat of deformation, roll force and coefficient of heat transfer are all controlled by rolling speed directly.
- Therefore, rolling speed can be considered as one of the important parameters for rolling. Strain rate is another parameter which plays a vital role in deciding the quality of roll. The strain rate can be interrelated to the speed of the roller. It can be suggested that the strain distribution is more homogeneous at high-speed rolling.
- Gearboxes are multiple open gear sets contained in a housing. The housing supports bearings and shafts, holds in lubricants and protects the components from surrounding conditions.
- Industrial gearboxes are machines primarily driven by a drive unit, reducing or increasing the speed and torque of the drive unit as per requirement. The aim of a gearbox is to increase or reduce speed.

General guide on considerations and adjustments for roller speed:

- **Refer to the Manual:**
  Consult the manufacturer's manual for your specific rolling machine. The manual often provides guidelines on recommended roller speeds based on the type of material and the rolling process.

- **Understand Material Properties:**
  Different materials have distinct properties that influence the optimal rolling speed. Consider the hardness, ductility, and other characteristics of the metal being processed.

- **Consider Material Thickness:**
  Thicker materials may require slower roller speeds to ensure proper reduction in thickness without causing material defects. Thinner materials might be processed at higher speeds.
- **Trial and Error:**

  Conduct trial runs with scrap material to find the optimal roller speed. Start with a moderate speed and adjust it incrementally until you achieve the desired results.
- **Temperature Considerations:**
  In some rolling processes, the material may be sensitive to temperature. Consider the effect of roller speed on material temperature, especially in processes where friction generates heat.
- **Uniformity of the Process:**
  Maintain a consistent and uniform speed throughout the rolling process. Variations in speed can result in uneven thickness or surface defects.
- **Safety Considerations:**
  Ensure that the chosen roller speed is within the safe operating limits of the machine. Excessive speeds can lead to safety hazards and equipment damage.
- **Real-Time Monitoring:**

  Some modern rolling machines may have features for real-time monitoring of the rolling process, allowing operators to adjust roller speed as needed during operation.
- **Document Settings:**
  Once you determine the optimal roller speed for a specific material and process, document these settings for future reference. This documentation helps maintain consistency in subsequent production runs

Practical Activity 2.2.2: Setting up rolling machine

Task:

1: You are requested to go in manufacturing workshop to set up rolling machine for producing kitchen chimney to be used in construction of kitchen of GS TSS.
2: Present your work to the trainer and the whole class.
3: Read the key reading 2.2.1 and ask for clarification where necessary.

4.: Perform the task provided in application of learning 2.2

Key readings 2.2.2: Setting up a rolling machine

- **Elements to consider while setting up a rolling machine**

✓ **Preparation and Safety Checks**

- **Read the Manual**: Review the machine's operating manual and understand its features, limitations, and specific setup requirements.
- **Wear Safety equipment**: Ensure all operators and personnel wear appropriate personal protective equipment (PPE), including safety glasses, gloves, and hearing protection.
- **Inspect the Machine**: Conduct a pre-operation inspection of the rolling machine to check for any visible damage or wear. Ensure that all safety guards are in place and functioning.
- **Verify Power Supply**: Confirm that the machine is correctly connected to the power supply and that the voltage and current specifications match the machine's requirements.

✓ **Setup and Calibration**

- **Clean the Machine**: Remove any debris, dust, or leftover material from previous operations to ensure a clean working area.
- **Load the Rollers**: Depending on the machine type, load the rollers or dies. Ensure they are correctly aligned and securely fastened.

✓ **Adjust Roller Settings**:

- **Roller Gap**: Set the gap between the rollers according to the material thickness and type. This is crucial for achieving the desired thickness and preventing material damage.
- **Roller Speed**: Adjust the speed settings based on the material and required production rate.
- **Align the Material**: Place the material (such as metal strips or sheets) on the rolling machine and ensure it is properly aligned with the rollers to avoid uneven rolling.
- **Set Up Guides and Supports**: Install and adjust any necessary guides, supports, or side rollers to help control and stabilize the material during the rolling process.

✓ **Testing and Calibration**

- **Run a Test Pass**: Perform a test pass with a sample piece of material to

check the machine's setup. Observe the results and make necessary adjustments to the roller gap and speed.

- **Measure the Output**: Measure the thickness and quality of the test pass output. Compare it with the desired specifications and make any necessary adjustments.
- **Check for Defects**: Inspect the test material for any defects or irregularities. Ensure that the material is rolling evenly and that there are no issues with the machine's alignment or settings.

✓ **Final Adjustments and Test**

- **Fine-Tune Settings**: Make final adjustments based on the test results. Ensure that all settings are optimized for the specific material and production requirements.
- **Secure and Lock Settings**: Once adjustments are complete, secure and lock all settings to prevent any changes during operation.

Points to Remember

- While setting up a rolling machine you should consider the following steps: read the manual, choose the right rolling machine, select the proper dies and rollers, inspect the machine, prepare the material, adjust the machine settings, install the material, test run and adjust.
- While setting up the speed of the roller of rolling machine, you should mainly read the manual, check the safety do calibration, and make the final adjustments.

Application of learning 2.2.

Suppose that you are tasked by one of the manufacturing workshops located in your district to make 20 cylindrical tanks within specification of 2m of diameter ,3m of length and 3mm of sheet metal thickness. You are requested to perform the following tasks:

i. Set the distance between rollers
ii. Set guides, meters and stops
iii. Set the speed of rollers
iv. Check working of rolling machine

Indicative content 2.3: Application of Rolling Operation

Duration: 8 hrs

Practical Activity 2.3.1: Performing Rolling Operation

Task:

1: You are requested to go in manufacturing workshop to perform rolling operations

2: Present your work to the trainer and the whole class.

3: Read the key reading 2.3.1 and ask for clarification where necessary.

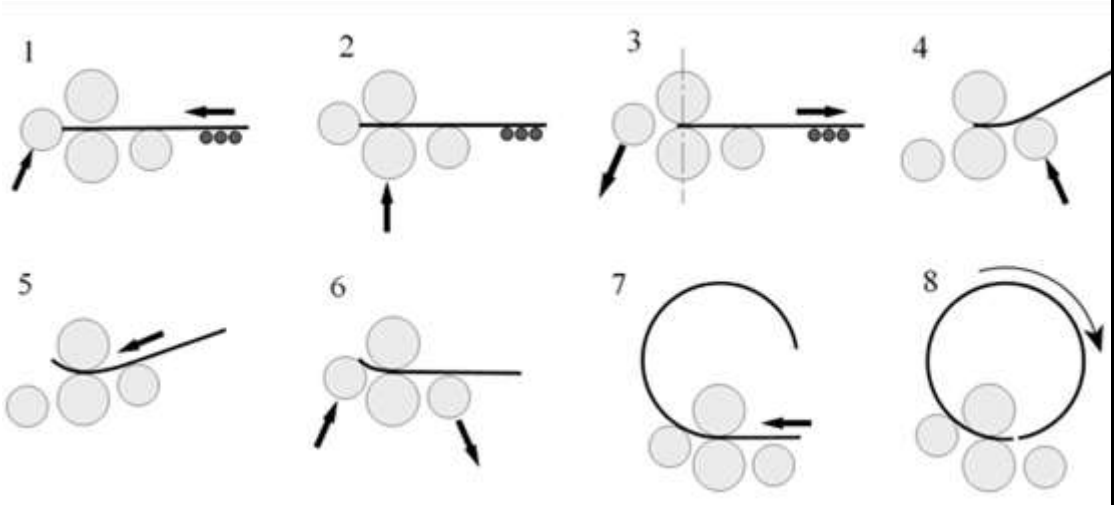
4.: Perform the task provided in application of learning 2.3

Key readings 2.3.1.: Description of rolling operation

- **Definition of metal rolling**

  It is a metal forming process in which metal stock is passed through one or more pairs of rolls to reduce its thickness and to make the thickness uniform. The metal can also be elongated in the process. The most common rolling process is hot rolling, which is carried out at elevated temperatures. Cold rolling is the process conducted at or near room temperature.

- **Working Principle**



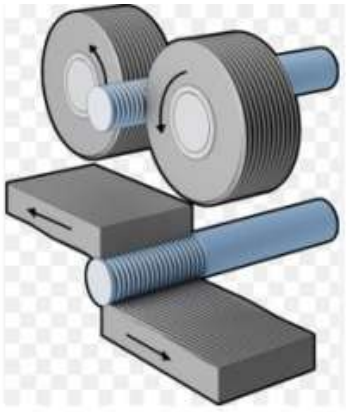
The upper roller position is fixed, and the lower roller linearly moves up to clamp the steel plate.

The rollers on either side of the line or the arc are moved up to the roll to adjust t he radius of curvature of the roll. The four-roller and the three-roller-roller have different roller movements, but the working principle is the same, and the three-point circular principle is used to perform the rolling of different radii. However, t he straight edge of the pre-rolling of the four-roller rolling machine and the roun dness of the calibration circle are better than those of the three rolls

- **Rolling operations**

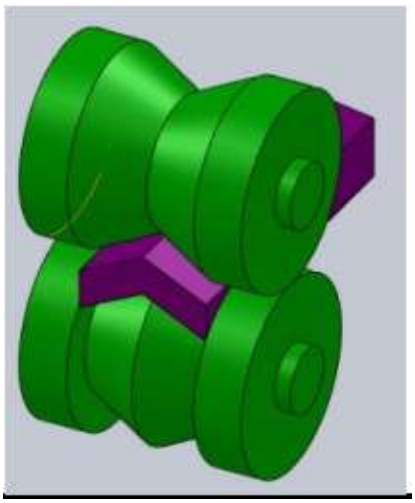
✓ **Thread and Gear Rolling:**

- Thread Rolling: A cold forming process where threads are formed on a workpiece by rolling it between two dies.
- Gear Rolling: The process of forming gear teeth on a blank by using two rotating d ies.



