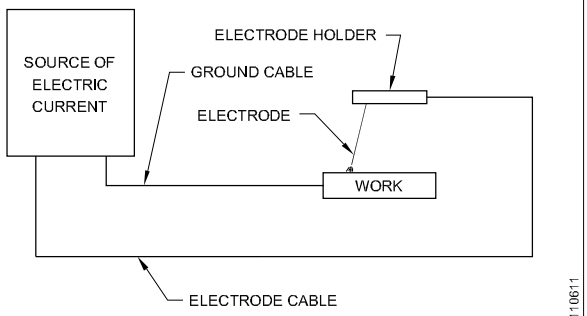
Arc welding machines

Objectives : At the end of this lesson you shall be able to
- **state the necessity of an arc welding machine**
- **name the different types of arc welding machine.**

In arc welding process, the source of heat is electricity. (High ampere-low voltage)

The required electrical energy for welding is obtained from an arc welding machine, a power source. (Fig 1)

Fig 1

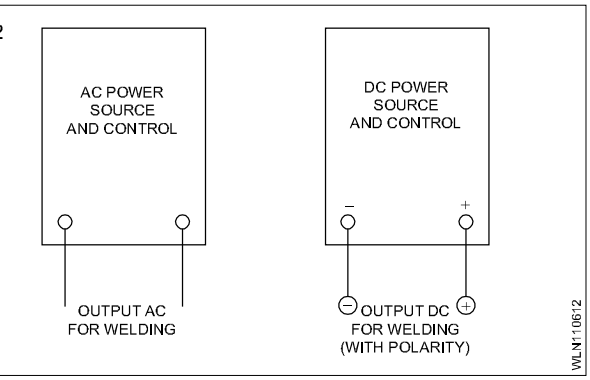


SIMPLE WELDING CIRCUIT

Necessity

- The equipment is used to
- Provide Ac or DC welding supply for arc welding
- Provide higher voltage (OCV) for striking the arc and lower voltage (AV) for maintaining the arc
- Change the high voltage of the main supply (AC) to low voltage and heavy current supply (AC or DC) suitable for arc welding
- Establish a relationship between arc voltage and welding current
- Control and adjust the required welding current during arc welding
- Weld with all gauges of electrode
- Weld thin and thick plates. both ferrous and non-ferrous metals.

Fig 2



Type (Fig 2): Basically power sources are:

- Alternating current welding machine
- Direct current welding machine.

These may be further classified as DC machines and AC machines.

DC machines

- Motor generator set
- Engine generator set
- Rectifier set

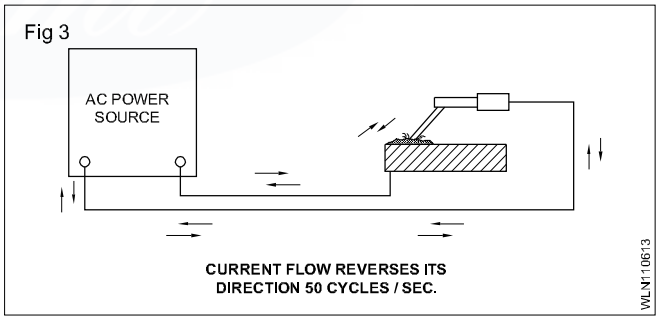
AC machines

- Transformer sets

AC means alternating current. It changes or reverses its direction of flow of current 50 times per second, if it is 50 cycles/sec. (Fig 3)

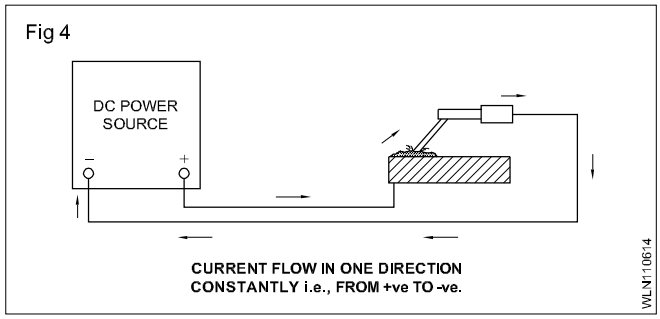
DC means direct current. it flows steadily and constantly in one direction. (Fig 4)

Fig 3



CURRENT FLOW REVERSES ITS DIRECTION 50 CYCLES / SEC.

Fig 4



CURRENT FLOW IN ONE DIRECTION CONSTANTLY i.e., FROM +ve TO -ve.

Care and maintenance of arc welding machines and accessories

Every machine and accessory used for any useful purpose requires some care and maintenance to increase its usage for a long time. In the case of arc welding machines and accessories the following points are important.

Arc welding machines: Do not keep the machine in open air. In a DC welding generator do not put the starting switch on DELTA position directly: keep the switch on START position first. Run it for a few seconds and then put the switch in DELTA position. Do not disconnect the cooling fan of a welding generator.

Maintain the cooling oil in the transformer welding set.

Periodically drain the cooling oil from the transformer and purify, and refill the transformer. Fix the input cables form the mains to the machine and the electrode and earth cable firmly. Replace the carbon brushes of the DC welding generator whenever necessary.

Do not clean any welding machine with water. The dust and other impurities are to be removed by compressed air only. Operate all control knobs and handles gently.

Avoid loose connections at the main fuses, starting switch.etc.

Arc welding accessories: Ensure the welding and earth cables are of standard amperage. The cables are to be joined only by sockets. Use the right capacity electrode holder and earth clamp. Avoid temporary arrangements to join cables or to connect earth clamp with the table or job. Avoid direct contact of electrode-holder with work table or job or earth connections. For this, hang the electrode-holder on the insulated hanger of the welding table. Use a properly insulated electrode-holder. Avoid over running of the trolley wheel etc. on the welding or return cable. Avoid stray arcing on the work table or on the job.

