Workshop–I (ME-110)

Sheet Metal Shop

Pankaj Biswas (PhD)
Department of Mechanical Engineering
IIT Guwahati

Introduction

- Sheet metal = 0.4 mm (1/64 in) to 6 mm (1/4 in) thick
- **Sheet Metal Shop:** It deals with working of thin sheets with hand tools and simple machines into various cutting products by:

  i. Cutting ii. Forming into shapes & iii. Joining

✓ Cutting and forming thin sheets of metal usually performed as cold working.

- **Some Examples:** Making of boxes, canisters, funnels, pipes, bends, cans, dust cleaner, car bodies, fuel tanks, cookware etc.
- **Important features**: Sheet components are less expensive and lighter in weight. It requires lesser force of deformation and it can easily replace the use of casting or forging.
- **Sheet material used:** Galvanized Iron, Black Iron, Stainless Steel, Cu, Al, Lead, Tin.

Basic Sheet Metal Hand Tools

- The basic sheet metal hand tools used in sheet metal work are as follows:

➢ (i). **Measuring tools** (ii). Scriber (iii). Staight edge (iv). Steel square (v). Divider (vi). Trammel points (vii). Chisel (viii). Punches (ix). Hammers (x). Snips or shears (xi). Pliers (xii). Groovers (xiii). Stakes (xiv). Rivet set (xv). Soldering iron.

- There are different types of **Measuring tools** which are as follows:

➢ (a). Vernier Caliper (b). Steel rule (c). Folding rule (d). Circumference rule (e). Micrometer (f). Thickness Gauge (g). Sheet Metal Gauge

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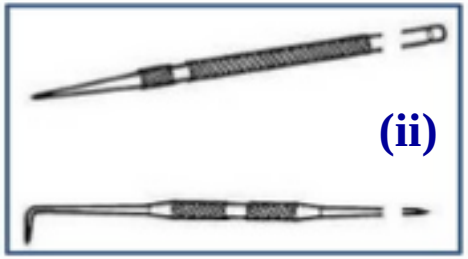
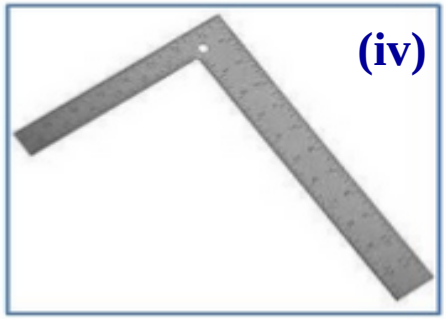
Basic Sheet Metal Hand Tools

- **(ii). Scriber:** It is also known as metal worker's pencil. To scratch line on sheet metal, it has one hardened sharp pointed edge.



- **(iii). Staight edge:** It is a flat graduated steel bar with one longitudinal edge bevelled. It is useful for scribing long straight lines

- **(iv). Steel square:** It is generally made of hardened steel. It is used for marking in the perpendicular direction to any base line.



- **(v). Divider:** It is used for drawing arc, circles on sheet metal. It is also used to mark a desired distance between two points.

Basic Sheet Metal Hand Tools

- **Trammel Points:** It consists of a bar with two movable heads. It is mainly used to draw large circles or arcs that are beyond the limit of the dividers.

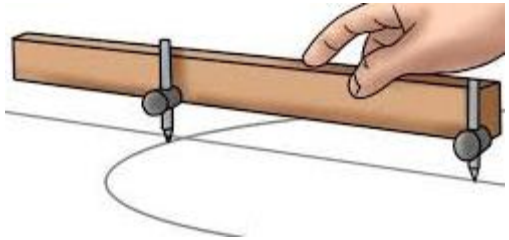


Fig. Trammel Points

- **Punch:** It used for marking the workiece, locating centers etc.

✓ **Prick punches** is used to make small marks on layout lines.

Fig. Prick punch

✓ **Centre punch** is used to make prick punch markers larger at the centre holes that are to be drilled.

Fig. Center punch

➢ Hand lever punch is used for marking holes with a punch and die incorporated in the tool when a large number of holes are to be punched.

Basic Sheet Metal Hand Tools

- **Chisel:** It is used for cutting sheets, bolts, rivets and chipping operations.

