TVET CERTIFICATE IV in WELDING

METAL CUTTING

WLDMC401

Perform Metal Cutting

Competence

Credits: 11

Learning hours:110

Sector: Mining and Manufacturing

Sub-sector: Welding

Module Note Issue date: September, 2020

Purpose statement

This specific module describes the performance outcomes, skills and knowledge required to correctly use cutting tools and equipment as well as to safely perform the metal cutting processes

Table of Contents

Total Number of Pages: 32

Learning Unit 1 – Analyze the metal cutting work

Metal cutting is operation of removing a layer of allowance from a workpiece or separation of a workpiece using cutting tools/cutting machine or other cutting equipment.

With steel and their rest of the metal working world, cutting and separating metals is a vital process. There is a numerous metal cutting methods out there, staring with basic hand held items like hacksaws, chisel or shears.

The Selection of the cutting process depends on the alloy to be cut, the availability of equipment, the amount of cutting to be done, and accessibility of the work.

Oxyacetylene cutting uses acetylene and oxygen to preheat metal to red hot and then uses pure oxygen to burn away the preheated metal.

Plasma cutting is a process that cuts through electrically conductive materials by means of an accelerated jet of hot plasma.

Shearing is the process of cutting off of sheets using a die and punch, applying shear stress along the thickness of the sheet.

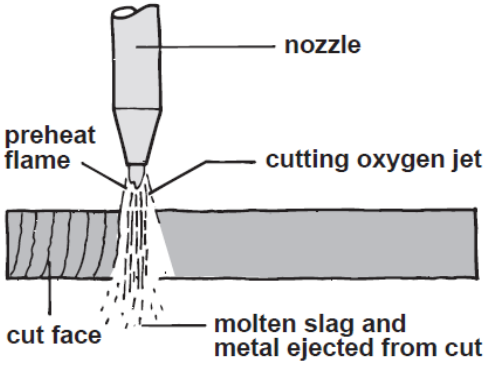
In fact, metal Cutting may be carried out using simple snips for thin gauge steel up to around 20 SWG, treadle-operated guillotines capable of cutting 14 SWG steel, and hand-lever shears for sheet up to 1.5 mm thick, oxy-acetylene gas cutting and/or plasma cutting for cutting plate of large thickness.

LO 1.1. Identify the work

Content/Topic 1. Principles of metal cutting processes:

a. **Oxy-acetylene gas cutting**

Oxygen-fuel gas cutting is widely used to cut straight lines and shapes in Plates, pipe end in preparation for welding and/or scrap metal. It can produce a variety of edge profiles on plates, pipes and sections



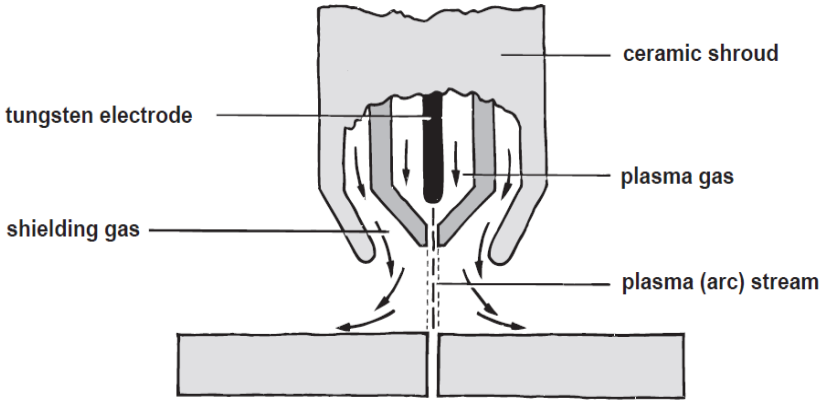
The cutting action depends on a chemical reaction between oxygen and hot iron or steel. A preheat-flame is used to raise the surface of the metal to the temperature at which the reaction takes place.

The heat from the reaction melts the metal which is blown from the cut by the oxygen jet. Metal

b. **Plasma cutting**

Accurate cuts can be made in stainless steel and non-ferrous metals such as aluminium by plasma arc cutting.

The cuts are made by a high temperature, high velocity gas jet generated by constricting an arc between a tungsten electrode and the component.



The heat from the arc melts the metal and the gas jet removes the molten metal from the cut.

The arc operates in an inert inner shield, whilst an outer shield provides protection for the cut surface.

Argon, helium, nitrogen and mixtures of these gases are used for both the inner and outer shields.

Plasma arc cutting is characterized by fast cutting speeds and is mainly used in mechanized systems.

The cutting is accompanied by a high noise level which can be reduced by operating the torch under water.

Hytec 35 is a gas mixture which has been specially formulated for plasma arc cutting. It contains 65% argon and 35% hydrogen. Hytec 35 is used as the plasma gas. The shielding gas can be nitrogen or argon.

The benefit of Hytec 35 are:

- Increased cutting speed
- Reduced oxidation
- Narrow kerf-less metal wastage
- Clean cut surface
- Handles thicker section material

c. Shear cutting

Shear cutting is the process of cutting off of sheets using a die and punch, applying shear stress along the thickness of the sheet.

The hand-lever shears are available, usually bench mounted for cutting thicker metals, up to 1.5mm,

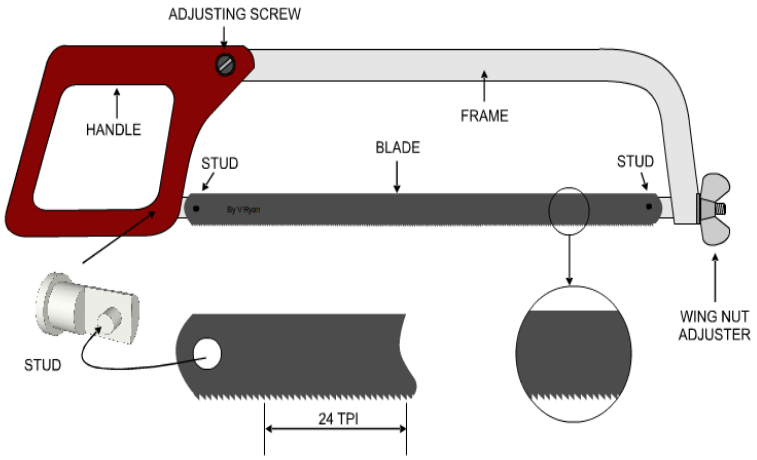
The length of the lever and the linkage to the moving shear blade ensure adequate leverage to cut the thicker metals. Where larger sheets are required to be cut with straight edges, the guillotine is used.

Sheet widths of 600 mm × 2 mm thick and up to 1200 mm × 1.6 mm thick can be accommodated in

treadle-operated guillotines. These have a moving top blade, which is operated by a foot treadle, and a spring which returns the blade to the top of its stroke. The table is provided with guides, to maintain the cut edges square, and adjustable stops to provide a constant size over a number of components. When the treadle is operated, a clamp descends to hold the work in position while cutting takes place, and this also acts as a guard to prevent injury. These machines can be extremely dangerous if not used correctly, so take great care.

d. <u>Hack saw cutting</u>

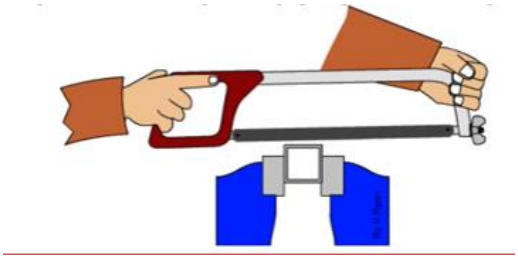
The hacksaw is used to cut steel and other metals. It can also be used to cut plastics, although it is not normally used to cut woods. It is sometimes called an adjustable hacksaw because the length of the frame can be altered to hold blades of different sizes. Blades are supplied in two lengths, 250mm and 300mm. If the adjusting screw is unscrewed, the frame can be pushed into the handle so that the smaller blades fit the hacksaw.