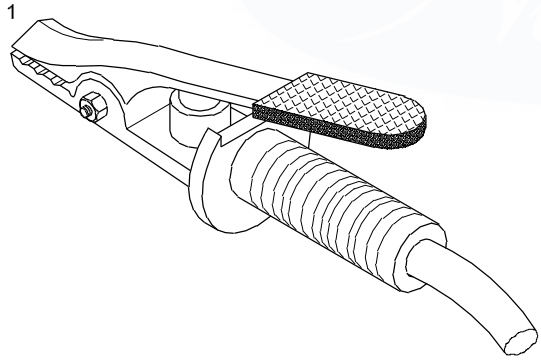
Arc welding accessories

Objectives: At the end of this lesson you shall be able to
- **identify the arc welding accessories**
- **explain the function of each accessory.**

Arc welding accessories: Some very important items, used by a welder with an arc welding machine during the welding operation, are called arc welding accessories.

Electrode-holder (Fig 1): It is a clamping device used to grip and manipulate the electrode during arc welding. It is made of copper/copper alloy for better electrical conductivity.

Fig 1



ELECTRODE HOLDER

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Partially or fully insulated holders are made in various sizes i.e. 200 - 300 - 500 amps.

The electrode-holder is connected to the welding machine by a welding cable.

Earth clamp (Fig 2): It is used to connect the earth cable firmly to the job on welding table. It is also made of copper/ copper alloys.

Screw or spring-loaded earth clamps are made in various sizes i.e. 200 - 300 - 500 amps. (Fig 3)

Welding cables/leads: These are used to carry the welding current from the welding machine to the work and back.

Fig 2

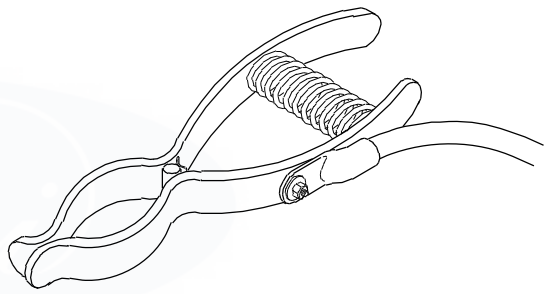

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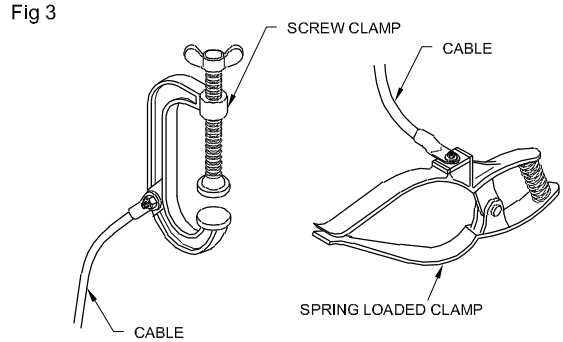
Fig 3



WORK CABLE ATTACHMENTS

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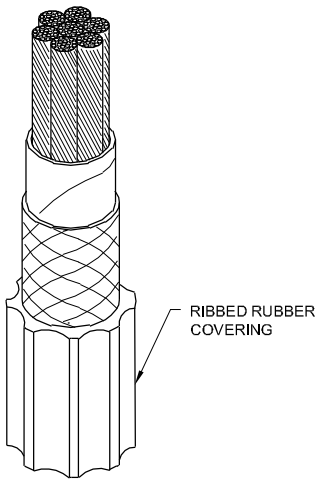
The lead from the welding machine to the electrode-holder is called electrode cable.

The lead from the work or job through the earth clamp to the welding machine is called earth (ground) cable.

Cables are made of super flexible rubber insulation, having fine copper wires and woven fabric reinforcing layers. (Fig4)

Welding cables are made in various sizes (cross-sections) i.e. 300, 400, 600 amps etc.

Fig 4



WELDING CABLE WITH HEAVY RIBBED
OUTER RUBBER COVERING

WLN110624

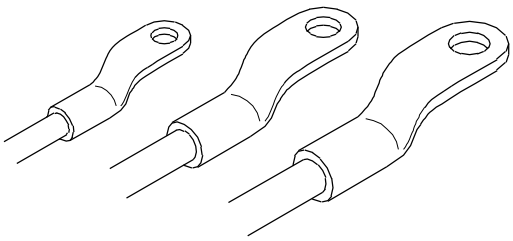
Loose joints or bad contacts cause overheating of the cables.

The same size welding cables must be used for the electrode and the job.

The cable connection must be made with suitable cable attachments (lugs). (Fig 5)

The length of the cable has considerable effect on the size to be used. (See Table1.)

Fig 5



LUGS FOR WELDING LEADS

THE THREE SIZES WILL FIT CABLES FROM NO 6 TO 4/0.
THEY MAY BE CONNECTED TO THE LEAD BY SOLDERING
OR MECHANICAL CRIMPING

WLN110625

Table 1

Recommendations of copper cable for arc welding

Cable dia.	Lengths of cable in metres current capacity in amperes		
(mm)	0 - 15	15 - 30	30 - 75
24.0	600	600	400
21.0	500	400	300
19.0	400	350	300
18.0	300	300	200
16.5	250	200	175
15.5	200	195	150
14.5	150	150	100
13.5	125	100	75