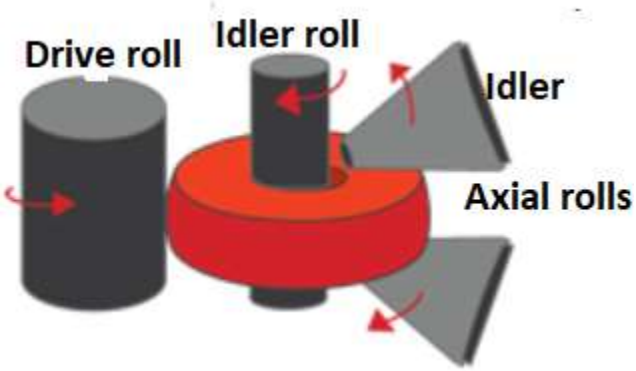
✓ **Shape Rolling:**

- In this process, flat metal stock is passed through a set of rolls to give it a desired shape.
- Common shapes produced include I-beams, H-beams, and various other profiles used in construction.



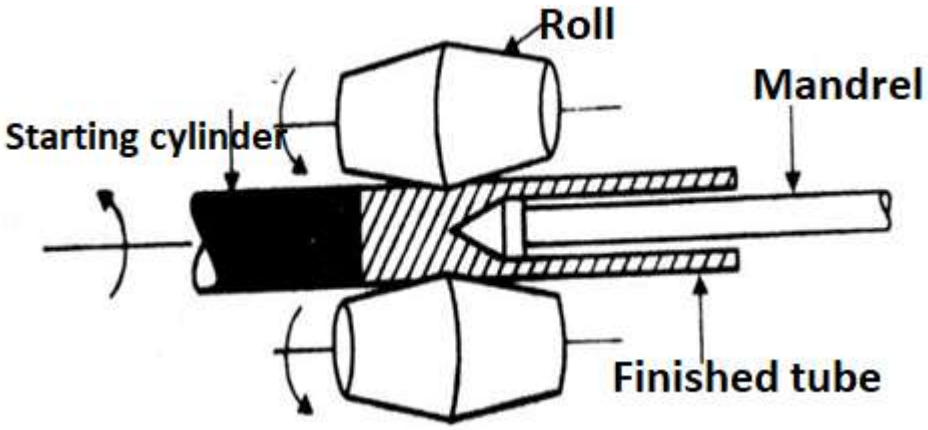
✓ **Ring Rolling:**

- A specialized form of hot rolling used to produce seamless rings.
- A thick-walled ring is gradually reduced in diameter and increased in height by usi ng radial and axial pressure.



✓ **Tube Piercing:**

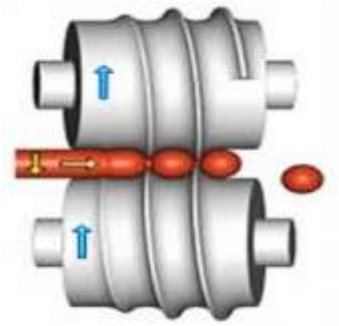
- Used in the production of seamless tubes.
- A red-hot billet is pierced through the center to create a hollow tube.



✓ **Skew Rolling:**

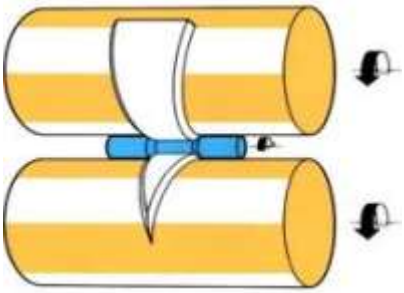
- Primarily used in the production of balls for bearings and grinding media.

- The round billet is rolled between two rotating rolls at an angle, resulting in a sph erical shape.



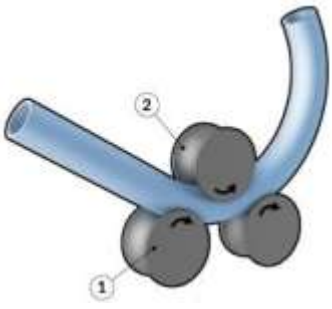
✓ **Transverse Rolling:**

- Metal is rolled between two rolls, and the direction of rolling is perpendicular to t he direction of the force applied.
- Used to produce long plates, sheets, and strips.



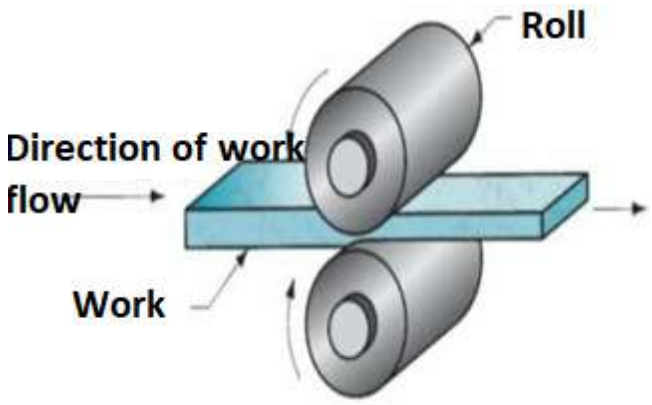
✓ **Roll Bending Process:**

- Also known as plate rolling, it involves bending a metal plate or sheet into a cylind rical shape.
- The plate is passed through a series of rolls to achieve the desired curvature
- This type of Rolling process is used to bend the metal passed through it. The rollers are ar ranged that, when the metal is passed through it, gets a curvature along the roller's directi on. The roll bending process is mainly used in bending tubes of chassis for the vehicle, w hich increases its aerodynamic efficiency.



✓ **Flat Rolling:**

- The most common type of rolling process.
- Metal is passed through a pair of flat parallel rolls to reduce thickness and increas e length.



✓ **Controlled Rolling:**

- A thermomechanical rolling process used to control the final properties of the me tal.
- Involves controlling the temperature, deformation, and cooling rate during rolling to achieve specific mechanical properties.

- **Work piece mounting**

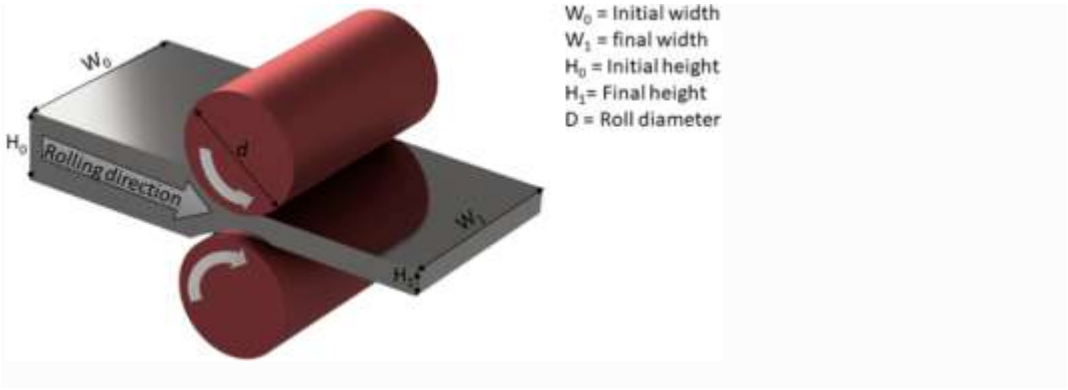
- In fact, most of the roll forming machine down rollers are fixed and for changing t he gap we adjust up roller by a connected screw on bearing housing. The most co mmon way is a feeler gauge to adjust roll forming machine the gap of up roller an d down roller engineering should change the gap when material thickness is chan ged.
- Likewise, workers should work and record bearing housing positions before movin g. This
- can help as a workbook for workers to have easier machine maintenance and roll er gap setup.
- Above all the final roller gap adjusting should be according to gears, bearing toler ance as well. For a higher roller gap will occur result in bigger radii of profile (not precise result) meanwhile sometimes material won't move forward through stand s by a bigger gap. meanwhile, once the roller gap is too tight machine will face se veral problems such as material marking, roller worn, and the final profile has wri nkle, twisting bow as well

At the Roll Former:

- Inspect the roller for damage and hazards.
- Place any necessary supports and align workpiece with infeed rolls.
- Adjust roll position for material thickness of workpiece such that it is a snug fit be tween the infeed rollers.
- Using a sample narrow strip of the same material and thickness as the final workp iece feed it into the rolls to ensure the proper infeed roll setting. Try this at severa l positions that will span the width of the final workpiece to ensure that the rolls

are parallel. For powered rollers, this step is to be done with the tool securely tur ned off.