Blades are also described by the number of teeth per inch (TPI). Blades have 14, 18, 24, 32 teeth per 25mm (inch). A blade with 14 TPI is coarse whilst a blade with 32 TPI is very fine.

TEETH PER INCH (25mm)	SUITABLE FOR CUTTING
14 TPI	LARGE SIZES, ALUMINIUM AND OTHER SOFT METALS.
18 TPI	SUITABLE FOR GENERAL WORKSHOP CUTTING.
24 TPI	FOR CUTTING STEEL PLATE UP TO 5/6mm.
32 TPI	FOR CUTTING HOLLOW SECTIONS AND TUBING.

The blades are eventually wear or break and need replacing, it can be replaced by loosening the wing nut adjuster until it comes off the two 'studs' that normally hold it in tension in the frame. A blade should always be positioned with its teeth pointing away from the handle.



Content/Topic 2. Advantages and disadvantages of metal cutting processes

Advantages of metal cutting

1. Oxy-fuel cutting uses several different preheating flames that allows for the direction of the cut to be changed seamless making cleaner cuts
2. Large and thick sections of material can be cut more efficiently as the oxy-fuel cutters is light and quiet, requiring little effort to use.
3. Plasma cutting is an economical, efficient manufacturing process used to cut medium to heavy thickness metals, including carbon steel, stainless steel, aluminium and alloys.
4. It is a quick cutting process, providing fast throughout, tolerance control and repeatability

Disadvantages of metal cutting:

1. Shear cutting is limited to the size, thickness and shape of metal to be cut.
2. Oxy-fuel gas cutting may results in changing mechanical properties of metals due to heat affected zone.
3. Larger heat affected zone compared due to plasma cutting
4. The quality with thinner sheets and plates not so good.

Content/Topic 3. Application of metal cutting processes

- Oxyfuel gas cutting, plasma arc cutting and powder cutting are the processes most often used for cutting of plate and pipe materials.
- Oxyfuel gas cutting is widely used on carbon and low alloy steels because of economy and simplicity.
- Plasma arc cutting does an excellent job of producing smooth, clean cuts on all metals (both ferrous and nonferrous), but the cost of equipment is significantly greater than for Oxyfuel gas cutting.
- Power hacksaw cutting machine can be used for cutting steel plate surfaces, round bar for welding,
- Oxy-acetylene gas cutting is applied in industries for preparing U-shaped grooves in square butt joints, and preparing weld bevels on square cut edges.

LO 1.2. Estimate of the cost

Content/Topic 1. Elements of Bill of quantity

A bill of quantity (BOQ) is a document which is especially used in tendering in the construction industry, supplies or other works in which materials, parts, and food too (and their costs) are itemized or described in details

Elements of Bill of quantity(BOQ):

Parts of BOQ can be varied according to the project size as well the practices.

Generally, it has:

1. **Serial number**: is a unique, identifying number or group of numbers and letters assigned an item
2. **Item Description and/or specifications:** Define exactly how each standard will be measured or give information about items
3. **Unity price**: is the price per one items required
4. **Total price:** is the price per total similar item required
5. **Labor cost**:30% of material total price: is the cost of labor is the sum of all wages paid to employees, as well as the cost of employee benefits and payroll taxes paid by an employer
   Labor cost=summation of all material total cost multiply with 30%
6. **Taxes:** is a mandatory financial charge or some other type of charge imposed upon a taxpayer (an individual or other legal entity) by a governmental organization in order to fund various public expenditures(outgoings). A failure to pay, along with resistance to taxation, is punishable by law
7. **Transport:** a particular movement of an items or things from a point A to the Point B
8. **Grand total:** is the sum of the sums of several groups of numbers

9. **Contingencies:** a future event or circumstance which is possible but cannot be predicted with certainty

Below is a sample of Bill of Quantity (cost estimation):

A bill of quantity (cost estimation) of cutting materials for 1 door

No	**Designation**	**Specification**	**Quantity**	**UNIT PRICE**	**TOTAL PRICE**
1	HS	6000mm	4p	400F	1200frws
2	Sheet metal	1,5mm	1/2p	200f	200frws
3	Tubes	20x20mm	1p	400f	400frws
4	Tee bar	2x20mm	1/4	400f	400frws
5	Flat bar	2x20mm	1/4	400f	400frws
6	Cutting disc	230x3x22 ,23mm	1p	2000f	2000frws
7	Grinding disc		1/2p	2000f	1000frws
Sub-Total					5600frws
Labor Cost (Main d'oeuvre)			(5600fx35) :100=9260f		
G.TOTAL			**6526frws**		

Prepared by……. Approved by……

The Importance of BOQ

BOQ shall be used in every phase (pre-contract & post-contract) of the project but need of BOQ differs based on different contract agreements & project. The major usages are listed below.

- It provides basic idea of the project by giving the quantities to tenderers.
- It defines the extent of the work.
- It gives estimated or anticipated contract sum. (very important to client)
- It provides a basis for valuation of variation. (Variation is to be discussed in detail).

Learning Unit 2 – Organize the workplace

LO 2.1. Arrange the workplace

Content/Topic 1. Work place layout

a. Cleaning of the workplace

The workplace cleaning protects the employees from getting injured, strengthens the brand image, and enhances the environment. If proper cleaning is not done at the workplace, then the regulatory bodies may compel the organization to close the facility. Apart from regular cleaning and dusting, here are some of the most crucial elements of workplace cleaning:

1**. Keep the Light Equipment Clean**

Good lighting is essential for commercial facilities. Therefore, the light fixtures ought to be cleaned regularly so that the accumulated dust doesn't affect the quality of light intensity in the room. Improper lighting has an impact on the performance of the workforce and also makes the place appear dingy.

2. Floor and Building Maintenance

The walls and the floors ought to be cleaned with perfection. If there are any oil, grease, or liquid spillages, then these must be cleaned immediately to prevent hazards from occurring. Warning signs must be placed if there are any spillages to make people aware. The walls should be painted in light color and the floors should be skid resistant.

3**. Upkeep the Tools and Equipment**

One of the basic elements of good cleaning is to check that the tools and equipment are functional. Inspection of tools should be done periodically in order to detect faulty equipment. Well-maintained tools and machinery prevent accidents from happening. Tools and equipment mist also be stored properly and should also have appropriate labels.

4. **Remove Clutter from Aisles and Stairways**

Most people trip over the stairways because of unnecessary clutter. Therefore, theses should always be kept clean and no object should be place in between that obstructs the path. Likewise, the aisles should be kept clean so that the movement between them is safe. Mirrors must be placed in blind corners so that no unforeseen injury takes place.

5. **Clean Storage Space**

A kempt storage space is a necessary element of good housekeeping. The packages must be stored on a solid base. The products must be secured in the storage areas properly so that they do not fall over. All hazardous products that can cause fore or any other catastrophe should be stored separately.

b. Fire fighting equipment arrangement

Every employee should know where the portable fire extinguishers, the hose reels and the controls for extinguishing are located and how to operate extinguishers in their working area. Training must include the use of extinguishers on simulated fires.

Portable fire extinguishers may be hanged on the workshop wall or stored in the safe place where it is easily reached in the case of fire.

All fire extinguishers manufactured to European Standard BS EN 3-7 are colored red with icons to indicate the type of fire to which they are suited and the means of operation.

The European Standard allows a small color zone at the top half front of the extinguisher body relating to the old British Standard extinguisher color coding system, i.e. red for water, cream for foam, blue for powder, black for CO2 and canary yellow for wet chemical.

The colors should be visible through a horizontal arc of 180° when the extinguisher is properly mounted. The area of the color zone should be up to 10% of the body area but not less than 3% of the body area.

LO 2.2. Select materials

Content/Topic 1. Type of metals:

The types of metals are classified according to their carbon content. Those are ferrous metals and non-ferrous metals.

The carbon content for ferrous metal like Cast Iron 2.5% carbon, mild Steel 0.15-0.3% carbon, medium Carbon Steel 0.35-0.7% carbon, High Carbon Steel 0.7-1.5% carbon, High-Speed Steel 0.35-0.7% carbon.