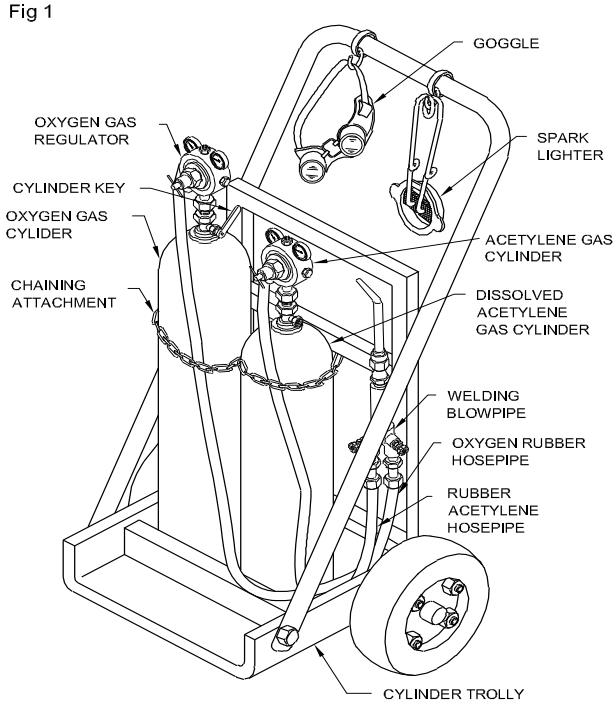
High pressure oxy-acetylene welding equipment and accessories

Objectives: At the end of this lesson you shall be able to

- **distinguish between the features of oxygen and acetylene gas cylinders**
- **compare the features of oxygen and acetylene gas regulators**
- **distinguish between the house-connectors used in oxygen and acetylene regulators**
- **describe the function of hose-protectors**
- **state the functions of blowpipes and nozzles.**

Oxy-acetylene welding is a method of joining metals by heating them to the melting point using a mixture of oxygen and acetylene gases. (Fig 1)

Fig 1



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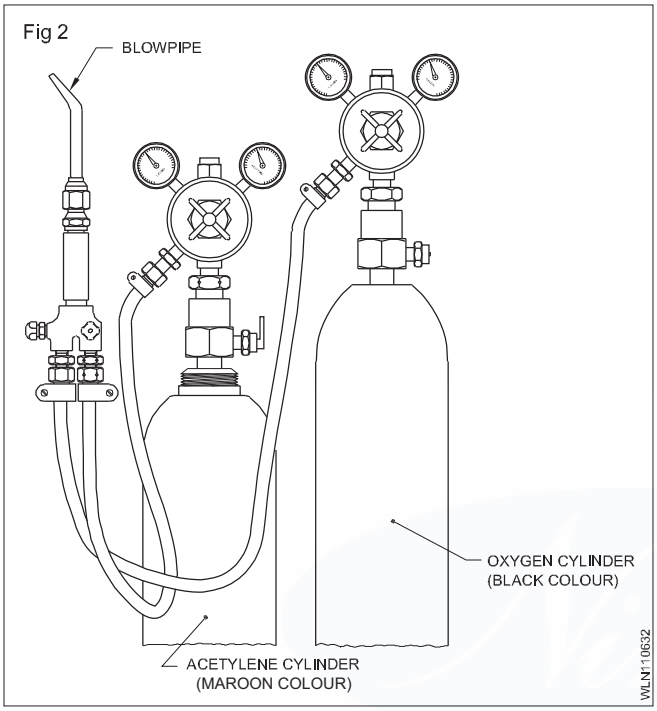
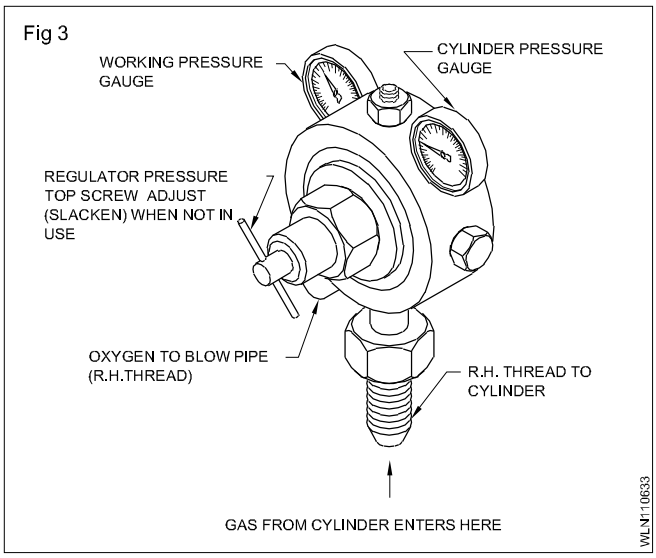
Oxygen gas cylinders: The oxygen required for gas welding is stored in bottle-shaped cylinders. These cylinders are painted in black colour. (Fig 2) Oxygen cylinders can store gas to a capacity of 7 m^3 with the pressure ranging between 120 to 150 kg/cm^2 . Oxygen gas cylinder valves are right hand threaded.

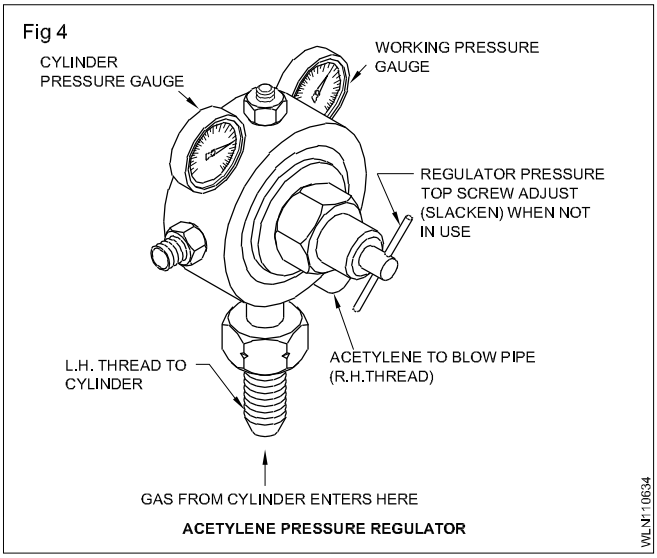
Dissolved acetylene cylinders: The acetylene gas used in gas welding is stored in steel bottles (cylinders) painted in maroon colour. The normal storing capacity of storing acetylene in dissolved state is 6m^3 with the pressure ranging between 15-16 kg/cm^2.