- Once the infeed rolls are set, continue to manually feed the sample workpiece int o the rolls until it engages the forming roll in the engaged position.
- Continue to feed and adjust the forming roll (usually using hand crank) to determi ne the appropriate displacement setting for the desired final radius of the workpi ece. This step may require several attempts and samples until the settings are cor rect for the desired outcome.
- In the flat rolling process, two rollers called working rolls are fed with the materia l having a rectangular cross-section. The space between the working rollers is adj usted such that it is less than the thickness of the input material. When the work piece is fed into the rollers as shown in Fig. bellow the deformation of the materi al [50], as the reduction in thickness, happens due to the friction generated at th e interface of the material and the working rolls. Further, the material elongates evenly too; this is due to even stress distribution and a decrease in material thick ness.
- However, the amount of deformation possible due to the friction between the w orking rolls is limited, as sometimes the rolls slip over the material if the thicknes s changes very large.



- **Workpiece mounting**

  Rolling process in which the workpiece is fed between two rotating rollers so that the thickness of the workpiece gradually decreases and creates a rod as follow:

  Workpiece mounting procedures for hot rolling

- Before processing can begin, the workpiece is heated up so that it's easier to pro cess.
- The rolls are molded to form several gap between them, where the gap diamete r decreases across the axial direction of the roll.
- The cylindrical workpiece is fed between the rolls at the point where the gap bet

ween the rolls is greatest, because this point provides the largest possible diamet er.

- The workpiece is then fed through the remaining gaps in order to gradually reduc e its thickness until the desired thickness is achieved.

Workpiece mounting for cold rolling of sheets:

Rolling process in which a workpiece is pressed between rotating rollers to reduce its thickness without recrystallization of the material grain.

- The work piece, typically a sheet metal blank, is fed between rotating rollers with out preheating.
- The rolls compress the plate so that its thickness is reduced by up to 50%.
- Shape change is without recrystallization of the grains [3] which makes it a strong er material, while its surface becomes smoother. Because the grains do not recry stallize, material show anisotropic properties.

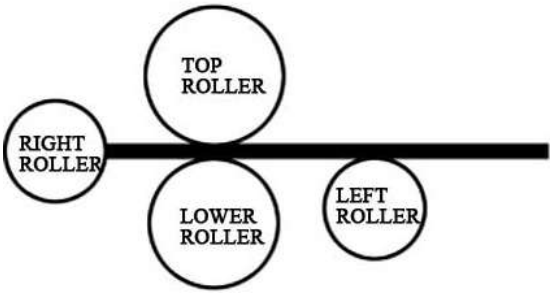
Align a workpiece in a section roller:

- Hold the workpiece sufficiently far back from the edge being fed into the rolls, to allow for the in-feed speed of the machine.
- Adjust the rollers at a slow even rate.
- Be aware of rotating rolls
- Only one person may operate this machine at any one time.
- Ensure the machine is left in a safe condition after use**.**

- **Steps of rolling process**

Step 1: Metal sheet cantering

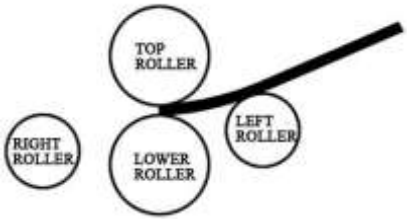
The purpose of plate cantering is to prevent the plate from slipping and deviation during the rolling process. Firstly, raise the left roller of the 4-roll steel plate rollin g machine along the track so that the centre line of the roller is within the openin g height of the upper roller and the lower roller, then raise the lower roller so tha t the distance between the generatrix and the generatrix under the upper roller is slightly larger than the working thickness, and then operate the right The side rol ler makes the upper busbar and the lower roller of 4-roll steel plate rolling machi ne on the same level, and the upper roller rotates to feed the steel plate so that t he end of the steel plate is in full contact with the left roller of 4-roll steel plate ro lling machine for alignment.



Step 2: Pre-bending beginning-sheet

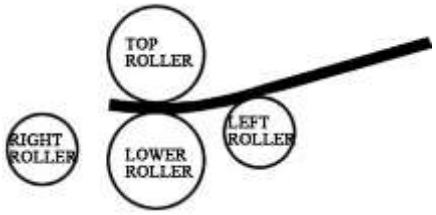
The upper and lower rollers of 4-roll steel plate rolling machine rotate forward to feed the material and continue rolling until the end of the plate reaches the verti cal center line of the upper and lower rollers. Currently, the position of the left ro ller rises by 10~20 mm to pre-bend the end of the plate.

Compared with the three-roll steel plate rolling machine the four-roll steel plate r olling machine can complete the pre-bending of the front and end of the plate wi thout using other equipment and molds and has a small remaining straight edge and high rolling efficiency and quality. After the plate alignment is completed, th e left roller returns to the initial position, the upper and lower rollers reverse and return to the vicinity of the axis of the upper and lower rollers, the right roller ris es to the pre-bending position, and then the upper and lower rollers feed forwar d for front-end pre-bending.



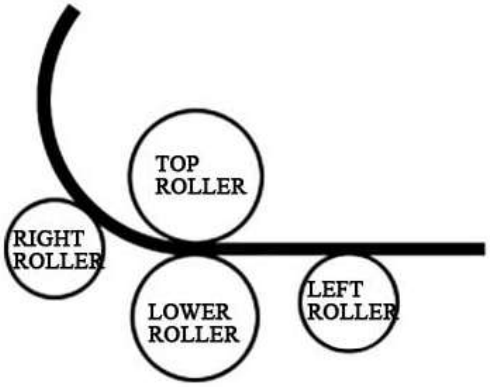
Step 3: Partially Rolled

After the pre-bending of the front section is completed, the right roller is lowered to a position 30~50 mm less than the pre-bending distance, and then partial rolli ng is performed to avoid discontinuity between the pre-bending section and the rolling section.



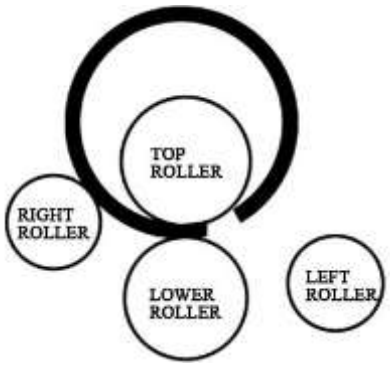
Step 4: Continuous rolling

After part of the rolling is completed, the right roller falls so that the height of its upper axis is slightly higher than the upper axis of the lower roller by 20 mm, and the left roller rises to the continuous rolling position (the left roller must overlap with the sheet in the forming arc section), Then the upper and lower rollers are f ed forward for continuous rolling.



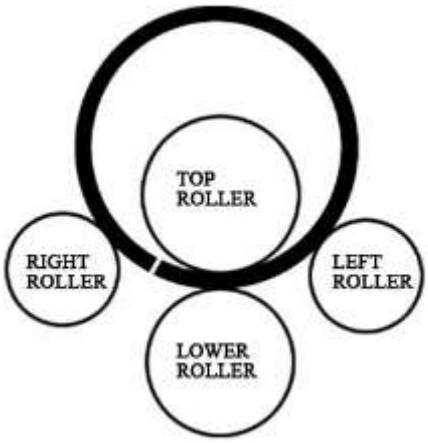
Step 5: Pre-bending end-sheet

The upper and lower rollers rotate forward to feed the material, and continue rol ling until the end of the plate reaches the vertical center line of the upper and lo wer rollers. At this time, the position of the left roller rises by 10~20 mm to pre-b end the end of the plate.



Step 6: Close the circle

The plate moves back to the position where it touches the edge of the right rolle r, then the right roller rises to the set value, the upper and lower rollers rotate in reverse to feed until the plate reaches the center of the left roller and stops, then the right roller rises to the set distance, back up to the vertical centerline of the r ight roll. According to the above steps, forward and reverse feeding, and constan tly adjust the feed displacement of the left roller and right roller until the plate ca n be closed.



Using plate rolling machine:

- Generally, the working efficiency and failure rate of mechanical equipment are cl osely related to the operators.
- As operators of plate rolling machines, they should know more about relevant kn owledge to effectively avoid some human errors or accidents.
- Let's learn about safety requirements and correct operation.

Safety regulations during rolling operation:

- The rolling machine must be managed by a specially assigned person.
- Operators must be familiar with the machine structure and performance.
- Start operation after the approval of the responsible management personnel.
- Before operation, check the safety devices carefully.
- There must be a special person to direct the multi person cooperative operation.
- Avoid the clothing corner involved in the roller during the operation.
- During operation, hands and feet are not allowed to enter between roller and tra nsmission parts.
- Pay attention to that the operator can only stand on both sides of the workpiece. This is the most reasonable and safe location.
- During work, don't stand on the finished products.
- It is also prohibited to stand on unprocessed workpieces.

- No overload work!
- A certain allowance must be reserved at the end of machining.
- After the work is interrupted, please put the clutch in neutral.
- Carry out the tilting, resetting, and balancing of the upper roll's lifting and overtu rning bearing after the main drive stops.
- Forbidden to pile up workpieces and sundries in the workplace.
- Keep the workshop clean and tidy all the time.
- At the end of the work, should cut off the power supply and lock the power box.

- **Procedures for performing rolling operation**

✓ **Safety Precautions:**

- Before starting any operation, ensure that you are wearing appropriate personal protective equipment (PPE) such as safety glasses, gloves, and any other required gear.
- Make sure the work area is clean and free of any potential hazards.