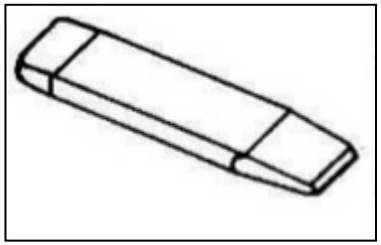


Fig. Flat chisel

✓ The **flat chisel** and **round nose chisel** are most widely used in sheet metal works.

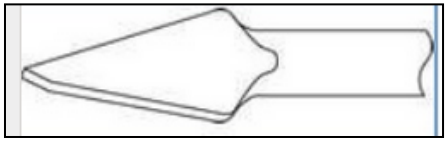
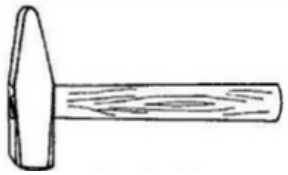


Fig. Round nose chisel

- **Hammers:** It is used for forming shapes by raising, stretching or throwing off.

✓ **Types of hammers**: **(i).** Setting hammer: It is used for setting down the edge while making a double seam .

✓ **(ii).** Riveting hammer: It is used for riveting.



✓ **(iii).** Raising hammer: It is used for forming of a flat sheet of metal into a curved or hollow shape like spoon.

Basic Sheet Metal Hand Tools

- **Mallet:** It is used to strike a light and soft blow on metal. It is a soft hammer made of rubber, copper, brass, wood etc.
- **Snips:** It is used to cut thin sheets. It is sometime called as shears.
- **Stakes:** It is sheet metal worker's anvils which is a supporting tool.
- **Pliers:** It is used for holding, bending and cutting the workpiece.
- **Hand Groover:** It is used for grooves and flatten a seam.
- **Rivet Set:** It is a hardened steel tool with hollow in one end. It is used to shape the end of rivet.

Fig. Mallet

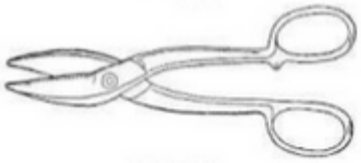


Fig. Snips

Fig. Stakes

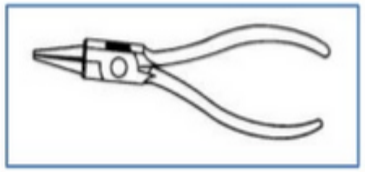


Fig. Pliers

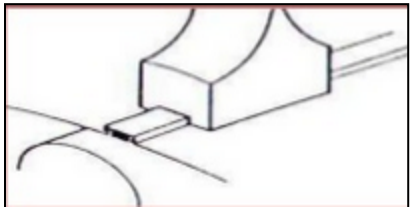


Fig. Hand Groover

Ref.https://www.google.com/search?q=sheet+metal+hand+tools

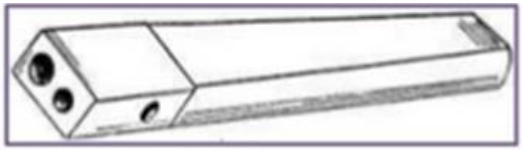


Fig. Rivet set

Basic Sheet Metal Hand Tools

❖ There are different types of **Measuring tools** which are as follows:

- **Steel Rule:** It is made of hardened steel and used for taking linear measurements of articles to an accuracy from 1 to 0.5 mm.

Fig. Steel Rule

- **Folding Rule:** This is very useful in measuring and laying out larger work with 0.5 mm accuracy.

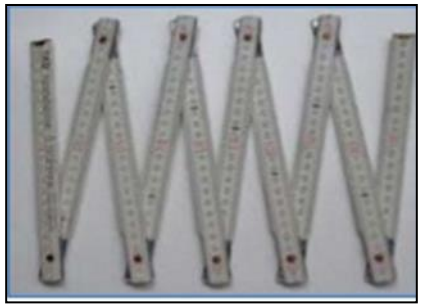


Fig. Folding Rule

- **Steel Circumference Rule:** It is used to find out directly the circumference of a cylinder.