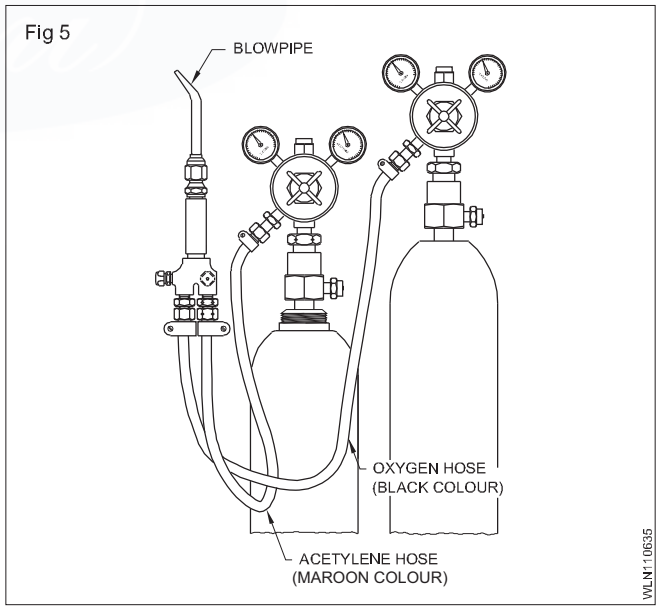
Oxygen pressure regulator: This is used to reduce the oxygen cylinder gas pressure according to the required working pressure and to control the flow of oxygen at a constant rate to the blowpipe. The threaded connections are right hand threaded. (Fig 3)



Acetylene regulator: As with the case of oxygen regulator this also is used to reduce the cylinder gas pressure to the required working pressure and to control the flow of acetylene gas at a constant rate to the blowpipe. The threaded connections are left handed, for quickly identifying the acetylene regulator, a groove is cut at the corners of the but. (Fig 4)

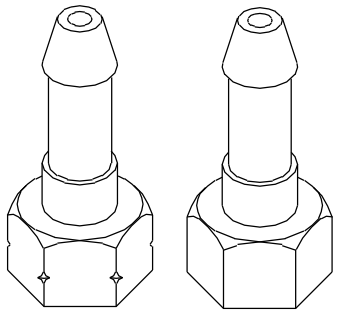


Rubber hose-pipes and connections: These are used to carry gas from the regulator to the blowpipe. These are made of strong canvas rubber having good flexibility. Hosepipes which carry oxygen are black in colour and the acetylene hoses are of maroon colour (Fig 5)



Rubber hoses are connected to regulators with the help of unions. These unions are right hand threaded for oxygen and left hand threaded for acetylene. Acetylene hose unions have a groove cut on the corners. (Fig 6)

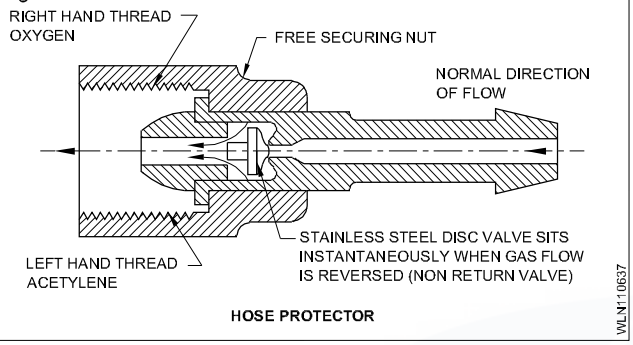
Fig 6



WLN110636

At the blowpipe end of the rubber hoses-protectors are fitted. The hose protectors are in the shape of a connecting union and have a non-return disc fitted inside to protect from flashback and backfire during welding. (Fig 7)

Fig 7



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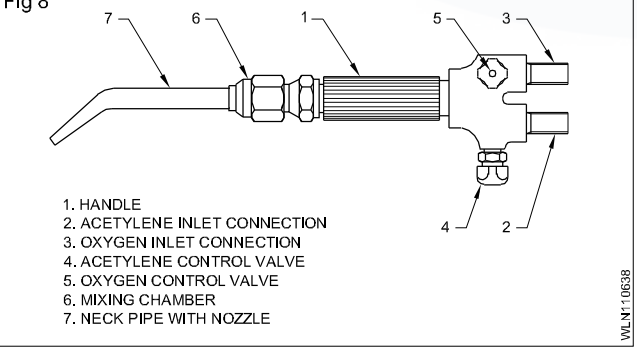
Blowpipe and nozzle: Blowpipe are used to control and mix the oxygen and acetylene gases to the required proportion. (Fig 8)