✓ **Setup:**

- Select the appropriate rolling machine based on the type of rolling operation needed (e.g., flat rolling, profile rolling, etc.).
- Ensure that the rolls are properly adjusted for the desired thickness or shape of the material.
- Set up any guides, supports, or fixtures needed to handle the material during the rolling process.

✓ **Material Preparation**:

- Ensure the material to be rolled is clean, free of defects, and of uniform thickness and width.
- Check that the material's dimensions are compatible with the rolling machine's capacity.

✓ **Loading the Material:**

- Place one end of the material between the rolls, ensuring it is properly aligned and positioned.
- Adjust the guides and supports as necessary to provide stability and prevent misalignment during rolling.

✓ **Perform the Rolling Operation**:

- Start the rolling machine according to the manufacturer's instructions.
- Gradually pass the material through the rolls, applying steady and even pressure.
- Monitor the rolling process to ensure that the material is being formed or shaped as desired.

✓ **Monitor Thickness and Dimensions:**

- Use measuring instruments like callipers or micrometres to periodically check the thickness and dimensions of the rolled material.
- Make adjustments to the rolling machine as needed to achieve the desired results.

✓ **Inspect and Adjust as Necessary:**

- Periodically stop the machine to inspect the rolled material for any defects, unevenness, or other issues.
- Make any necessary adjustments to the machine settings or material positioning.

✓ **Repeat as Needed:**

- If further passes through the rolls are required to achieve the desired outcome, repeat the rolling process as necessary.

✓ **Unload and Finish:**

- Once the rolling operation is complete, carefully remove the finished material from the rolls.
- Perform any additional finishing operations, such as trimming or surface treatment, if required.

✓ **Clean-Up and Maintenance:**

- Clean the rolling machine and the work area to remove any debris or residue.
- Perform routine maintenance on the rolling machine to ensure it remains in good working condition.

✓ **Sheet Metal Rolling Procedure**

- In terms of the CNC forging industry, it is necessary to establish strict technical op eration rules.
- It can not only greatly improve the production efficiency, but also avoid the safet y production accidents caused by improper operation.
- And perfect and orderly operation regulations can effectively extend the service l ife of the machines.

✓ **Preparations:**

- Please tidy up the working environment first. Maintain a good working environm ent.
- Wear the required labor protection appliances, such as safety helmet, work cloth es, etc.
- Keep clean and tidy to avoid getting clothes into the rollers.

- Make sure all the machine components are normal and reliable.
- Adjust the distance between work rolls in strict accordance with the plate thickness.
- Don't overload!
- Strictly forbidden to roll the workpiece beyond the specified range of mechanical properties.

✓ **During operation:**

- The signal should be clear. Appoint a person to direct the work.
- Only after the workpiece is in a stable position, you can turn on the power to start operation.
- Do not place hands on rolled steel plates.
- After the workpiece enters the roller, it is necessary to prevent hands and clothes from being drawn into the rolling machine.
- To adjust or measure the size and roundness, you must stop the machine. It is forbidden to carry out it when the machine is running.
- When measuring the roundness of dimensions, don't stand on the cylinder rolled.
- The rolling not round enough sheet: when rolling to the end of the plate, reserve a certain amount of allowance. Prevent the workpiece from falling down and hurting people.
- For some parts that are difficult to process, such as thicker or larger diameter, higher hardness or strength of raw materials, etc. Users should work through a small number of operations and multiple processing to achieve the desired results.
- For some parts with a small diameter, users should place them in the middle of the roll for rolling operation.

✓ **Stop working:**

- If there is abnormal sound in the operation of the bending machine, you should stop the machine tools immediately, and check & repaired.
- Turn off the switch and cut off the power supply.
- After shutdown, put the workpiece in the designated place.

Follow the below-listed steps to ensure safe and precise rolling without any material damage.

Step1: Adjust the tension using the front knobs.

Step2: Adjust the radius using the back knobs.

Step3: Place the sheet metal to be formed between the rollers.

Step4: Rotate the handle gently.

Step5: The flat sheet metal is now rolled to your specifications.

Checklist of Roll inspection before rolling:

- Dimensions of diameters, length, etc.
- Hardness of roll barrel.
- Hardness of roll neck.
- Roughness & scratches on roll surface.
- Ultrasonic testing for defects.
- Barrel hardness uniformity test.

Points to Remember

- While performing rolling operation, you should consider required product specifications

Application of learning 2.3.

Conduct a study visit to one of the manufacturing companies located in your surroundings. The company should be performing different rolling operations required for making rolling products. Help the company to perform the following rolling operations:

a) Thread rolling
b) Gear rolling
c) Shape rolling
d) Ring rolling
e) Tube piercing
f) Skew rolling
g) Transverse rolling
h) Roll bending process
i) Flat rolling
j) Controlled rolling

Indicative content 2.4: Checking Rolled Products

Duration: 2 hrs

Practical Activity 2.4.1: Checking of rolled products

Task:

1: You are requested to go in manufacturing workshop to check rolling defects.

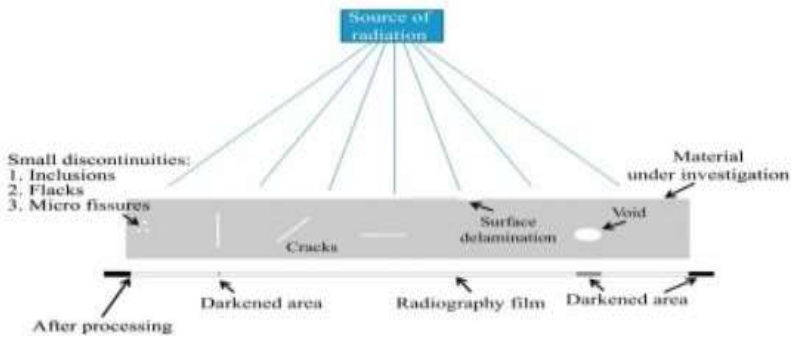
2: Present your work to the trainer and the whole class.

3: Read the key reading 2.4.1 and ask for clarification where necessary.

4.: Perform the task provided in application of learning 2.4

Key readings 2.4.1.: Description of checking rolled products

- **Non-destructive mmethods of checking rolled products**
  - ✓ **Visual inspection**
    - Visual inspection (VT) relies upon the detection of surface imperfections using the eye.
    - Normally applied without the use of any additional equipment, VT can be improved by using aids such as a magnifying glass, color enhancement and projector to improve its effectiveness and scope.
  - ✓ **Radiographic inspection**
    - Radiographic inspection Radiographic inspection or testing (RT) is a non-destructive inspection method based on using short wavelength electromagnetic radiation passing through the material.
    - Materials with areas of reduced thickness or lower material density allow more, and therefore absorb less, radiation.
    - The radiation, which reaches the film after passing through the material, forms a shadow image on a photographic film (radiograph).

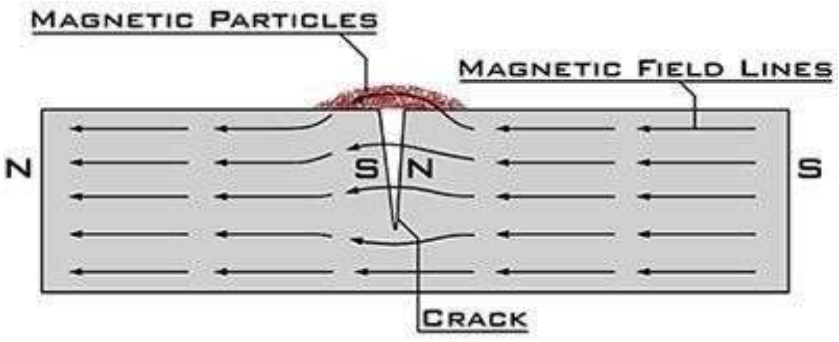


Limitation:

- Radiation is safety hazard require control of facilities or area where radiation will be used and require special monitoring of explosion level and dosage to personnel.

✓ **Magnetic particle testing**

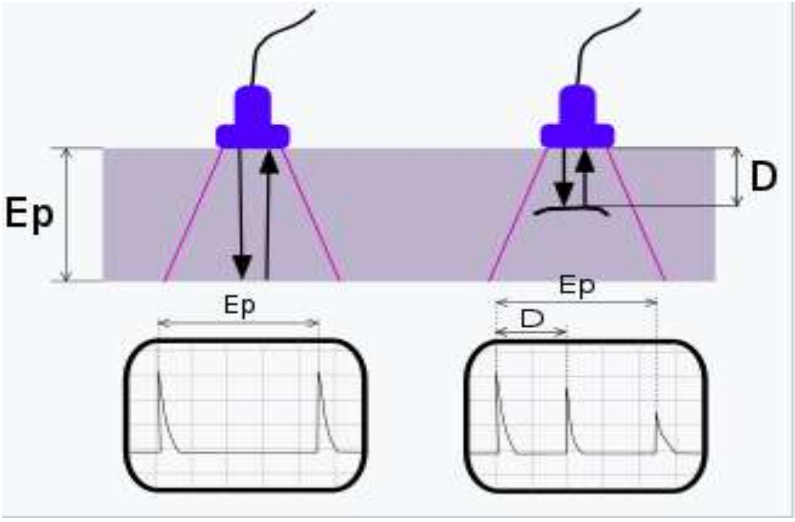
- Magnetic particle testing Magnetic particle testing (MT) is used to locate surface and slight subsurface discontinuities or defects in ferromagnetic materials. Such flaws present in a magnetized part will cause a magnetic field, i.e., flux, to leave the part.
- If magnetic particles are applied to this surface, they will be held in place by the flux leakage to give a visual indication.
- While several different methods of magnetic particle tests can be used, they all rely on this same general principle.