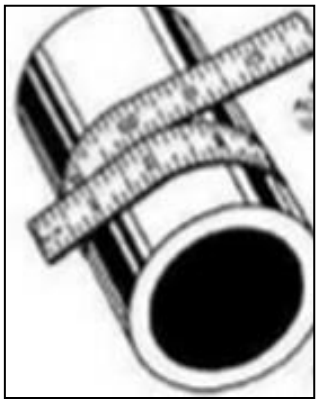


Fig. Steel Circumference Rule

- **Swing Blade Protractor:** It is typically made of transparent plastic or metal. It is used for marking and measuring the angle.

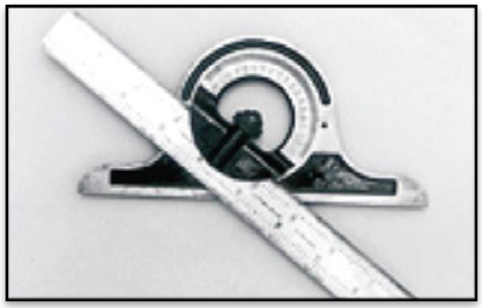


Fig. Swing Blade Protractor

Ref.1https://www.google.com/search?q=measuring+tools+in+workshop

Basic Sheet Metal Hand Tools

- **Vernier Caliper:** It is used for measuring both inside and outside dimensions upto 0.02 mm.
- **Micrometer Caliper:** It is used to measure the thickness of metal sheets accurately upto 0.01 mm.
- **Thickness Gauge:** It is also called slip gauge and used to measure the clearance between parts during assembly.
- **Sheet Metal Gauge:** This gauge is used to measure the thickness of sheets.

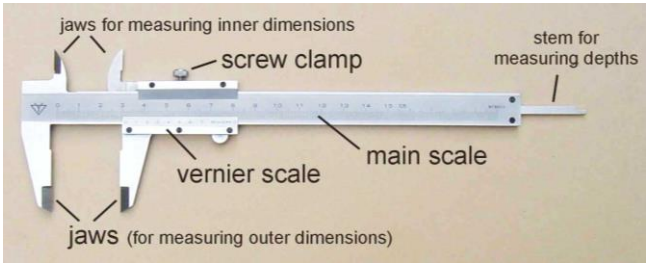


Fig. Vernier Caliper

Fig. Micrometer Caliper

Fig. Thickness Gauge

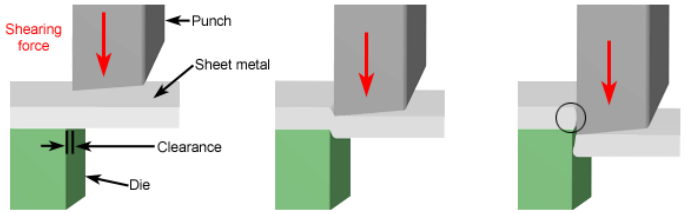
Fig. Sheet Metal Gauge

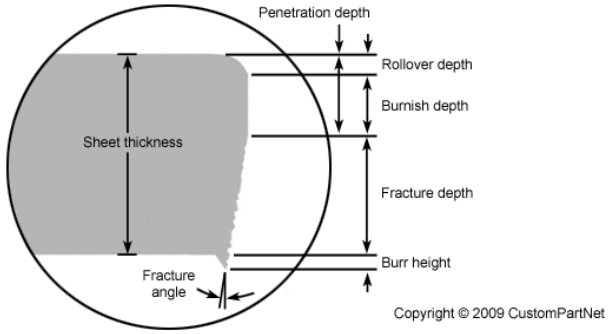
Sheet Metal Operations

- SHEARING
- BENDING
- BLANKING
- PUNCHING (PIERCING)
- STAMPING
- DRAWING
- DEEP DRAWING
- EMBOSSING
- SPINNING
- ROLL FORMING

Sheet Metal Operations

- **SHEARING:** This has three basic stages
  i. Plastic Deformation
  ii. Fracture
  iii. Shear





Ref. custompartner.com

➢ Types of shearing operations are:

✓ **Parting:** cutting a strip between two pieces to part them

Fig. Parting

✓ **Cutting off:** cutting off a piece from a strip

✓ **Blanking:** Here cutting a flat shape from a sheet metal. The part punched out is called the blank and the remaining sheet is the scrap.