Below are some examples of ferrous metal with their carbon contents:

Item	Aprrox. % of Carbon
Pig iron	4%
White cast iron	3.5%
Gray cast iron	2.5 – 4.5%
Malleable cast iron	2 – 3.5%
Tool steel	0.9 – 1.7%
High-carbon steel	0.5 – 0.9%
Medium-carbon steel	0.3 – 0.5%
Cast steel	0.15 – 0.6%
Low-carbon steel	up to 0.3%

Ferrous Metals are the metals mostly contain Iron. They have small amounts of other metals or elements added, to give the required properties. Ferrous Metals are magnetic and give little resistance to corrosion. Some examples of the ferrous metals we deal with: steels and cast iron.

Non-Ferrous Metals do not contain Iron, are not magnetic and are usually more resistant to corrosion than ferrous metals.

Some examples of Non-Ferrous Metals we deal with are:

- Aluminium & Aluminium Alloys: Pure aluminium is light, soft, ductile, corrosion resistant and highly conductive to heat and electricity.

  One of the most important characteristics of aluminium and its alloys is the thin oxide film which forms on their surfaces when exposed to the atmosphere.
- Copper: it is a soft ductile material which increases in hardness and strength when cold-worked, i.e. in bending, spinning and drawing.

- Brass: is essentially an alloy of copper and zinc, but may also contain small amounts of other alloying elements to improve strength, corrosion resistance and machining characteristics.
- Lead: Lead in its pure state is very soft and has low mechanical strength. In this form it is used widely in the chemical industry, due to its high corrosion resistance.

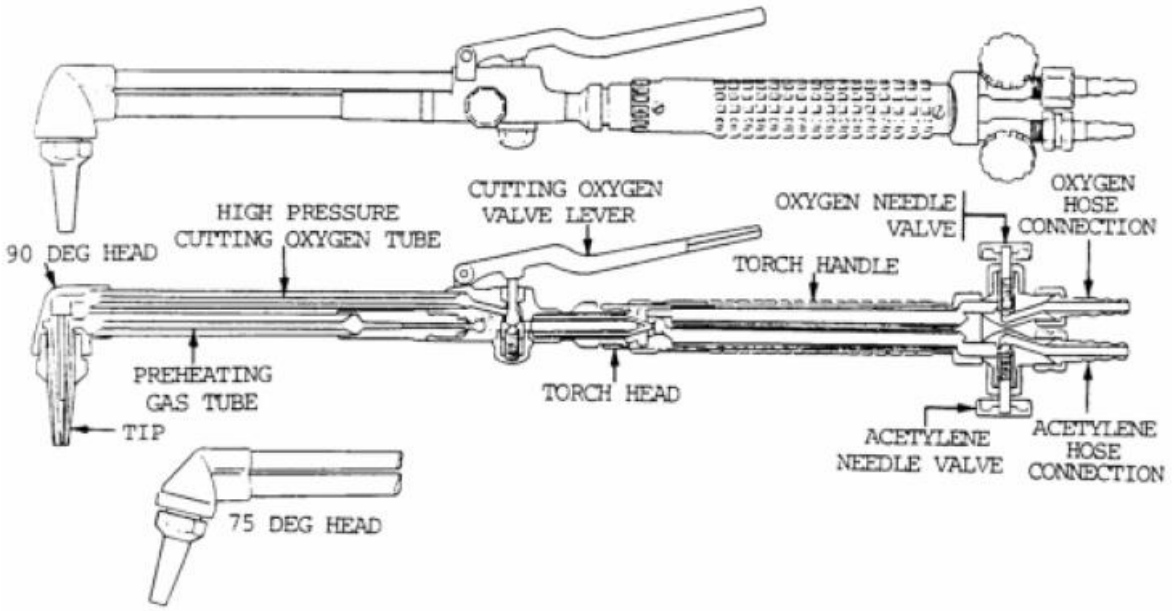
- Bronze: is essentially an alloy of copper and tin, but may also contain additional elements such as zinc and phosphorus.

LO 2.3 – Select cutting equipment

Content/Topic 1. Differentiate cutting equipment:

a. Oxy-acetylene gas cutting equipment

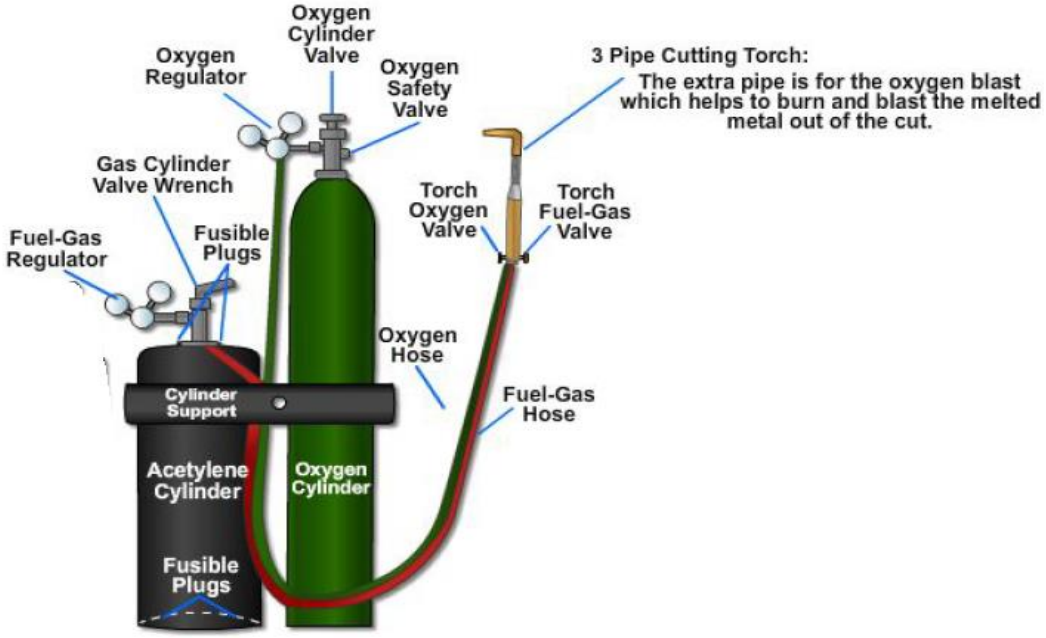
The equipment and accessories for oxy-gas cutting are the same as for oxy-gas welding except that you use a cutting torch or a cutting attachment instead of a welding torch. The main difference between the cutting torch and the welding torch is that the cutting torch has an additional tube for high-pressure oxygen, along with a cutting tip or nozzle. The tip is provided with a center hole through which a jet of pure oxygen passes. Mixed oxygen and acetylene pass through holes surrounding the center holes for the preheating flames. The number of orifices for oxyacetylene flames ranges from 2 to 6, depending on the purpose for which the tip is used. The cutting torch is controlled by a trigger or lever operated valve. The cutting torch is furnished with interchangeable tips for cutting steel from less than ¼" to more than 12.0" in thickness.



For a typical oxy-acetylene gas cutting outfit, also referred to as a cutting rig, you Need the following equipment:

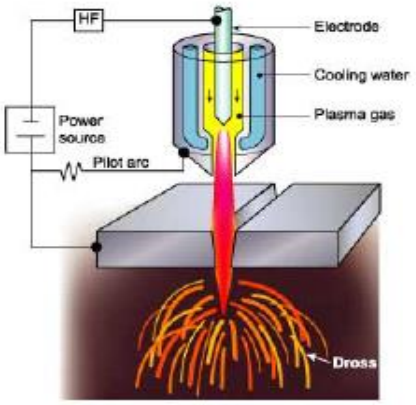
- A cylinder of acetylene or MAPP (C3H4 methyl-acetylene propadiene) gas
- A cylinder of oxygen

- Two pressure regulators
- Two lengths of hose (usually joined) with fittings
- A cutting torch with tips



b. Plasma cutter

The plasma arc cutting process is illustrated in figure below. The basic principle is that the arc formed between the electrode and the workpiece is constricted by a fine bore, copper nozzle. This increases the temperature and velocity of the plasma emanating from the nozzle. The temperature of the plasma is in excess of 20 000°C and the velocity can approach the speed of sound. When used for cutting, the plasma gas flow is increased so that the deeply penetrating plasma jet cuts through the material and molten material is removed in the efflux plasma.