- Therefore, any magnetic particle test will be conducted by creating a magnetic field in a part and applying the magnetic particles to the

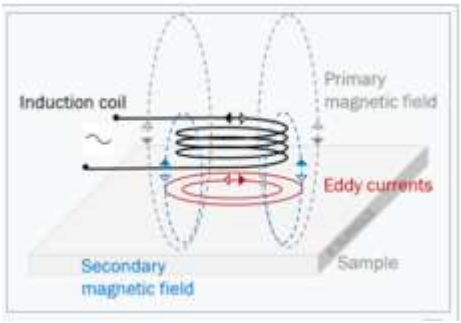
✓ **Ultrasonic testing**

- Ultrasonic testing Ultrasonic testing (UT) is a non-destructive inspection method that uses high frequency sound waves (ultrasound) that are above the range of human hearing, to measure geometric and physical properties in materials.
- Ultrasound travels in different materials at different speeds (velocity). However, the speed of sound propagation in each material is a constant. There are several ways that sound travels through a material.



✓ **Eddy current testing**

- An alternating magnetic field induces a current in a conductor, called an Eddy cu rrent
- The Eddy current generates a new superposed magnetic field. This field is detect ed by a receiver coil.
- If the current meets a material defect, a reaction is produced in the receiver coil.
- The strength of the induced current decreases as depth increases.
- Penetration depth decreases with increasing test frequency.
- Eddy current inspection can be done with EDDY CHECK Systems for ERW Tubes, seamless tubes, precision tubes, double wall tubes, corrugated tubes, bright tub es, hot rolled bars, wires, hot rods, fasteners& many other products.



✓ **Measurements**

- Modern continuous hot-strip and cold rolling mills operated under automatic control provide high throughput and production rate. Of all the metal working processes, rolling is the best suited for the adoption of automatic control because it is an essentially steady-state process in which the tooling geometry (roll gap) may be changed readily during the process.
- Automatic control in rolling such as the development of online sensors to continuously measure sheet thickness. The most widely used instruments are flying micrometre and x-ray or isotope, gauges which measure thickness by monitoring the amount of radiation transmitted through the sheet.
- More recently control procedures have been aimed at controlling strip shape as well as thickness. In a continuous hot mill, the strip thickness is measured indirectly by measuring the rolling load and using the characteristic curve of the mill to establish the thickness.
- The error signal is feedback to the rolling mill screws to reposition them so as to minimize the error.
- An x-ray gauge is used after the last stand to provide an absolute measurement of sheet gauge.

Thickness measurement in continuous cold strip mills:

- Thickness is measured by x-ray gauges while the error in the thickness following the first stand is usually feed backed to adjust the gap sitting on the first stand.
- Gauge control in subsequent stands usually is achieved by controlling the strip tension through controlling the relative roll speed in successive stands or the coiler speed.
- Gauge control through control of strip tension has faster response time than control through change in roll setting. sensors Thickness gauging is achieved by using two opposing sensors with laser spots aimed at opposite sides of a target. The sensor readings are subtracted from the sensor separation distance to yield a real-time thickness measurement.

Points to Remember

- While checking rolling defects, you should remember that all rolling defects must be corrected with its proper correcting methods.

Application of learning 2.4.

Suppose that you are conducting an Industrial Attachment Program in one of the manufacturing workshops located in your district The main tasks include checking rolled products after their production. You are requested to perform the following tasks:

i. Check rolling defects

ii. Check measurements

Learning outcome 2 end assessment

Written assessment

Q1. Define the following terms

i. Part list
ii. Item description.
iii. Non-destructive rolled test

Q2. Read the following statement and answer by True if it is right Answer by true or false

i. Visual inspection (VT) relies upon the detection of surface imperfections using the eye
ii. In rolling operation, the upper roller and lower roller always move in the same direction
iii. Non-destructive testing is a one method of testing rolled product
iv. During rolling operation, hands and feet are allowed to enter between roller and transmission parts.

Q4. List the main elements of

i. Upper roller
ii. Supporting roller

Answer

i. The upper roller device is mainly composed of the main oil cylinder, bearings, and upper roll supporting roll, wedge mechanism and adjusting hand wheel
ii. The supporting roller device is composed of supporting roll, wedge mechanism and adjusting hand wheel

Q5. In work mounting for rolling operation. Explain what will happen when higher roller gap is too high.

Q6. Identify 6 steps of plate rolling process of 4-roll steel plate rolling machine

Q6. Read the following questions and choose the correct answer by writing it .

a. What is the primary purpose of metal rolling?

i. To heat treat the metal
ii. To reduce thickness and make thickness uniform
iii. To weld pieces together
iv. To paint the metal surface

b. Which type of rolling is typically performed at elevated temperatures?

i. Cold Rolling
ii. Thread Rolling
iii. Hot Rolling
iv. Shape Rolling

c. What is the main function of the upper roller in the rolling machine?

i. To support the material
ii. To provide rotational force
iii. To be fixed while the lower roller moves
iv. To gauge the thickness

d. In which rolling operation are threads formed on a workpiece?

i. Shape Rolling
ii. Gear Rolling
iii. Thread Rolling
iv. Controlled Rolling

e. What is the purpose of pre-bending in the rolling process?

i. To start the cooling process
ii. To align the workpiece with the rollers
iii. To ensure the rolled piece has a proper contour
iv. To increase the thickness of the material

f. Which rolling process is used to produce seamless tubes?

i. Flat Rolling
ii. Ring Rolling
iii. Tube Piercing
iv. Skew Rolling

g. What safety precautions should be taken during the rolling operation?

i. Only one person can operate the machine
ii. Hands should be placed on rolled steel plates
iii. The rolling machine can be operated without supervision
iv. The area should be cluttered for easy access

h. What happens if the roller gap is set too tight?

i. It improves the final profile
ii. The material moves forward smoothly
iii. It may cause material marking and roller wear
iv. It ensures a precise result in thickness

Practical assessment

EDK manufacturing workshop Located in Nyabihu District won a tender of producing chimney made of alloyed steel metal of 2mm thick for Nyabihu TSS. The chimney should have cylinder of 18cm diameter and 3.5m height with cap cone shaped of 15 cm height and 22 cm radius. As a fabricator, you are assigned by the head of workshop at EDK manufacturing to perform the following tasks in four hours by referring to the previous activities, all resources are available in EDK

Required to:

i. Interpret drawing
ii. Set the rolling machine
iii. Execute rolling operation
iv. Check rolled products

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END

Indicative contents
3.1 Finishing the product
3.2 Routine maintenance of rolling machine
3.3 Site clearance
3.4 Reporting

Key Competencies for Learning Outcome 3: Perform Post-Operation Activities

Knowledge	Skills	Attitudes
• Description of • finishing operations • Description of routine maintenance on rolling machine • Identification of methods of storage • Identification of types • of wastes • Identification of methods of waste disposal • Identification of reporting methods •	• Polishing edge of rolled products • Coating rolled products • Painting rolled products • Cleaning rolling machine • Lubricating rolling machine • Adjusting rolling machine • Disposing wastes • Reporting work done	• Being consistent and reliable in performing post-operations of rolling activities • • Maintaining a culture of cleanliness and hygiene in the rolling workplace • Timely making fair reports about the work done in rolling operations

Duration: 7 hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly products to be finished in rolling operation

2. Identify clearly methods of finishing rolled products

3. Apply correctly methods of finishing rolled products

4. Identify effectively operations of preventive maintenance for rolling machine

5. Perform appropriately preventive maintenance operations of rolling machine

6.Identify effectively storing methods of materials, tools and equipment used on rolling machine

7.Manage properly storage of materials, tools and equipment for rolling

8. Identify correctly reporting methods on rolling operation

9. Report correctly the work on rolling

Resources

Equipment	Tools	Materials
• PPE • Fire extinguishers • First aid kit • Benches • Anvil • Shear machine • Cut-off machine • Material handling • Equipment	• Micrometre • Taper Measure • Callipers • Ruler • Gauges • Marking pens and pencils • Wire brushes • Abrasive pad • Solvents and degreasers • Screwdriver	• PPE • Fire extinguishers • First aid kit • Benches • Anvil • Shear machine • Cut-off machine • Material handling • Bending machine • Rolling machine • Air compressor

● Rending machine ● Rolling machine ● Air compressor ● Metal scrap yard	● Grease gun ● Oil cans ● Lubrication Pumps ● Files ● Reamers ● Paint ● Brush ● Wire brushes ● Bloom and ● Spray gun	● Metal scrap yard

Indicative content 3.1: Finishing the Product

Duration: 3 hrs

Practical Activity 3.1.1: Performing finishing operations

Task:

1: You are requested to go in manufacturing workshop to perform finishing operations on rolled products.

2: Present your work to the trainer and the whole class.

3: Read the key reading 3.1.1 and ask for clarification where necessary.