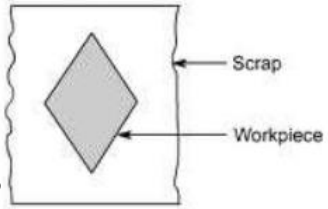


Fig. Blanking

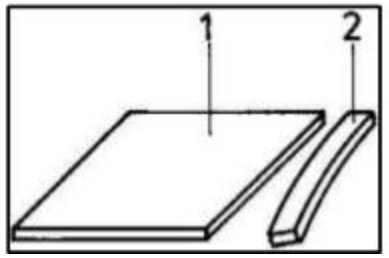


Fig. Cutting off

Sheet Metal Operations

- ✓ **Punching:** By this cutting operation various shaped holes are made in the sheet metal.
- ➢ In this operation, the hole is the required operation and the material punched out is the scrap.
- ✓ **Lancing:** This makes a cut part way across a strip.
- ✓ **Trimming:** cutting away excess material or flash from a piece.
- ✓ **Notching:** removing the metal from the edge of sheet metal.

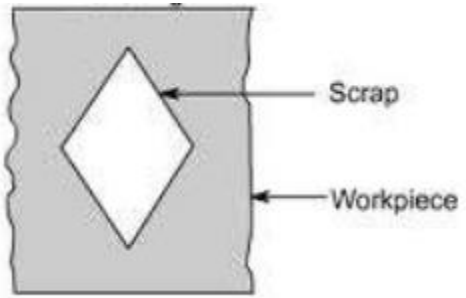


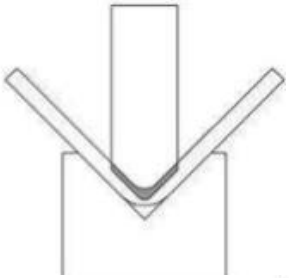
Fig. Punching

Fig. Lancing

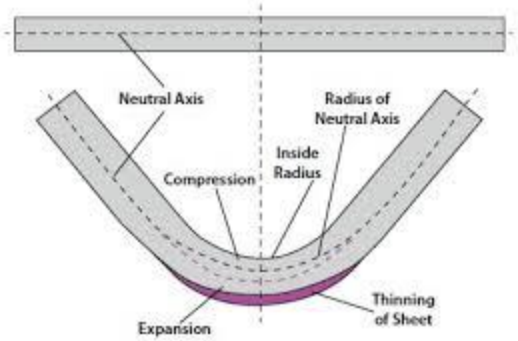
Fig. Notching

Sheet Metal Operations

- **BENDING:** By this process an angular displacement is provided in a sheet metal work piece.

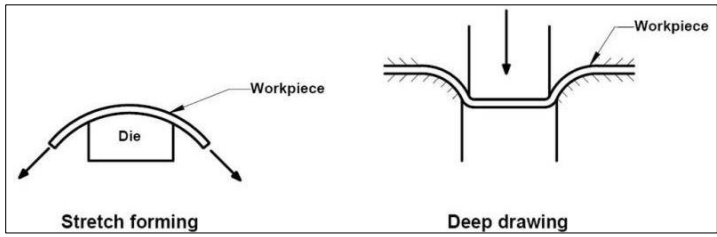


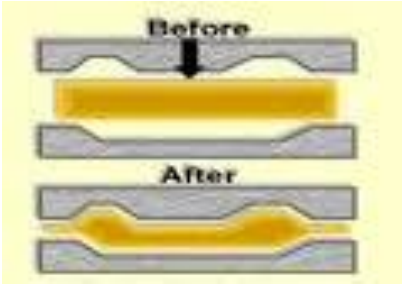
✓ In this operation, the material in the form of flat sheet or strip is uniformly strained around a linear axis.



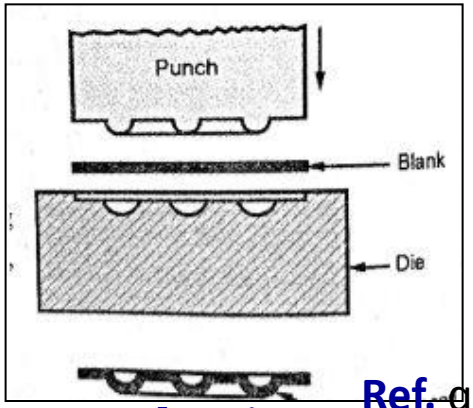
Ref. thefabricator.com

- **SQUEEZING:** In this operation, the metal is squeezed within the cavity of the die and the punch to attain the desired shape.