The process differs from the oxy-fuel process in that the plasma process operates by using the arc to melt the metal whereas in the oxy-fuel process, the oxygen oxidizes the metal and the heat from the exothermic reaction melts the metal. Thus, unlike the oxy-fuel process, the plasma process can be applied to cutting metals which form refractory oxides such as stainless steel, aluminium, cast iron and non-ferrous alloys.

c. **Angle grinder**

An angle grinder, also known as a side grinder or disc grinder, is a handheld power tool used for grinding (abrasive cutting) and polishing. Although developed originally as tools for rigid abrasive discs, the availability of an interchangeable power source has encouraged their use with a wide variety of cutters and attachments.

Angle grinders can be powered by an electric motor, petrol engine or compressed air. The motor drives a geared head at a right-angle on which is mounted an abrasive disc or a thinner cut-off disc, either of which can be replaced when worn. Angle grinders typically have an adjustable guard and a side-handle for two-handed operation. Certain angle grinders, depending on their speed range, can be used as sanders, employing a sanding disc with a backing pad or disc. The backing system is typically made of hard plastic, phenolic resin, or medium-hard rubber depending on the amount of flexibility desired.

Angle grinders may be used for removing excess material from a piece. There are many different kinds of discs that are used for various materials and tasks, such as cut-off discs (diamond blade), abrasive grinding discs, grinding stones, sanding discs, wire brush wheels and polishing pads. The angle grinder has large bearings to counter side forces generated during cutting, unlike a power drill, where the force is axial.

In addition, angle grinders produce sparks when cutting ferrous metals. They also produce shards cutting other materials. The blades themselves may also break. This is a great hazard to the face and eyes especially, as well as other parts of the body, and as such, a full face shield and other protective clothing must be worn. Angle grinders should never be used without their guard or handle attached; they are there as a necessary precaution for safety. All work should be securely clamped or held firmly in a vise.

d. Cut-off machine

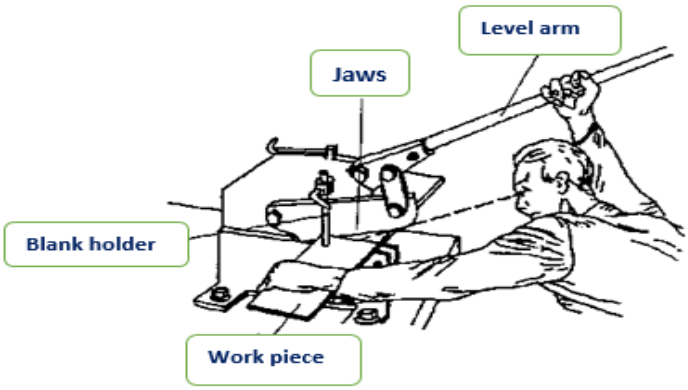
A cut-off machine also known as abrasive or chop saw is a circular saw (a kind of power tool) which typically used cut hard materials and/or steel plate. The cutting action is performed by an abrasive disc, similar to a thin grinding wheel.

These cut-off machine are available in a number of configurations including table top. In table top cut-off machine, the cutting wheel and motor are mounted on a pivoting arm

attached to a fixed base plate. They are designed with the handles and motor near the operator for providing motion on cutting disc, (as shown in figure above)

e. Shearing machine

Shearing is a cutting operation used to remove a blank of required dimensions from a large sheet. To understand the shearing mechanism, consider a metal being sheared between a punch and a die. Typical features of the sheet and the slug are also shown in this figure. As can be seen that cut edges are neither smooth nor perpendicular to the plane of the sheet.



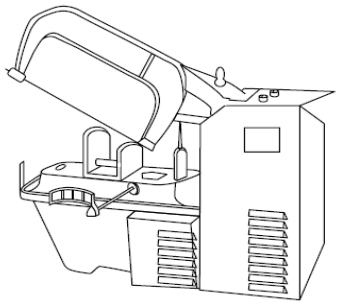
For cutting thicker metals, up to 1.5 mm, hand-lever shears are available, usually bench mounted.

The length of the lever and the linkage to the moving shear blade ensure adequate leverage to cut the thicker metals.

Where larger sheets are required to be cut with straight edges, the guillotine is used.

f. Power hacksaw machine

A power hacksaw is an essential machine in most machine shop operations. For many years a hand-operated hacksaw was the only means for sawing off metal. Power-driven machines for driving metal-cutting saw blades have been developed to make the task easier. The power hacksaw can do the work much more rapidly and accurately. The machinist should be familiar with these machines, the blades used on the machines, and the operations performed on them. One type of power hacksaw commonly found in machine shops is below:



Power hacksaws are designed to make the sawing of metal a mechanical operation. The stock is usually held in a vise mounted on the base of the machine. An electric motor is used to supply power for the machine.

LO 2.4 – Prepare equipment

Content/Topic 1. Assembling and dismantling of the cutting equipment

When assembling and dismantling of the plasma cutting equipment, Use the following guidance:

1. Properly secure the cylinder.

2. Before connecting a regulator, purge the valve of dust and debris.

3. When you attach a regulator to a cylinder, be sure it is in a fully closed condition.

Once you have opened the cylinder valve slowly, adjust the screw on the regulator slowly until you obtain the correct pressure.

4. When the cylinder is not in use, close the valve and the regulator.

For setting up an oxy acetylene torch, the important steps should be followed:

1. Ensure that the cylinders or tanks containing oxygen and acetylene are properly secured and in an upright position. Use a cylinder cart if available but if not, ensure that they are properly fastened or chained to a sturdy object, post, beam, or wall. They should never be knocked down during operation and even when not in use.

2. Remove any coverings placed on the valve of the cylinder or tank. But if protective covers were not used, remove any dust or debris that has settled inside the valves, which can cause the torch to malfunction. To do so, stand away from the valve's opening or outlet (preferably on its opposite side), turn the valve quickly about a quarter of the way, and immediately close it. This quick release of gas will immediately blow away the dust or debris.

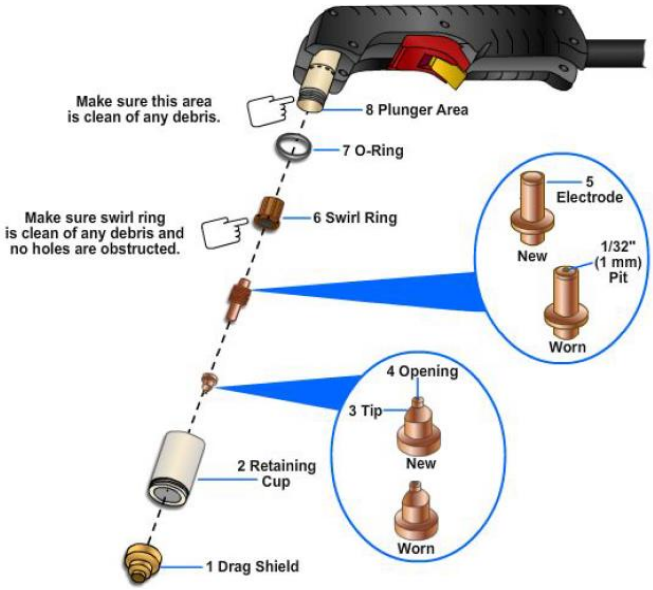
3. Connect the regulators to the valves but confirm first that they have the same threads. If not, use an adaptor to connect them. It is important that they have a completely tight and secure fit not just for safety but also for proper monitoring of the pressure settings. Manually screw them by hand as tight as you can, and use a wrench with a fixed opening to finish tightening them.