Fig 8



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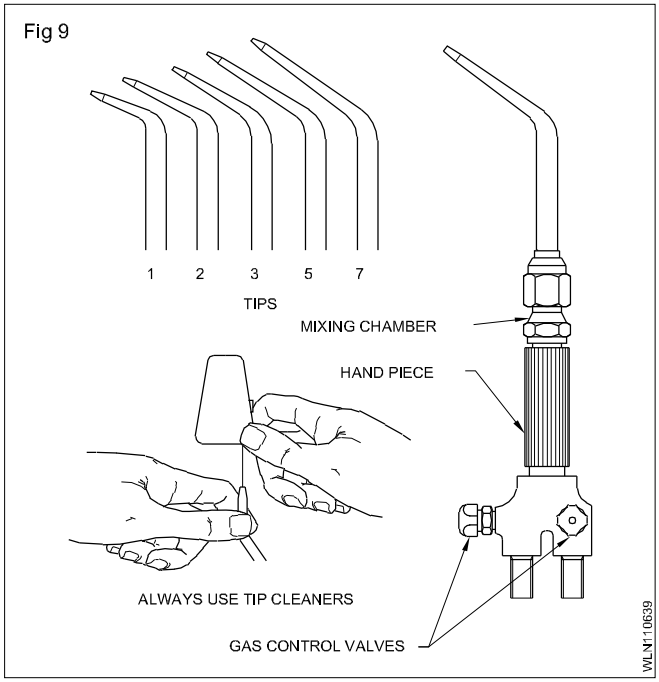
A set of interchangeable nozzles/tips of different sizes is available to produce smaller bigger flames. (Fig 9)

Fig 9



WLN110639

The size of the nozzle varies according to the thickness of the plates to be welded. (Table)

Table 1

plate thickness	Nozzle size
mm	Number
0.8	1
1.2	2
1.6	3
2.4	5
3.0	7
4.0	10
5.0	13
6.0	18
8.0	25
10.0	35
12.0	45
19.0	55
25.0	70
Over 25 .0	90

Gas welding hand tools

Objectives: At the end of this lesson you shall be able to

- **identify and name the hand tools used by a welder**
- **state their uses**
- **state the care and maintenance to keep the hand tool in good working condition.**

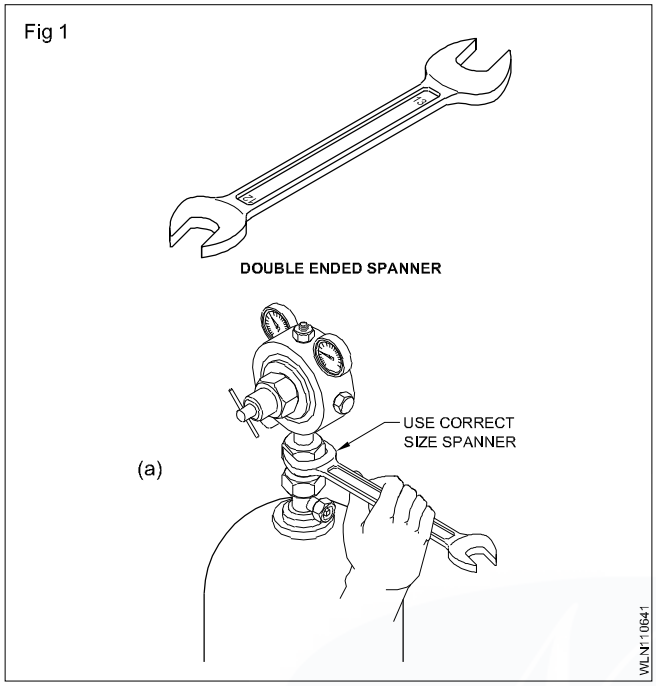
The following are the details of different hand tools used by a welder.

Double ended spanner: A double ended spanner is shown in Fig.1 and 1a. It is made of forged chrome vanadium steel. It is used to loosen or tighten nuts, bolts

with hexagonal or square heads. The size of the spanner is marked on it as shown in Fig 1. In welding practice the spanners are used to fix the regulator onto the gas cylinder valves, hose connector and protector to the regulator and blow pipe, fix the cable lugs to the arc welding machine output terminals, etc.

Do not use any size of hammer; use the correct size of spanner to avoid damage to the nut/bolt head,

Fig 1



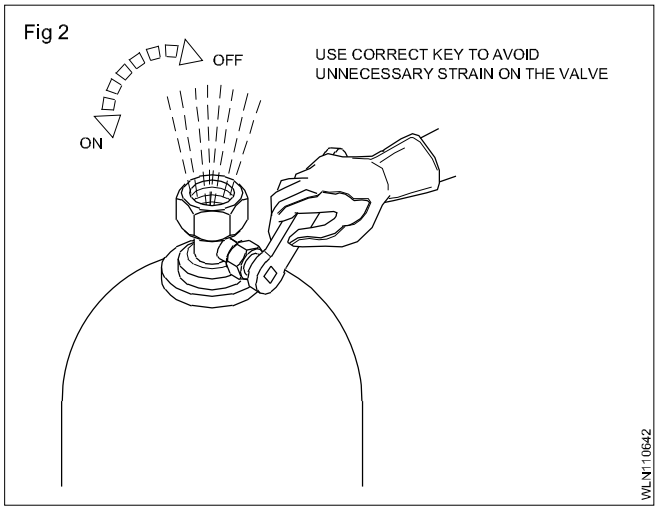
Cylinder Key: A cylinder key is shown in Fig 2. It is used to open or close the gas cylinder valve socket to permit or stop the gas flow from the cylinder to the regulator.

Always use correct size key to avoid damage to the square rod used to operate the valve. The key must always be left on the valve socket-itself so that the gas flow can be stopped immediately in case of flash back/back fire.