4.: Perform the task provided in application of learning 3.1

Key readings 3.1.1.: Description of finishing operations

- **Definition of finishing**

  Finishing is an all-encompassing term used to describe the process of placing some type of metal coating on the surface of a metallic part, typically referred to as a substrate. It can also involve the implementation of a process for cleaning, polishing or otherwise improving a surface

- **Types of finishing operations**

✓ **Edge polishing:**

- No common stainless-steel specification requires that a finish meet specific surface roughness requirements. Surface roughness influences appearance and corrosion performance so it can be important to specify a maximum allowable surface roughness or surface roughness range.
- Either finish can be polished wet or dry. Wet polishing produces a smoother, finer finish. When they are applied to sheet, the polishing lines are usually short, but on pipe, tube, and fabricated components the polishing lines are often long. This should be considered when matching finishes.
- Polished finishes on tubing and pipe are described by the grit rather than a finish number. Fabricators or specialty polishers normally apply polished finishes to stainless steel bars and shapes. Small cross section flat round, hex and square bars are available “cold finished.” Heavier sectioned flats, angles, other shapes are

commercially available only “hot rolled” or “extruded”.

- They are typically purchased with a rough abrasive blasted and pickled surface that must be ground smooth before polishing. Polishing such shapes is more expensive. Thinner angles, channels and shapes can be cold rolled after polishing. If this is done with a protective strippable plastic film in place that is suitable for forming, no further polishing is required. A soft, satin, directional It is usually purchased already machine polished in sheet form and requires specifying stainless steel with very low sulphur (0.005 or less) levels. If the right quality of stainless steel is not specified, impurities in the metal can cause flaws during polishing. A true mirror finish obtained by hand polishing is expensive.

Metal edge polishing techniques:

- Grinding and Buffing: Use a grinder or file to remove rough edges and shape the metal. Then, employ a buffing wheel with polishing compound to achieve a smooth, shiny finish.

- Hand Tools: Files, deburring tools, or sandpaper wrapped around a block can be used for intricate edges to remove burrs and refine the surface

✓ **Coating**

- It is the process of applying a layer of material to the surface of an object or substrate. This layer, known as the coating, can be composed of various substances including paints, varnishes, polymers, metals, ceramics, or other specialized compounds. Coatings serve a wide range of purposes, such as providing protection, enhancing appearance, adding functionality, or achieving specialized properties.
- They are used in industries ranging from construction, automotive, aerospace, and electronics, to healthcare, marine, and many others.
- The choice of coating material and application method depends on the specific requirements and intended use of the coated surface.

Metal coating techniques:

- Electroplating: This involves immersing the metal to be coated (like steel or aluminum) in a solution containing ions of the coating metal. An electric current is passed through the solution, causing the coating metal ions to adhere to the surface of the base metal. It’s commonly used for decorative finishes, corrosion resistance, and to enhance conductivity.

- Powder Coating: This method involves spraying a dry powder onto a metal surface, which is then cured under heat. The powder adheres electrostatically to the metal before the curing process, resulting in a durable, high-quality finish. It’s

environmentally friendly as it produces minimal waste.

- Anodizing: This technique is primarily used for aluminum. It involves creating an oxide layer on the metal's surface through an electrochemical process. Anodizing enhances corrosion resistance and can also provide color options. The metal is immersed in an electrolyte solution and an electric current is passed through, causing oxidation to occur.
- Galvanization: This process involves coating metal (typically steel or iron) with a layer of zinc to protect against corrosion. Hot-dip galvanizing involves immersing the metal in molten zinc, while electro-galvanizing uses an electric current to deposit the zinc onto the metal's surface.
- Metal Cladding: This involves bonding a layer of one metal (such as stainless steel or aluminum) onto another base metal. It can be achieved through processes like welding, rolling, or explosive bonding, and it enhances properties like corrosion resistance, strength, and appearance.
- Physical Vapor Deposition (PVD): This high-tech method involves depositing a thin film of metal or other materials onto a substrate in a vacuum environment. It's used for applications requiring precise coating thickness, uniformity, and specific properties.

✓ **Painting:**

- It is a creative process of applying coloured pigments, typically in liquid form, to a surface to create images, patterns, or designs.
- This can be done using various tools such as brushes, rollers, sponges, or spray eq uipment. The purpose of painting can be artistic, decorative, functional, or a com bination of these.
- Painting rolled metal requires proper preparation and painting techniques to ensure a durable and visually appealing finish.

General painting process:

Step 1: Prepare the object to be painted:

- **Clean the Surface:** Use a degreaser or a solvent to remove any oil, grease, or contaminants from the metal surface. This step ensures proper adhesion of the paint.
- **Sand and Prime:** Lightly sand the metal surface to create a slightly rough texture, which helps the paint adhere better. Apply a primer specifically designed for metal to create a suitable base for the paint.

Step2: Choose the Right Paint:

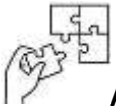
- Opt for a high-quality paint suitable for metal surfaces.
- Consider enamel or epoxy-based paints as they offer durability and resistance to corrosion.

Step3: Apply the paints:

- Spray Painting: This method provides an even and smooth finish. Use a paint sprayer for large surfaces or areas that need an even coat.
- Brush or Roller: For smaller areas or detailed work, use a brush or roller. Ensure the strokes are even and in the same direction for a uniform finish.
- Thin Coats: Apply paint in thin, even coats to prevent drips or uneven coverage. Allow each coat to dry completely before applying the next one.
- Drying and Curing: Follow the manufacturer's instructions regarding drying times. Typically, the paint needs time to air dry or cure completely to achieve its maximum durability and finish.
- Protective Finish: Consider applying a clear protective coat or varnish over the paint to add an extra layer of protection against environmental factors

Points to Remember

- While performing finishing operations, you should remember that after coating a product it must be stored in good conditions.



Application of learning 3.1.

Suppose there is a manufacturing workshop located in your district that wants to perform finishing on their rolled products. You are invited to perform the following tasks:

a) Edge polishing of the rolled products
b) Coating the products
c) Painting products

Indicative content 3.2: Routine Maintenance of Rolling Machine

Duration: 2 hrs

Theoretical Activity 3.2.1: Describing routine maintenance of a rolling machine

Tasks:

1: You are requested to provide answers to the following questions:

i. What do you understand about routine maintenance?

ii. Differentiate cleaning, lubrication and adjustment as techniques of routine maintenance?

iii. What do you think should be the objectives of routine maintenance for rolling machine?

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard

3. Present your findings/answers to the trainer and/or the whole class

4. Pay attention to the trainer's clarification and ask questions where necessary

5: For more clarification, read the key readings 3.2.1.

Key readings 3.2.1.: Describing routine maintenance of a rolling machine

- **Definition of routine maintenance**

Routine maintenance refers to any maintenance task that is done on a planned and ongoing basis to identify and prevent problems before they result in equipment failure.

- **Types of routine maintenance**

✓ **Cleaning**

- Cleaning must be done every time the machine has been used following all the rules to prevent malfunctioning of the machine and for hygienic purposes.
- Using a proper brush, first clean the residue of flour and dough. Release the springs, loosen the dough scrapers then turn the regulating levers in position, maximum opening of the rollers.
- Clean very carefully the machine and all the parts, also the disassembled parts, using a sponge or a cloth dampen with tepid water and detergent. Rinse out very well so to remove completely the detergent. Dry with blotting paper, then clean first the surface in contact with the dough and then all the machine

with a clean and soft cloth soaked with a specific disinfectant for alimentary machines.

- Clean pipes and hydraulic components. Hydraulic systems in general (cylinders, valves, motor/pump units, piping systems, etc.) must be externally cleaned at least once a month.
- This cleaning is designed to identify any leak areas and is used to eliminate the risk of contaminants entering the system when replacing components. It also avoids a reduction in heat exchange between the system and the environment

Steps of routine maintenance for cleaning metal surfaces:

- ✓ Dusting and Wiping:
- Use a soft, dry cloth or a microfiber cloth to remove dust and loose debris from the metal surface. This should be done regularly to prevent buildup.
- ✓ Mild Soap and Water Cleaning:
- Prepare a solution of mild soap or detergent with warm water. Use a soft cloth or sponge to gently clean the metal surface. Rinse thoroughly and dry with a clean cloth.
- ✓ Polishing:
- Apply a metal-specific polish or wax to maintain the shine and protect the surface.

Follow the manufacturer's instructions for application:

- Prevent Scratching: Use non-abrasive cleaning tools and avoid harsh chemicals or abrasive cleaners to prevent scratches or damage to the metal surface.
- Protective Coating (for outdoor surfaces): Consider applying a protective coating or sealant designed for outdoor metal surfaces to shield them from the elements and prevent corrosion.
- Rust Removal (if necessary): If rust appears on the metal surface, use a wire brush, sandpaper, or rust remover to clean it off. Afterward, apply a rust-inhibiting primer and paint to prevent further rusting.
- Inspection: Regularly inspect metal surfaces for signs of damage, wear, or corrosion. Address any issues promptly to prevent further damage.

- ✓ **Lubrication:**
- Lubrication is the application of a lubricant, typically a liquid or semi-solid substanc e, to reduce friction between two surfaces in relative motion.
- The primary purpose of lubrication is to minimize wear and tear, dissipate heat, an d protect moving parts from damage. Lubricants can be oils, greases, or solid lubric ants, and they are applied to various mechanical systems, such as engines, gears, b earings, and machinery components.

Steps involved in the method of lubrication for routine maintenance:

Step1: Identify Lubrication Points:

Locate the areas on the machinery or equipment that require lubrication. This might include bearings, gears, joints, hinges, or any moving parts indicated by the manufacturer's manual.