4. Attach the proper hoses if they are not yet connected to the respective regulators. If you have already used them before, connect them to the same tanks as before. Note that the standard practice is to use green hoses for oxygen and red hoses for acetylene. Never apply any oil, grease, or any form of lubricant to the hoses, especially on its ends.

When looking about assembling and dismantling of hacksaw, always start with taking a handle and then ix it with frame by means of adjusting screw, then the blade is ready to be fixed in frame by means of stud at handle and the wing nut adjuster at the end of frame.

Content/Topic 2. Checking the condition of the cutting equipment

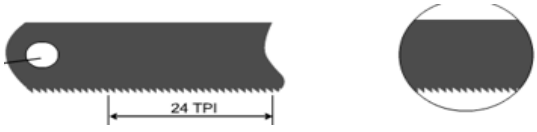
Good preventive maintenance on plasma cutting equipment requires keeping a supply of electrodes, tips, and shield cups on hand and replacing them as wear appears. You should inspect the shield cup, tip and electrode before each use, hourly during operation, or whenever the cutting speed has reduced significantly. The figure below shows a comparison of consumables inspection process.



For oxy-acetylene gas cutting, the general requirements include (follow manufacturer's directions):

1. Always check for tight hose connections and leaks
2. Blow out the cylinder value
3. Do not stand behind or in front of regulator when opening the cylinder value
4. First turn on cylinder value and then adjust the regulator pressure screw
5. Make sure mixing know is off before lighting torch
6. Never use with grease or oil. Do not handle with greasy gloves or oily hands.
7. Keep the work area clean
8. Note that oxyacetylene becomes unstable above 15 PSI, do not use above this level (oxygen max is 40 psi)
9. Do not pick up materials with gloves after cutting

For hacksaw cutting, it is necessary to check the condition of the cutting blade if it is firmly fixed and tightened correctly, then inspect if its blades is still sharp for easy cutting as shown in this figure.



Always also check tooth form and tooth set of a blade before cutting operation takes place.

Learning Unit 3. Carry out metal cuts

LO 3.1 – Set the cutting Equipment

Content/Topic 1. Setting of oxy- acetylene gas cutting equipment

a. Set the working pressure

One of the most widely used cutting tools around is the oxy-fuel or oxy acetylene cutting torch, also commonly referred to as the blow torch. While using a cutting torch is easy in theory, many people find it difficult to properly use, let alone make a proper cut. Most of them have no idea about the proper settings, particularly involving the working pressure, that is why the cuts they made are of poor quality.

The proper use of an oxy acetylene cutting torch, especially with the right pressure settings, ensures that the quality of the cuts made would rival that of machine cuts. Not only that, but this will also guarantee a safe operation.
Here are the important steps to follow when setting up an oxy acetylene torch:

- Ensure that the cylinders or tanks containing oxygen and acetylene are properly secured and in an upright position. Use a cylinder cart if available but if not, ensure that they are properly fastened or chained to a sturdy object, post, beam, or wall. They should never be knocked down during operation and even when not in use.
- Remove any coverings placed on the valve of the cylinder or tank. But if protective covers were not used, remove any dust or debris that has settled inside the valves, which can cause the torch to malfunction.
- Stand away from the valve's opening or outlet (preferably on its opposite side), turn the valve quickly about a quarter of the way, and immediately close it. This quick release of gas will immediately blow away the dust or debris.
- Connect the regulators to the valves but confirm first that they have the same threads. If not, use an adaptor to connect them. It is important that they have a completely tight and secure fit not just for safety but also for proper monitoring of the pressure settings.
- Manually screw them by hand as tight as you can, and use a wrench with a fixed opening to finish tightening them.
- Attach the proper hoses if they are not yet connected to the respective regulators. If you have already used them before, connect them to the same tanks as before. Note that the standard practice is to use green hoses for oxygen and red hoses for acetylene. Never apply any oil, grease, or any form of lubricant to the hoses, especially on its ends.
- Connect the torch handle to both of the hoses. Once they are securely attached, install the cutting torch to the handle and manually tighten the nut. Check the valves on both the cutting torch and its handle, as they must be closed before opening the valves of both cylinders.

- Turn the valve of the oxygen tank or cylinder until it is fully open. Locate the regulator's adjusting screw and turn it clockwise until the gauge shows that the pressure being released is between 40 to 60 psi. For the acetylene cylinder, do a counterclockwise turn for the valve, but only a quarter of the way. Turn the adjusting screw on the regulator until it releases acetylene and the gauge shows 10 psi.
- Find the oxygen valve of the cutting torch and open it slightly to allow oxygen to flow. Do the same for the cutting torch's acetylene valve but do not open it by more than 45 degrees or a 1/8 turn.
- To do a leak test, coat the valves and connections between the cylinder, hose, and regulators with a leak-test solution or a thin paste made by dissolving Ivory soap and use a clean brush for its application. A leak is present if you see any small bubbles on the coated surfaces after letting the solution sit for a few minutes. If leaks are present, you must retighten or reattach connections first and do another leak test before lighting the torch.
- Once there are no more leaks present, follow the manufacturer's instructions to light up the torch. Remember to watch the flame as you use the torch. If it goes out when using the torch, stop and simply relight the torch. This occurrence is known as a backfire and it happens when the torch itself and the metal being cut get into direct contact.

<u>Oxy-Acetylene Torch Working Pressure Settings</u>

- ✓ Adjust acetylene gas pressure by opening torch needle valve and turning fuel-gas regulator screw clockwise. Adjust regulator to working pressure needed for particular tip size; close torch needle valve.
- ✓ Adjust oxygen pressure by opening torch needle valve and proceed as with fuel-gas.

While there should be equal amounts of acetylene and oxygen to produce a neutral flame, you must observe the right pressure settings when working with an oxy-acetylene cutting torch. Note that the ratio of oxygen to acetylene is different from the pressure required. This means that oxygen and acetylene should not have equal psi readings.

In general, oxygen must have a higher pressure setting than acetylene. The actual setting will depend on the cutting tip being used and manufacturer recommendations. But as a rule, more pressure for both oxygen and acetylene is needed for bigger-sized cutting tips.

In case the recommended working pressure settings are not indicated, safe numbers are 40 psi for oxygen and 10 psi for acetylene, regardless of cutting tip size. Simply adjust them until you get a neutral flame, but pay close attention to the acetylene pressure to prevent it from exceeding the limit.

The maximum working pressure for acetylene gas when using a cutting torch is 15 psi or 103.4 kpa. If the pressure goes beyond that, raw acetylene gets unstable and becomes

dangerous to use. Acetylene is a flammable gas and when it becomes unstable, it is at risk of spontaneously combusting. Raw acetylene can cause an explosion even with a slight shock.

If the acetylene pressure exceeds 15 psi, it will use up the acetone present in the cylinder to be stable. While it has a positive effect on acetylene, it negatively affects the components of your system.

b. **Adjust the flame**

Adjusting an oxy-acetylene cutting flame is easy – especially when following the proper procedures. In addition to that, you must always be sure to follow the torch manufacturer's operating procedures.