Squeezing/coining



Embossing

Ref. ques10.com & slideplayer.com

Sheet Metal Joints

- **Hem:** It is an edge or border made by folding. These are commonly used to reinforce an edge, hide burrs & rough edges and improve appearance.

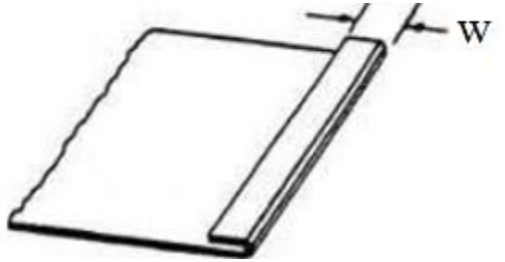


Fig. Single Hem

✓ Categories of hem : i. Single Hem ii. Double Hem and iii. Wired Hem

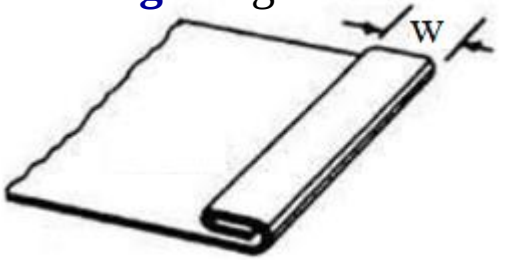


Fig. Double Hem

- **Seams:** It joins the edges of two materials. These are commonly used in the food industry on canned goods, in the automotive industry and on amusement park cars.

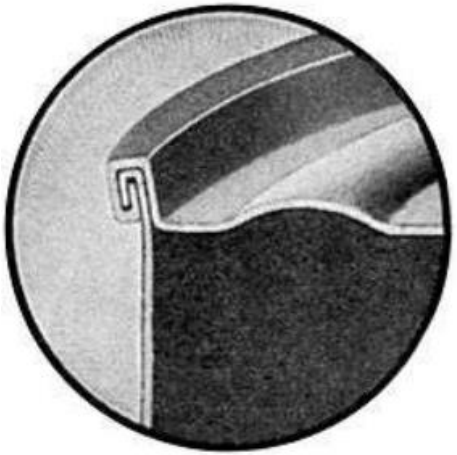
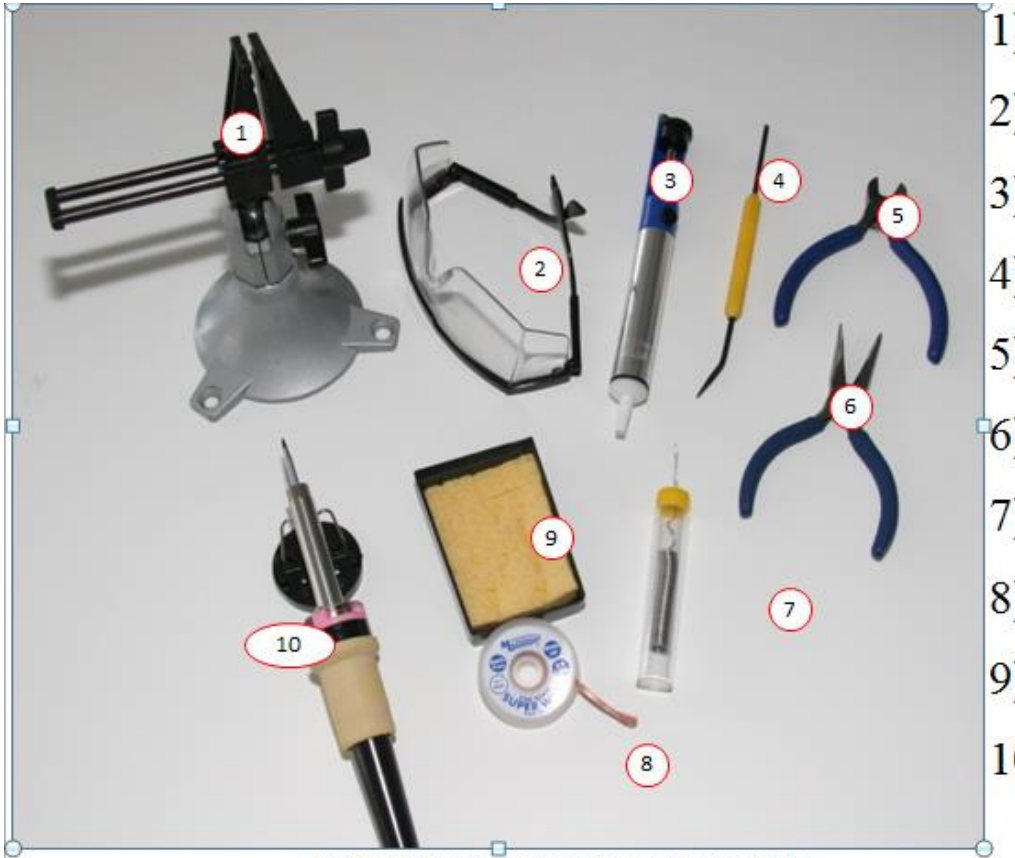