Step2: Choose the Right Lubricant:

Use the lubricant recommended by the equipment manufacturer. Different types of machinery might require specific lubricants, such as oil, grease, or dry lubricants, based on their function and the materials involved.

Step3: Clean the Parts:

Before applying new lubricant, ensure that the parts are clean and free from old lubricant, debris, or dirt. This prevents contamination and ensures the effectiveness of the new lubrication.

Step4: Apply Lubricant:

Use the appropriate method to apply the lubricant. This might involve applying a few drops of oil to a specific point or applying grease to a larger area. Ensure the proper amount is used; over-lubrication can be as damaging as insufficient lubrication.

Step5: Follow Manufacturer Recommendations: Abide by the manufacturer's guidelines regarding the frequency of lubrication. Some equipment might require lubrication on a daily, weekly, or monthly basis, while others might need it less frequently.

Step6: Record Keeping: Maintain a log or schedule of lubrication activities. Note the date, type of lubricant used, and the parts lubricated. This documentation can help ensure consistency and prevent over or under-lubrication.

Step7: Regular Inspection: Alongside lubrication, regularly inspect the equipment for signs of wear or any issues that might indicate a need for further maintenance.

- ✓ **Adjustment:**

Adjustment involves making changes or modifications to the settings, position, or configuration of a mechanism, system, or object to ensure proper function, alignment, or performance.

General outline for adjustment during maintenance:

- Identify Adjustment Points: Refer to the equipment manual or manufacturer's guidelines to locate areas or components that might need adjustment as part of routine maintenance. This could include settings for tension, alignment, clearance,

or other adjustable features.

- Examination and Measurement: Inspect the equipment to identify signs of misalignment, wear, or deviations from recommended settings. Use measuring tools or indicators to accurately assess the current state of the components.
- Make Necessary Adjustments: Depending on the type of equipment, adjustments might involve tightening or loosening specific parts, aligning components, calibrating settings, or repositioning elements to meet the manufacturer's specifications.
- Testing and Validation: After making adjustments, test the equipment to ensure that it is functioning correctly. This might involve running tests, observing the behavior of moving parts, or checking performance metrics.
- Documentation: Record any adjustments made, including the nature of the adjustment, measurements before and after, and any changes to settings. This documentation helps maintain a history of maintenance and assists in tracking the equipment's condition over time.
- Regular Review and Follow-Up: Periodically review the adjusted components to ensure they remain in the desired state. Monitor their performance and functionality to identify if further adjustments are necessary in subsequent maintenance schedules.
- Professional Assistance, if Needed: For complex adjustments or those requiring specialized knowledge, consider involving professionals or technicians who are experienced in the equipment.

Practical Activity 3.2.2: Performing routine maintenance on rolling machine

Task:

1: You are requested to go in manufacturing workshop to perform finishing operations on rolled products.

2: Present your work to the trainer and the whole class.

3: Read the key reading 3.2.1 and ask for clarification where necessary.

4.: Perform the task provided in application of learning 3.2

Points to Remember

- While describing types of routine maintenance of the rolled products, you should consider cleaning, lubrication and adjustment.
- While performing routine maintenance, you must remember that equipment should be turned off

Application of learning 3.2.

Suppose that you are conducting an Industrial Attachment Program in one of the manufacturing workshops located in your district. Your tasks include performing routine maintenance of rolling machines. You are requested to perform the following tasks:

i. Clean rolling equipment
ii. Lubricate rolling equipment
iii. Adjust rolling equipment

Indicative content 3.3: Site Clearance

Duration: 1hr

Theoretical Activity 3.3.1: Description of site clearance

Tasks:

1: You are requested to provide answers to the following questions:

i. What do you understand about site clearance and waste?
ii. How can you store tools, equipment and product?
iii. How can you dispose waste after carrying out rolling works?

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard

3. Present your findings/answers to the trainer and/or the whole class

4. Pay attention to the trainer's clarification and ask questions where necessary

5: For more clarification, read the key readings 3.3.1.

Key readings 3.3.1.: Description of site clearance

- **Main elements to consider in site clearance:**
  - ✓ **Storage:**

- Storage of materials refers to the designated area or facility where raw materials, intermediate products, or finished goods are kept, organized, and maintained until they are needed for production, distribution, or use.
- Effective material storage involves proper handling, stacking, shelving, and inventory management to ensure that materials remain in good condition and are readily accessible when required
- It also includes considerations for factors like security, climate control, and compliance with safety regulations.

✓ **How to handle storage during site clearance?**

- Designate Storage Areas: Identify and allocate specific zones for different types of materials or equipment. This might include areas for salvaged materials, recyclables, waste, machinery, and tools.
- Temporary Storage Solutions: Utilize containers, bins, or temporary structures such as storage tents or portable storage units to organize and secure salvaged materials, tools, and equipment.

- Segregation of Materials: Differentiate and categorize materials. Create separate sections for salvageable items, recyclables, hazardous materials, and general waste. This helps streamline disposal and recycling processes.
- Protection and Security: Use covers, tarps, or fencing to protect stored items from weather damage and theft. Secure storage areas to prevent unauthorized access and ensure the safety of stored materials.
- Efficient Layout: Organize the storage areas in a way that allows easy access for machinery and workers. Maintain clear pathways for movement and transportation of materials.
- Labeling and Inventory: Label containers or storage sections to indicate the type of material stored within. Maintain an inventory to keep track of salvaged items and waste for efficient management.
- Compliance and Safety: Adhere to regulations and safety standards concerning the storage of hazardous materials or waste. Ensure proper disposal or recycling methods for different types of waste.
- Regular Monitoring and Removal: Periodically assess stored materials. Remove items that are no longer needed, have been properly processed, or are hindering the clearance process to maintain an organized workspace.

Practical Activity 3.3.2: Cleaning site

Task:

1: By referring to the previous activity 3.3.1, you are requested to perform site clearance by cleaning the site and managing waste disposal. You need also to refer to trainer's demonstration.
2: Present your work to the trainer and the whole class.
3: Read the key reading 3.3.2 and ask for clarification where necessary.
4: Perform the task provided in application of learning 3.3

Key readings 3.3.2.: Performing site clearance

- **Waste Disposal:**

- Waste disposal encompasses the process of properly managing and removing w aste materials or substances in a manner that is safe, environmentally responsi ble, and compliant with legal regulations.
- This includes the collection, transportation, treatment, recycling, or disposal of

waste products generated from various sources, such as industrial processes, h ouseholds, commercial activities, and construction sites. Proper waste disposal aims to minimize environmental impact, protect public health, and adhere to lo cal, regional, and national waste management guidelines.

- Methods of waste disposal can include landfilling, incineration, recycling, comp osting, and more sustainable approaches like waste-to-energy technologies.
- Waste disposal during site clearance is a critical part of the process, ensuring that debris and materials are removed responsibly and in compliance with regulations.

✓ **Guide to effective waste disposal:**

- **Segregation and categorization:**

Sort waste into different categories such as wood, metal, concrete, plastics, and hazardous materials. This categorization aids in proper disposal and recycling.

- **Identify responsible disposal methods:**

- Recycling Centers: Research local recycling centers or facilities that accept different types of materials for recycling. Separate recyclables and arrange for their proper disposal at these facilities.
- Hazardous Waste: Identify and handle hazardous materials separately. Ensure they are disposed of following specific guidelines and regulations to prevent environmental contamination.

- **Utilize Waste Removal Services:**

- Waste Management Companies: Engage with waste management or disposal companies equipped to handle different types of waste.

- They can provide dumpsters or containers for waste collection and ensure proper disposal.

- **Compliance with Regulations:**

- Follow Legal Guidelines: Adhere to local regulations regarding waste disposal. Different types of waste might have specific guidelines for their disposal to prevent environmental harm.

- **Record Keeping:**

- Maintain Documentation**:** Keep records of waste disposal activities, including the type and quantity of waste removed, the disposal method used, and any relevant receipts or documents.

- **Clean-Up and Final Inspection:**
  - **Post-Disposal Site Inspection:** After waste removal, conduct a final inspection to ensure all debris has been removed, and the site is clean and ready for further construction or development

Points to Remember

- While cleaning the rolling site, you should consider cleaning and storing techniques of tools and equipment.
- For best practices, remember to dispose rolling wastes in appropriate ways. This will make the working place more conducive.

Application of learning 3.3.

Suppose that XN manufacturing workshop located in your home district has finished to produce 20 mild steel chimneys. Referring to the activity 3.3.1 and 3.3.2. You are asked to perform the following tasks:

i. Clean tools and equipment
ii. Store tools and equipment
iii. Dispose wastes

Indicative content 3.4: Reporting

Duration: 1 hr

Theoretical Activity 3.4.1: Description of reporting

Tasks:

1: Answer the following questions:

i. What do you understand about “technical report”?
ii. Identify types of reports
iii. Explain the ways/forms of reporting

2. Write your findings/answers on paper, flipchart, blackboard or whiteboard

3. Present your findings/answers to the trainer and/or the whole class

4. Pay attention to the trainer’s clarification and ask questions where necessary

5: For more clarification, read the key readings 3.4.1.

Key readings 3.4.1.: Description of reporting

- **Definition of reporting**

Reporting refers to the process of documenting and communicating information about tasks, activities, progress, and outcomes related to a specific job or project. It involves summarizing work-related details in a structured format to provide stakeholders, supervisors, or team members with a clear understanding of what has been the i mportance of reporting

Reporting is a critical aspect of communication and information management in various contexts, including business, government, education, healthcare, and more.