First - before you attempt to light the torch follow these checks:

- Make sure regulator pressure adjustment screws are backed out!
- Make sure torch valves are closed!
- Stand away from front of regulator
- Separately and slowly open the oxygen and acetylene cylinder valves
- Adjust regulator pressure adjusting screws to tip pressure settings
- Open/close torch valves separately and fine tune pressure settings on regulators
- Depress cutting lever and adjust pressure if necessary

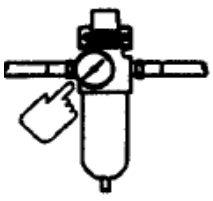
Adjusting the torch (with a positive/equal pressure mixer):

- ✓ Separately purge both oxygen and fuel gas lines
- ✓ Open fuel gas valve 1/2 turn
- ✓ Ignite flame with striker
- ✓ Increase fuel gas flow until flame leaves end of tip and no smoke is present
- ✓ Decrease until flame goes back to tip
- ✓ Open oxygen valve and adjust to neutral flame
- ✓ Depress oxygen lever and make necessary adjustments

Content/Topic 2. Setting of the plasma cutter

i. **Set the working pressure**

Air pressure required to operate the torches is anywhere between 55 to 70psi. low amperage cuts will require less air pressure for more stable operation, sometimes down to 45psi or so, or the arc will be blown out. In general, the blowback design torch found on the power plasma 50 work best around 60-60psi for most pressures. Simply look for signs such as dross (slag) residual, cleanness off cut lines, and kerf width to help you find the best pressure for the amp level and metal you are cutting



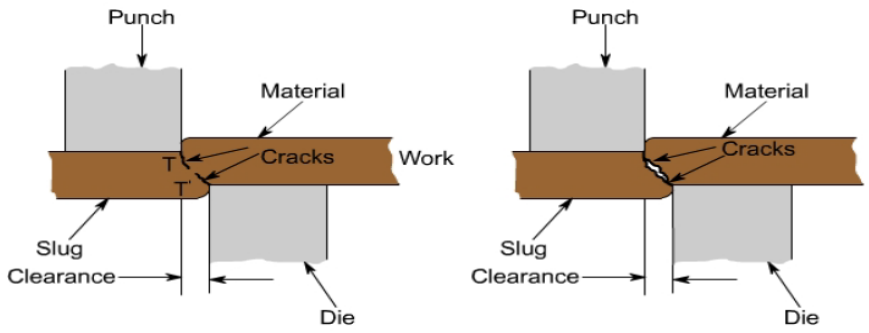
ii. Set the working current

The plasma cutter has output data Current adjustment range from 20A-100A Maximum current is 100A. Input data Supply voltage 440Volt, Frequency Hz 50-60 Below is the recommendation setting of power related to Working current

	Plate thickness mm	Speed mm/min	Orifice size mm	Power kW	Flow rate l/min
Aluminium	6	7607	3	60	82.6
	12	2536	3	70	82.6
	25	1268	4	80	94.4
	50	507	4	80	94.4
	75	380	5	90	94.4
	100	304	5	90	94.4
Stainless Steel	12	2536	3	60	70.8
	25	1268	4	80	80.2
	50	507	4	100	94.4
	75	406	5	100	94.4
	100	203	5	100	94.4

Content/Topic 3: Setting of shear cutting

Shearing a blank involves plastic deformation due to shear stress. Therefore, the force required for shearing is theoretically equal to the shear strength of blank material. Due to friction between blank and tool, the actual force required is always greater than the shear strength. Variation of punch force during shearing process is shown below. The maximum force required on the punch for shearing can be empirically given as: **Fmax = 0.7 tL** where **t** is blank thickness and **L** is the length of the sheared edge. For reducing the shearing force, the cutting edges of the punch are made at an angle. This ensures cutting of a small portion of the total length of cutting.



Shearing starts as the punch presses against the sheet metal. At first, cracks form in the sheet on both the top and bottom edges (marked T and T', in the figure). As the punch descends further, these cracks grow and eventually meet each other and the slug separates from the sheet. A close look at the fractured surfaces will reveal that these are quite rough and shiny; rough because of the cracks formed earlier, and shiny because of the contact and rubbing of the sheared edge against the walls of the die.

The clearance between the punch and the die plays an important role in the determination of the shape and quality of the sheared edge. There is an optimum range for the clearance, which is 2 to 10% of the sheet thickness, for the best results. If the clearance increases beyond this, the material tends to be pulled into the die and the edges of the

sheared zone become rougher. The ratio of the shining (burnished) area to the rough area on the sheared edge decreases with increasing clearance and sheet thickness. The quality of sheared edge is also affected by punch speed; greater the punch speed better the edge quality.

LO 3.2- Smooth cut of work piece

Content/Topic 1. Smooth cut with oxy- acetylene gas cutting equipment

Before you begin any cutting operation, make a thorough inspection of the area for any

combustible materials that could be ignited by sparks or slag. If you are burning into a wall, inspect the opposite side and post a fire watch as required.

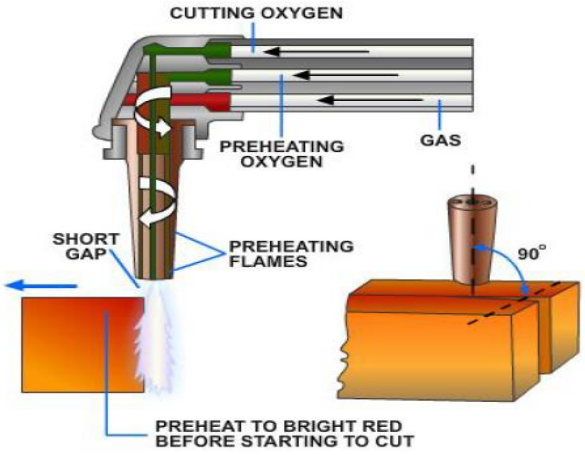
When you use the oxy-acetylene cutting process, proceed as follows:

- ✓ Heat a spot on the metal to kindling or ignition temperature (1400°F to 1600°F for steels)
- ✓ The term for this oxy-acetylene flame is the preheating flame.
- ✓ Press lever on the cutting torch to direct a jet of pure oxygen at the heated metal.

The oxygen causes a rapid chemical reaction known as oxidation. This rapid oxidation is called combustion or burning. Slow oxidation is known as rusting. When you use an oxy-acetylene gas torch to cut metal, the oxidation of the metal is extremely rapid and part of the metal actually burns. Heat, liberated by the burning of the iron or steel, melts the iron oxide formed by the chemical reaction and accelerates the preheating of the object. The molten material runs off as slag, exposing more iron or steel to the oxygen jet.

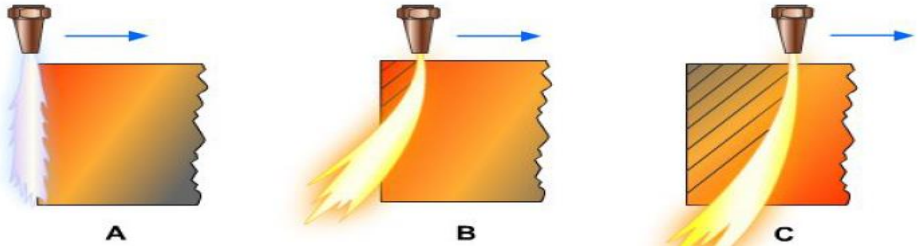
For smooth cutting of Mild-Carbon Steel;

- Hold the torch perpendicular to the work, with the inner cones of the preheating flames about 1/16 inch above the end of the line to be cut
- Hold the torch in this position until the spot you are heating is a bright red.
- Open the cutting oxygen valve slowly but steadily by pressing down on the cutting valve lever. When the cut is started correctly, a shower of sparks will fall from the opposite side of the work, indicating that the flame has pierced the metal.



A quality cut leaves the kerf walls fairly smooth and parallel with no excess of slag. When you develop your torch handling skills, you should be able to keep the cut within close tolerances; guide the cut along straight, curved, or irregular lines, and cut bevels or other shapes that require holding the torch at an angle.

For steel thicker than 1/8-inch, hold the torch so the tip is almost vertical to the surface. One method, if you are right-handed, is to start at the right edge and move to left. Left handed people tend to cut left to right but either direction is correct, and if conditions permit, cut in the direction that is most comfortable for you.

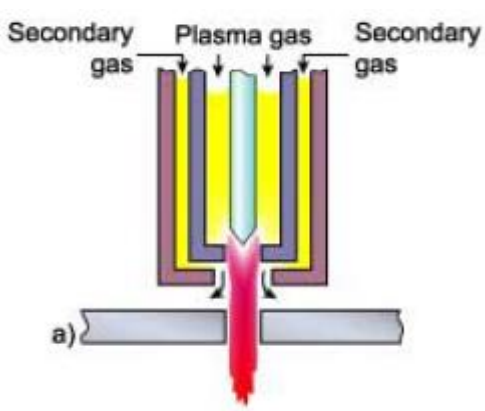


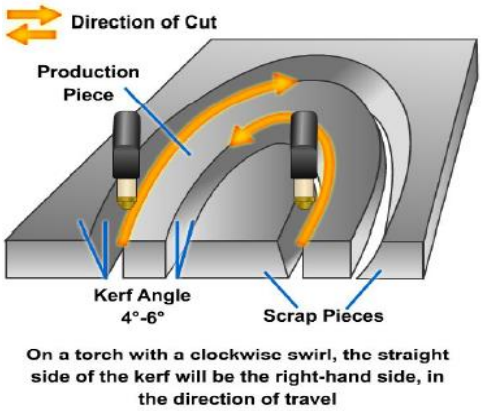
Carbon steels are easily cut by the oxy-acetylene process, but special techniques are required for cutting many other metals.