Nozzle or tip cleaner

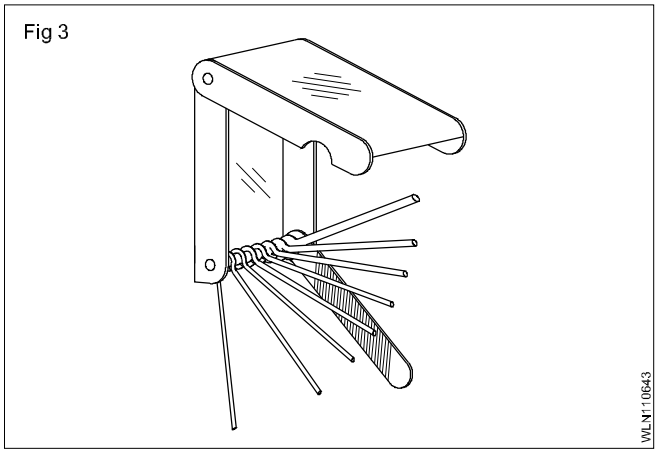
Cleaning the tip: All welding torch tips are made of copper. They can be damaged by the slightest rough handling. Dropping, tapping or chopping with the tip on the work may damage the tip beyond repair.

Fig 2



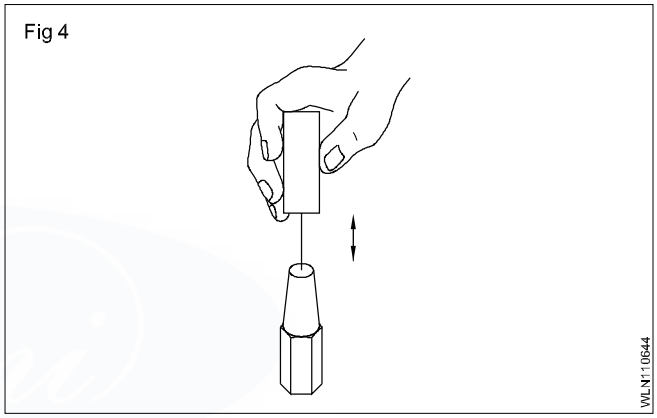
Tip cleaner: A Special tip cleaner is supplied with the torch container. For each tip there is a kind of drill and a smooth file Fig 3.

Fig 3



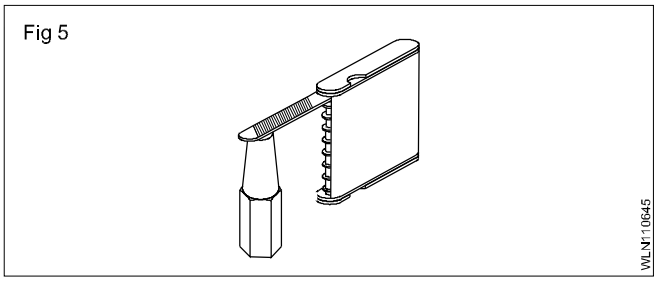
Before cleaning the tip, select the correct drill and move it, without turning, up and down through the tip Fig 4.

Fig 4



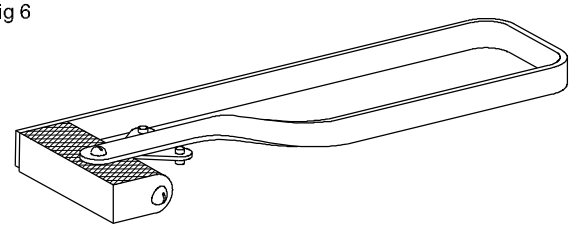
The smooth file is then used to clean the surface of the tip Fig 5. While cleaning, leave the oxygen valve partly open to blow out the dust.

Fig 5



Spark lighter: The spark lighter, as illustrated in Fig 6 & 7 is used for igniting the torch. While welding, form the habit of always employing a spark lighter to light a torch. Never use matches. The use of matches for this purpose is very dangerous because the puff of the flame produced by the ignition of the acetylene flowing from the tip is likely to burn your hand.

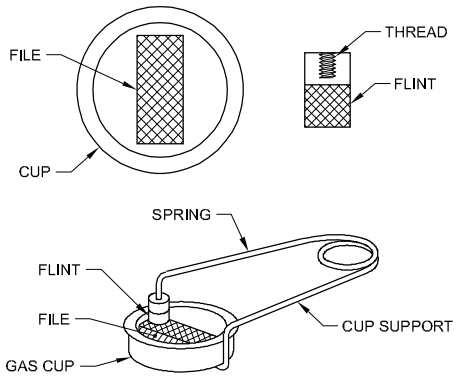
Fig 6



ALWAYS USE A SPARKLIGHTER TO LIGHT A TORCH

WLN110646

Fig 7



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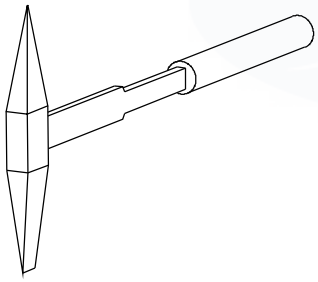
Chipping hammer: The chipping hammer (Fig 8) Is used to remove the slag which covers the deposited weld bead. It is made of medium carbon steel with a mild steel handle. It is provided with a chisel edge on one end and a point on the other end for chipping off slag in any position.

Fig 8



CHIPPING HAMMER

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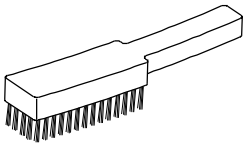
Care should be taken to maintain the sharp chisel edge and the point for effective chipping of slag.

Carbon steel wire brush: A carbon steel wire brush is shown in Fig 9. It is used for

- Cleaning the work surface from rust, oxide and other dirt etc. prior to welding.
- Cleaning the inter bead weld deposits after chipping off the slag
- General cleaning of the weldment.

Fig 9



WIRE BRUSH

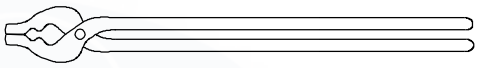
WLN110649

A stainless steel wire brush is used for cleaning a non ferrous and stainless steel welded joint.

It is made of bunch of steel wires fitted in three to five rows on a wooden piece with handle. The wires are hardened and tempered for long life and to ensure good cleaning action.