- **Importance of reporting:**

✓ **Decision-Making:**

- Business reporting provides data and insights that support informed decision-making by stakeholders, ranging from executives to frontline employees.
- It helps identify trends, challenges, and opportunities, enabling strategic planning and resource allocation.

✓ **Performance Evaluation:**

- Regular reporting allows organizations to assess the performance of individuals, teams, and departments.

- Key performance indicators (KPIs) and metrics are often reported to gauge success and areas for improvement.

✓ **Accountability and Transparency:**

- Whether in the public sector or private organizations, clear and accurate reporting demonstrates responsibility, helping to build trust among stakeholders, customers, employees, and the public.

✓ **Regulatory Compliance:**

- Many industries and organizations are subject to regulations and standards.
- Reporting ensures compliance with these regulations, providing evidence of adherence to legal and ethical standards.
- Failure to comply can result in legal consequences.

✓ **Communication:**

- Reporting serves as a means of communication within and outside an organization.
- It facilitates the exchange of information, progress updates, and future plans.
- Effective reporting ensures that all relevant parties are well-informed.

✓ **Monitoring and Evaluation:**

- Reporting is crucial for monitoring the progress of projects, initiatives, and goals.
- It allows for continuous evaluation of performance against predefined objectives and helps in making timely adjustments or improvements.

✓ **Resource Allocation:**

- Organizations rely on reporting to allocate resources efficiently.
- This includes financial resources, manpower, time, and other assets.
- Reports help identify areas of high and low performance, guiding resource distribution accordingly.

✓ **Risk Management:**

- Reporting enables the identification and assessment of risks.
- By analyzing reported data, organizations can proactively address potential issues, mitigate risks, and enhance their overall risk management strategies.

✓ **Continuous Improvement:**

- Reporting provides valuable feedback that supports continuous improvement efforts.
- By analyzing data and identifying areas for enhancement, organizations can

implement changes and measure the impact over time.

✓ **Benchmarking:**

- Reporting allows organizations to compare their performance against industry benchmarks or competitors.
- Benchmarking helps identify areas where improvements are needed to stay competitive in the market.

✓ **Educational and Research Purposes:**

- In academic and research settings, reporting is essential for sharing findings, methodologies, and conclusions.
- It contributes to the collective knowledge base and allows for peer review and validation.

✓ **Customer and Stakeholder Satisfaction:**

- Organizations often use reporting to gauge customer and stakeholder satisfaction.
- Feedback and performance metrics help identify areas where improvements can enhance overall satisfaction accomplished and any relevant insights or findings.

- **Forms of report**
  - ✓ **Verbal report:**
    - A verbal report is a form of communication in which information is conveyed orally, typically through spoken words.
    - This mode of reporting is often used in meetings, presentations, or discussio ns and can be a valuable means of sharing information efficiently
  - ✓ **Written report:**
    - A written report is a formal document that presents information, analysis, fi ndings, or recommendations in a structured and organized format.
    - This mode of reporting is widely used in academic, business, scientific, and p rofessional contexts
  - ✓ **Electronic report:**
    - An electronic report is a digital or online document that conveys information , analysis, findings, or recommendations through electronic means.
    - Electronic reports leverage technology to create, share, and distribute infor mation, offering several advantages in terms of accessibility, interactivity, an d multimedia integration
- **Types of report**
  - ✓ **Progress Reports**

- Provides updates on the progress of ongoing projects or tasks.
- It includes details about completed work, remaining tasks, and any challenges encountered.

✓ **Financial Reports:**

- Focuses on financial aspects, including budget allocation, expenses, revenue, and financial performance metrics.
- This type of report is crucial for financial planning and decision-making.

✓ **Quality Assurance Reports:**

- Evaluates the quality of products or services delivered. It may include data on defects, customer complaints, adherence to quality standards, and improvement initiatives.

✓ **Inventory Reports:**

- Provides an overview of available inventory levels, including stock quantities, replenishment needs, turnover rates, and any discrepancies or variances.

✓ **Safety Reports:**

- Focuses on workplace safety and incidents. It includes information on accidents, near misses, safety measures, and compliance with safety protocols.

- **Parts of a report**

✓ **Title Page:**

- Includes the title of the report, the author's name, the name of the institution or organization, and the date of submission.

✓ **Abstract or Executive Summary:**

- Provides a concise summary of the report, highlighting key findings, recommendations, and conclusions.
- It is usually placed at the beginning of the report but written after completing the entire document.

✓ **Table of Contents:**

- Lists the main sections and subsections of the report along with their page numbers for quick reference.

✓ **List of Figures and Tables:**

- Enumerates the figures and tables in the report, along with their corresponding page numbers.

✓ **Introduction:**

- Introduces the topic or problem addressed in the report, outlines the objectives, and provides background information.
- It may also include the scope and limitations of the study.

✓ **Literature Review:**

- Summarizes relevant existing literature, research, or theoretical frameworks related to the report's subject.
- This section provides context and establishes the theoretical foundation for the study.

✓ **Methodology:**

- Describes the research methods or procedures used to gather data, conduct experiments, or analyze information.
- It includes details on the study design, participants, materials, and data analysis techniques.

✓ **Findings or Results:**

- Presents the outcomes of the research or analysis in a clear and organized manner.
- This section often includes text, tables, graphs, and figures to support the findings.

✓ **Discussion:**

- Interprets and analyzes the results, relating them to the objectives and addressing any research questions or hypotheses.
- It may also explore implications, limitations, and areas for further research.

✓ **Conclusion:**

- Summarizes the key points of the report, restates the main findings, and offers conclusions and recommendations based on the research or analysis.

✓ **Recommendations:**

- Suggests specific actions or strategies based on the conclusions drawn from the study. This section may include practical steps, policy recommendations, or further research suggestions.

✓ **References or Bibliography:**

- Lists all the sources cited in the report, following a specific citation style (e.g., APA,

MLA,).

- ✓ **Appendices:**

Contains additional supporting materials such as raw data, detailed charts, questionnaires, or supplementary information that is referenced in the main body of the report

Points to Remember

- While reporting the work done, remember to select use the appropriate template.

Application of learning 3.4.

Suppose XN manufacturing workshop have produced 200 mild steel chimneys for newly opened Technical Secondary Schools. Chief of technician in XN manufacturing workshop need a technician for preparing report of the work done. You are requested to perform the following tasks:

i. Prepare the report template
ii. Identify form of reporting to be used
iii. Fill in the report template.

Learning outcome 3 end assessment

Written assessment

Q1. Read the following statement and choose the right by writing it.

a. What is the primary goal of proper waste disposal

i. To generate profit from waste
ii. To minimize environmental impact and protect public health
iii. To increase landfill space
iv. To create more waste products

b. Which of the following is NOT a method of waste disposal mentioned in the text?

i. Landfilling
ii. Incineration
iii. E-waste dumping
iv. Composting

c. What is the first step recommended for effective waste disposal?

i. Engage waste management companies
ii. Conduct a final site inspection
iii. Segregate and categorize waste
iv. Identify hazardous materials

d. Why is it important to identify hazardous waste separately?

i. It is more valuable than other waste types
ii. It requires different disposal guidelines and regulations to prevent contamination
iii. It reduces the overall volume of waste
It can be mixed with other recyclables

e. What should be documented during waste disposal activities?

i. The location of disposal sites only
ii. The type and quantity of waste removed and disposal methods used
iii. The cost of garbage bags
iv. The personal information of workers involved

Q2. Read the following statement and answer by True if the statement is right and False if it is wrong

a. Routine maintenance is performed only when equipment has already failed to identify problems.
b. Cleaning is an essential type of routine maintenance that should be performed after every use of a machine.

c. It is not necessary to inspect and clean hydraulic systems monthly as long as they are cleaned at the start of the operation.
d. Using abrasive cleaners is recommended for cleaning metal surfaces to ensure they are free of grime and dirt.
e. Routine lubrication is essential to minimize wear and tear on machinery and ensure efficient operation.
f. Over-lubrication is generally harmless and will not affect machinery performance.
g. True or False: Adjustments during routine maintenance should only be made if
h. Finishing exclusively refers to polishing the surface of metallic parts.
i. choice of metal coating technique cannot differ based on the specific requirements of the application.
ii. Edge polishing operations can either be polished wet or dry, and wet polishing results in a smoother finish.
iii. Electroplating involves applying a layer of zinc to steel or iron for corrosion protection.
iv. Anodizing can provide anodized aluminum with enhanced corrosion resistance and color options.
v. Painting rolled metal requires no specific preparation to ensure a good finish.
vi. Physical Vapor Deposition (PVD) is a method that operates in a vacuum to deposit thin films of material onto a substrate.
vii. The use of protective clear coats over paint can enhance durability against environmental factors.

Q3. Why is it important to define the purpose of a report before writing it?

Q4. What role does the audience play in report writing?

Practical assessment

Suppose XN manufacturing workshop have produced 200 mild steel chimneys for newly opened Technical Secondary Schools. Chief of technician in XN manufacturing workshop need a technician for performing post operation activities. Ask learners to perform the following tasks:

i. Finishing the product
ii. Routine maintenance of rolling machine
iii. Cleaning site
iv. Reporting the work done

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END

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