Content/Topic 2. Smooth cut with plasma cutter

The quality of the plasma cut edge is similar to that achieved with the oxy-fuel process. However, as the plasma process cuts by melting, a characteristic feature is the greater degree of melting towards the top of the metal resulting in top edge rounding, poor edge squareness or a bevel on the cut edge. As these limitations are associated with the degree of constriction of the arc, several torch designs are available to improve arc constriction to produce more uniform heating at the top and bottom of the cut.

The process operates basically in the same manner as the conventional system but a secondary gas shield is introduced around the nozzle, the beneficial effects of the secondary gas are increased arc constriction and more effective 'blowing away' of the dross. The plasma forming gas is normally argon, Argon-H or nitrogen and the secondary gas is selected according to the metal being cut.

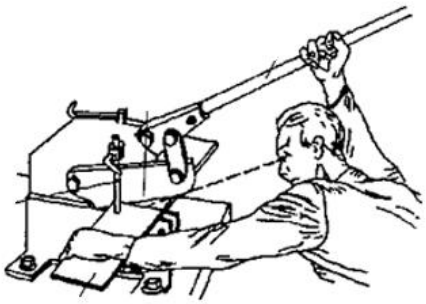




The basic principle is that the arc formed between the electrode and the workpiece is constricted by a fine bore, copper nozzle. This increases the temperature and velocity of the plasma emanating from the nozzle. The temperature of the plasma is in excess of 20 000°C and the velocity can approach the speed of sound. When used for cutting, the plasma gas flow is increased so that the deeply penetrating plasma jet cuts through the material and molten material is removed in the efflux plasma.

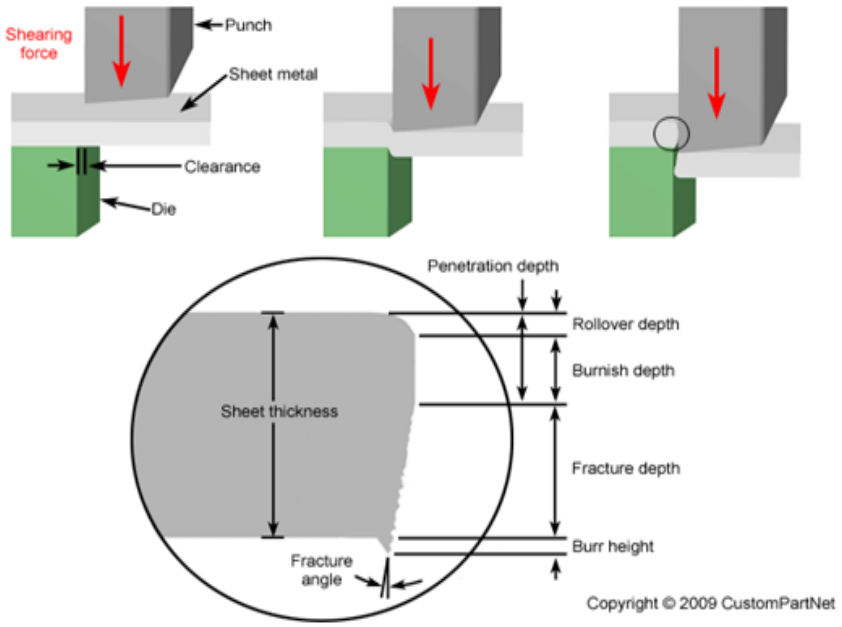
Content /Topic3. Smooth cut with shear cutter

Shearing is the process of cutting off of sheets using a die and punch, applying shear stress along the thickness of the sheet. To understand the shearing mechanism, consider a metal being sheared between a punch and a die, typical features of the sheet is shown in figure. As can be seen, the cut edges are neither smooth nor perpendicular to the plane of the sheet.



Shearing happens by severe plastic deformation locally followed by fracture which propagates deeper into the thickness of the blank.

The clearance between the die and punch is an important parameter which decides the shape of the sheared edge. Large clearance leads to rounded edge. The edge has distortion and has burr. The shearing load is also higher for larger clearance.



For harder materials and larger sheet thickness, larger clearances are required. Generally, clearance can vary between 2% and 8% of the sheet thickness.

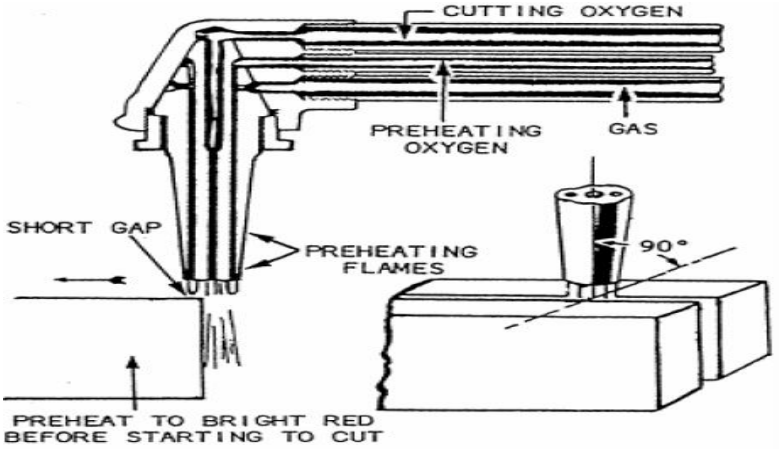
Usually shearing begins with formation of cracks on both sides of the blank, which propagates with application of shear force. A shiny, burnished surface forms at the sheared edge due to rubbing of the blank along the shear edge with the punch or the die wall. Shear zone width depends on the speed of punch motion. Larger speed leads to narrow shear zone, with smooth shear surface and vice-versa.

A rough burr surface forms if clearance is larger. Similarly, a ductile material will have burr of larger height. Shearing a blank involves plastic deformation due to shear stress. Therefore, the force required for shearing is theoretically equal to the shear strength of blank material. Due to friction between blank and tool, the actual force required is always greater than the shear strength. Variation of punch force during shearing process is shown below. The maximum force required on the punch for shearing can be empirically given as: Fmax = 0.7 tL t is blank thickness and L is the length of the sheared edge. For reducing the shearing force, the cutting edges of the punch are made at an angle. This ensures cutting of a small portion of the total length of cutting.

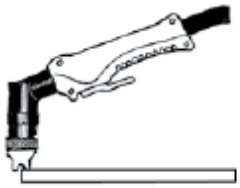
LO 3.3 – Position the work pieces

Content/Topic 1. Work pieces positioning during oxy- acetylene gas cutting

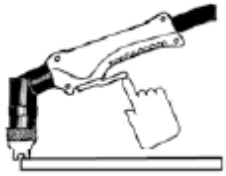
To cut mild-carbon steel with the oxyacetylene cutting torch, you should adjust the preheating flames to **neutral**. Hold the torch perpendicular to the work, with the inner cones of the preheating flames about 1/16 inches above the end of the line to be cut (refer figure below). Hold the torch in this position until the spot you are heating is a bright red. Open the cutting oxygen valve slowly but steadily by pressing down on the cutting valve lever.