Tongs: Fig.10 and Fig.11 show a pair of tongs used to hold hot work pieces and to hold the job in position.

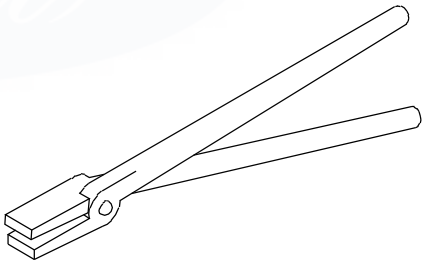
Fig 10



TONGS

WLN11064A

Fig 11



TONGS

WLN11064B

Various welding processes and their application

Objectives: At the end of this lesson you shall be able to
- **state and classify the electric welding processes**
- **state and classify the gas welding processes**
- **name and classify the other welding processes**
- **state the applications of various welding processes.**

According to the sources of heat, welding processes can be broadly classified as:

- Electric welding processes (heat source is electricity)
- Gas welding processes (heat source is gas flame)
- Other welding processes (heat source is neither electricity nor gas flame)

Electric welding processes can be classified as:-

- Electric arc welding
- Electric resistance welding
- Laser welding
- Electron beam welding
- induction welding

Electric arc welding can be further classified as:

- Shielded Metal Arc Welding/Manual Metal Arc Welding
- Carbon arc welding
- Atomic hydrogen arc welding
- Gas Tungsten Arc Welding / TIG Welding
- Gas Metal Arc Welding / MIG/MAG Welding
- Flux cored arc welding
- Submerged arc welding
- Electro-slag welding
- Plasma arc welding

Electric resistance welding can be further classified as:

- Spot welding
- Seam welding
- Butt welding
- Flash butt welding
- Projection welding.

Gas welding processes can be classified as:

- Oxy-acetylene gas welding
- Oxy-hydrogen gas welding
- Oxy-coal gas welding
- Oxy-liquified petroleum gas welding
- Air acetylene gas welding.

The other welding processes are:

- Thermit welding
- Forge welding
- Friction welding
- Ultrasonic welding
- Explosive welding
- Cold pressure welding
- Plastic welding.

Code	Welding process
AAW	Air Acetylene
AHW	Atomic Hydrogen
BMAW	Bare Metal Arc
CAW	Carbon Arc
EBW	Electron Beam
EGW	Electro Gas
ESM	Electro slag
FCAW	Flux Cored Arc
FW	Flash
FLOW	Flow
GCAW	Gas Carbon Arc
GMAW	Gas Metal Arc
GTAW	Gas Tungsten Arc
IW	Induction
LBW	Laser Beam
OAW	Oxy-Acetylene
OHW	Oxy-Hydrogen
PAW	Plasma Arc
PGW	Pressure Gas
RPW	Resistance Projection
RSEW	Resistance Seam
RSW	Resistance Spot
SAW	Submerged Arc
SMAW	Shielded Metal Arc

SCAW	Shielded Carbon Arc
SW	Stud Arc
TW	Thermit
UW	Ultrasonic

Applications of Various welding processes

Forge welding: It is used in olden days for joining metals as a lap and butt joint.

Shielded Metal arc welding is used for welding all ferrous and non-ferrous metals using consumable stick electrodes,

Carbon arc welding is used for welding all ferrous and non-ferrous metals using carbon electrodes and separate filler metal. But this is a slow welding process and so not used now-a-days.

Submerged arc welding is used for welding ferrous metals, thicker plates and for more production.

Co_2 Welding (Gas Metal Arc Welding) is used for welding ferrous metals using continuously fed filler wire and shielding the weld metal and the arc by carbon-di-oxide gas.

TIG welding (Gas Tungsten Arc Welding) Is used for welding ferrous metals, stainless steel, aluminium and thin sheet metal welding.

Atomic hydrogen welding is used for welding all ferrous and non-ferrous metals and the arc has a higher temperature than other arc welding processes.

Electro slag welding is used for welding very thick steel plates in one pass using the resistance property of the flux material.

Plasma arc welding: The arc has a very deep penetrating ability into the metals welded and also the fusion is taking place in a very narrow zone of the joint.

Spot weding is used for welding thin sheet metal as a lap joint in small spots by using the resistance property of the metals being welded.

Seam welding is used for welding thin sheets similar to spot welding. But the adjacent weld spots will be overlapping each other to get a continuous weld seam.

Projection welding is used to weld two plates one over the other on their surfaces instead of the edges by making projection on one plate and pressing it over the other flat surface. Each projection acts as a spot weld during welding.

Butt welding is used to join the ends of two heavy section rods/blocks together to lengthen it using the resistance property of the rods under contact.

Flash butt welding is used o join heavy sections of rods/blocks similar to butt welding except that arc flashes are produced at the joining ends to melt them before applying heavy pressure to join them.

Oxy -acetylene welding is used to join different ferrous and non ferrous metals, generally of 3mm thickness and below.

Oxy-other fuel gases welding: Fuel gases like hydrogen, coal gas, liquified petroleum gas (LPG) are used along with oxygen to get a flame and melt the base metal and filler rod. Since the temperature of these flames are lower than the oxy-acetylene flame, these welding are used to weld metals where less heat input is required.

Air-acetylene gas welding is used for soldering, heating the job etc.

Induction welding is used to weld parts that are heated by electrical induction coils like brazing of tool tips to the shank, joining flat rings, etc.

Thermit welding is used for joining thick, heavy, irregularly shaped rods, like rails, etc using chemical heating process.

Friction welding is used to join the ends of large diameter shafts, etc by generating the required heat using the friction between their ends in contact with each other by rotating one rod against the other rod.

Shielded Metal ARC Welding

Objectives: At the end of this lesson you shall be able to
- **state the types and classify electric welding processes**
- **state the principle of electric arc welding**

Electric welding: This is a process of welding in which the heat energy is obtained from electricity.

When electric current passes through a, medium material it generates heat.

The amount of heat generated depends upon:

- the amount of current passing through the medium
- the changes taking place in the medium
- the resistance of the medium.

By adjusting current and resistance, sufficient heat can be produced to melt the metals.

Principle of shielded Metal Arc Welding

An electric arc is maintained between the end of a coated metal electrode and work piece.

The flux covering melts during welding and forms gas and slag to shield the arc molten weld pool. The flux also provides a method of a adding scavengers, deoxidizers and alloying elements to the weld metal

Various Name Stick Electrode welding,
Electric Arc welding,
Shielded Metal Arc welding (SMAW)
Manual Metal Arc welding (MMAW)
Popularly known as Arc welding

IIt is a manual & ancient welding process, 100 years old

Main parts in SMAW

- Welding Machine
- Electrode Holder
- Ground Clamp(Earth)
- Welding Cables

Types of power source

1 AC welding Transformer
2 DC motor Generator
3 Rectifier set
4 Inverter

SMAW advantages / Disadvantages

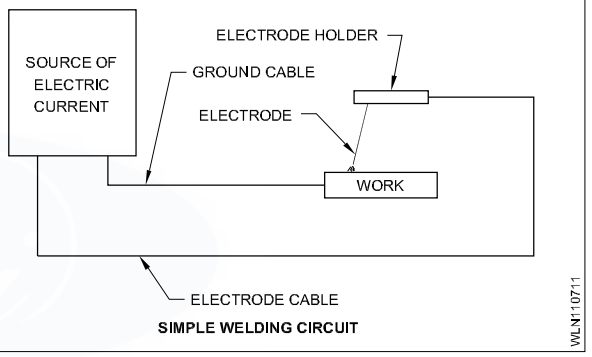
Advantages:

1 Field or shop use; less sensitive to wind and dirt
2 Wide range of consumables
3 All positional; flexible
4 Very portable; can reach limited access areas
5 Simple, inexpensive equipment

Disadvantages:

1 High skill factor
2 Slag inclusions
3 Low deposition rate and operating factor
4 High level of fume
5 Hydrogen control
6 Can't weld low melting point (e.g.pb,sn,zn) or reactive metals (e.g.ti)

Fig 1



SIMPLE WELDING CIRCUIT

Welding Terms & Its Definition

1 **Butt Weld:** joining of two pieces placed in 180° (surface level) & the welding performed is called as Butt weld.

2 **Fillet weld:** joining of two pieces placed in 90° (surface level / one surface & another edge surface/both edge surface) & the welding performed is called as fillet weld.

3 **Weld reinforcement:** the material which is above the place surface/miter surface is called as weld reinforcement.

4 **Miter line:** the straight line which is bisecting two toe points is known as miter line.

5 **Toe of weld:** the point at which the weld reinforcement is resting on base metal surface is known as toe point.

6 **Toe Line:** the line on which the weld reinforcement is resting on base metal surface.

7 **Concave bead:** the weld metal below the miter line is known as concave bead.

8 **Convex bead:** the weld metal above the miter line is known as convex bead.

9 **Miter bead:** If the weld bead is up to the level of miter line it is known as miter bead.

10 **Gas welding torch:** A device which is used for mixing, carrying, flow control and flame igniting of gases is known as gas welding torch.

11 **Gas cutting torch;** A device which is used for mixing, carrying, flow control and flame igniting of gases is known as gas cutting torch.

12 **Gas pressure regulator:** A device which monitors content of gas pressure in cylinder and regulates drawing/working gas pressure.

13 **Gas Rubber hose pipe:** A rubber hose which carries gases from gas pressure regulators and supplies to gas welding/cutting torches.

14 **Back fire:** If gas flame is snapped out due to wrong gas pressure setting is known as back fire.

15 **Flash back:** When the gas flame is snapped out and starts reverse burning towards cylinder with hissing sound which is very hazardous is known as flash back,

16 **Flash back arrestor:** Sometimes during backfire, the flame goes off and the burning acetylene gas travels backward in the blowpipe, towards the regulator or cylinder. At the time in between the device which has to be arrested the backfire.

17 **Electrode holder:** A device by which electricity provided by cable will be carried to the electrode and which holds the electrode in desired angles. (This device is available with different capacities and type i.e. 300 Amps, 400 Amps and 600 Amps partly, semi and fully insulated).

18 **Earth clamp:** A device by which electricity will carry provided by cable will be carried to the job table. (This device is available with different capacities and type i.e. 300 Amps, 400 Amps and 600 Ams. It is prepared by brass casting, G.I. Coated in spring or fixed form.

19 **Arc welding cable:** This is made of copper/aluminium strands to carry electricity from welding machine to electrode holder and earth cable.

20 **Cable Lug:** This is available with different capacities and type i.e. 300Amps, 400Amps and 600Amps. This is preferably made of copper metal.

21 **SMAW:** Shielded Metal Arc Welding. Also known as manual metal arc welding and stick welding. (In this process the electrode is consumable).

22 **GMAW:** Gas Metal Arc welding covers CO2 welding (MAG), metal inter gas arc welding (MIG) & flux cored arc welding. (In these processes the electrode is consumable).

23 **GTAW:** Gas Tungsten Arc welding. (In this process the electrode is consumable).

24 **FCAW:** Flux cored Arc welding. Flux cored arc welding. (In the process the electrode is consumable).

25 **Electrode** (Flux coated) A metal stick which is coated with flux and having parts indicated as stub end, tip, bare/core wire and flux coating. The size of this is determined by size of bare/core wire diameter. (This is used in shielded Metal Arc welding as consumable material).

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