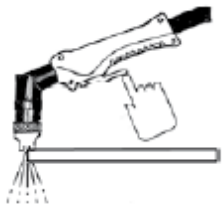
Content/Topic 2. Work pieces positioning on plasma cutter



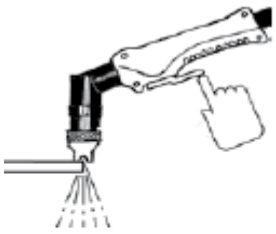
Place the torch in position for cutting or gouging. For most cutting operations the contact cutting shield should be used. It is placed directly on the work piece at the edge where cutting should start



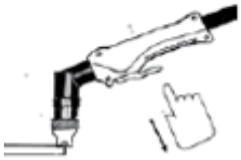
Press the trigger-switch on the torch handle. Air will flow for one second before the pilot arc strikes. The pilot arc will burn for about 3 seconds.
If contact with the work piece is not obtained within this time, the pilot arc goes out. Reposition the torch to ensure that the pilot arc will reach the work-piece and make a new try.



When the cutting arc is established, pull the torch slowly across the surface that is to be cut. At correct speed the sparks go straight through the metal with only a slight bending towards the beginning of the cut



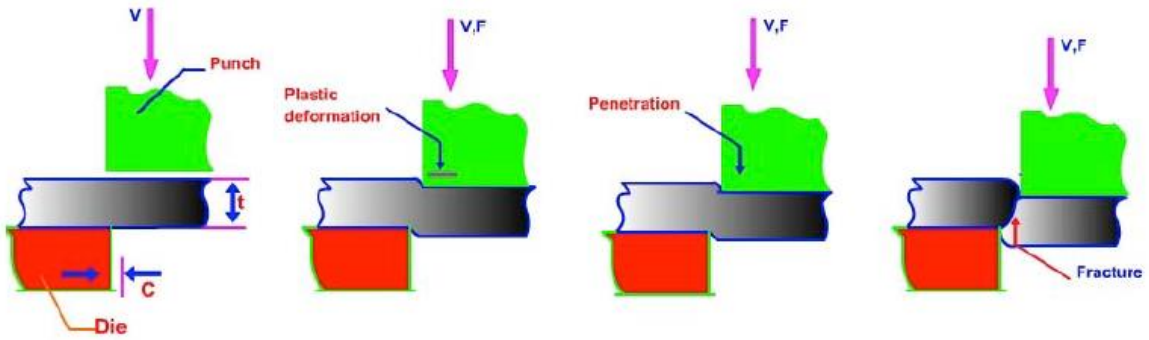
Pause briefly at the end of cut before releasing the trigger.



The plasma arc goes out immediately. Air will continue to flow for about 30 seconds.

Content /Topic3. Work pieces positioning during shear cutting

Considering the shearing of a blank, we understand that the top surface of the sheet where the punch contacts the blank, a small projection called rollover forms. This region corresponds to the small depression made by the punch on the sheet. Below this, the burnished surface which is a smooth surface formed by the rubbing of the shear surface against die and punch is present. The burnished surface is located below the rollover in case of a blank. Whereas, the burnished region is located on the upper side in case of a punched sheet. In the case of a punched hole on a sheet, the fracture zone is located below the burnished zone.



The burr forms below the fracture zone. Burr is a sharp edge formed at the end of the process due to elongation of the material before completely getting severed off. The depth of the deformation zone depends on the ductility of the sheet metal. If ductility is small, the depth of this zone is small. The depth of penetration of the punch into the sheet is the sum of the rollover height and burnishing zone height. The depth of rough zone increases with increase in ductility, sheet thickness or clearance. There is severe shear deformation in the fracture zone.

LO 3.4 – Clean the work piece after cutting

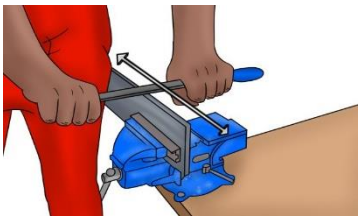
Content/Topic 1. Cleaning techniques

a. Grinding

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool to remove some amount of material on a given workpieces in order to obtain the desired sizes and shape of the finished product

b. Filing

Filing is a machining process that uses a file as the cutting tool to remove some amount of material on a given workpieces in order to obtain the desired sizes and shape of the finished product



c. Brushing

Brushing is a process of removing some amount of material on a given workpieces by using wire brush in order to obtain the desired sizes and shape of the finished product

d. Polishing

Polishing is a finishing process for smoothing the workpieces' surface using an abrasive and a work wheel

Learning Unit 4. Perform Housekeeping

LO 4.1 – Clean tools, equipment and workplace

Content/Topic 1. Cleaning tools and materials:

Following are some of the equipment and tools which you will come across during the process of cleaning.

a. **Brush**: It is used for cleaning the working surface prior to welding and general cleaning of the weldment. Most of the brushes used for cleaning tools and equipment in workshops are wire brushes.

b. **Cloth rugs -** these are made of soft absorbent cloth such as flannel. Dry polishing cloth helps to clean and shine the polished surfaces by rubbing them vigorously.

c. **Mops:** a tool for cleaning floors made of a bundle of cloth or yarn or a sponge fastened to a long handle, something that looks like a cloth or yarn mop. this process is known as mopping and is generally coarser than a duster. Mopping is mostly done on floors.

d. **Soapy water:** is a mixture of powder detergent in water used for cleaning equipment and/or workplace.
e. **Compressed air**: air which is compressed by air compressor then perform cleaning process, an air compressor is a pneumatic machine used for cleaning tools and even heavy machinery in the workshop.

Content/Topic 2. Methods of cleaning

a. **Dusting:** the term “dust” is already familiar, but how dust should be removed? If any surface is wiped with a piece of dry cloth (duster), it carries the loose dust with it and the process is known as dusting. This should be done with a clean soft cloth or soft brushes.

b. **Removal of dirt:** this is the process of removing dirt on tools and equipment. sometimes mopping alone is not sufficient to remove dirt. Such surfaces are then scrubbed with the help of a yard (bamboo) broom along with plenty of water.

Eventually the dirt loosens and is carried off by water. In case of tougher stains or dirt, detergent may be added to the water.

c. **Chemical spraying**: Chemicals was mostly sprayed on farms, around the home, in gardens, parks and reserves to control pests and diseases, now it can also be used in workshops for the purpose of cleaning most equipment and/or tools used there.

During chemicals spraying, care must be taken to avoid hazards because droplets are produced that can remain suspended in air and may be carried by wind away from the target area.

LO 4.2 – Store tools, equipment and materials

Content/Topic 1. Care and storage procedures of tools, equipment and materials

Regardless of the location in which you store your tools, you may want to consider storing them in a sand/oil mixture, which can be used for years. This can be done by using a five-gallon bucket filled with sand and a half gallon of mineral (or motor) oil. Shovels, hoes, pitchforks, etc., can all be stored in this mixture. These buckets may be used year after year as long as they are kept away from rain. Simply add oil each year as needed.

In addition to buckets containing a sand/oil mixture, other methods can be used to preserve your tools. Below are some more tips for storing your gardening equipment:

Put clean tools in an empty plastic container, such as a trashcan. Also, consider hanging tools up on a rack or installing brackets to hold and organize your equipment. Hardware stores offer strong adhesives to hold tools that will not leave residue when you decide to remove the bonding agents. Both of these methods will keep your tools off of the ground, away from dirt and bugs, and out from underfoot.

Gloves should always be kept in a closed container so your hand will not get eaten by visitors when you put them on. Consider using an empty coffee can, ice cream tub or a popcorn tin that can also hold random excess nuts and bolts that may be lying around. Space bags that use vacuum suction to remove air can also be a nice place to protect gloves when storing them for a longer period of time.

Special care should be taken to store larger machines such as lawn mowers and big power tools in accordance with manufacturer directions.

Hoses should be drained before storage. Also, roll up hoses to prevent them from getting cracked or being damaged during moves.

Put chemicals and fertilizers in a locked case away from children and pets.

Gardening tools should be kept in a cool, dry place, such as a garage or storage unit. This will help keep your valuables away from humidity.

Overall, be sure to take care of your tools to ensure their longevity and efficiency. Inspect your tools each season and take the proper steps, some of which are mentioned above, to keep them in good condition.

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