Fig. Seam

- Categories of seams: i. Lap Seam ii. Grooved Seam: made by hooking two hems and locking them by groover. iii. Single Seam iv. Double Seam v. Burred bottom Seam iv. Dovetail Seam.

Joining by Soldering

- **Soldering** is defined as a joining process wherein coalescence is produced between the adherents by heating them to a suitable temperature below 427ºC and by using a filler nonferrous alloy having its liquidus temperature below 427ºC and below solidus temperature of used base metals.



1) Vise
2) Safety glasses
3) Solder sucker
4) Solder tool
5) Diagonal cutters
6) Needle nose pliers
7) Solder
8) Solder wick
9) Damp sponge
10) Soldering iron

Ref.3https://www.google.com/search?q=soldering

Soldering Tools (*contd.*)

- The basic tools and materials need for most of the soldering work.
  - ✓ Soldering Iron
  - ✓ Soldering Station
  - ✓ Brass or Conventional Sponge
  - ✓ Soldering Iron Stand
  - ✓ Solder (Common solder tin/lead 60/40 (60% tin, 40% lead). It can be Tin/Copper alloy also)

- **Soldering Iron:** A soldering iron is a hand tool that plugs into a standard 120 V AC outlet and heats up in order to melt solder around electrical connections.

- ✓ It can come in a few variations such as pen or gun form. For beginners, it's recommended the pen style soldering iron in the 15W to 30 W range. Tip Temperature is around 750°F (400 °C).
- ✓ Most soldering irons have interchangeable tips that can be used for different soldering applications.

Type of Sheet Material

- **Galvenised Iron:** It is a iron sheet with Zn coating which is usually known as GI Sheets.

✓ Zn coating: It resists rusting, improves the appearance of metal permit to be soldered at greater ease, Reduce weldability by producing toxic fumes and residues,

✓ Applications: Use to make pans, buckets, heating ducts, gutters etc.

- **Black Iron:** It is the Cheapest sheet metal, Bluish black appearance. It is often referred to as uncoated sheet Corrodes rapidly.

✓ Applications: Use is limited to the articles that are to be painted such as tanks, pans, stove pipes etc.

- **Stainless Steel:** This is an alloy of steel with chromium(min.10-12%), nickel and some other materials. Good corrosive resistance, Good weldability, Cost is very high, Tougher than GI sheets.

✓ Applications: food processing, dairy industry, chemical plants, kitchenwares etc.

Type of Sheet Material

- **Tin Plates:** It is a thin sheet of iron coated with tin to prevent rusting which is very bright silvery appearance.

✓ Applications: roofs, food containers, dairy equipments, furnace fittings, cans etc.

- **Lead:** It can be worked by hand without using any mechanical device. It is very soft and heavy.

✓ Applications: highly corrosive acid tank linings, nuclear shielding, roof flashing, sound-proofing, vibration absorbers, x-ray shielding and waterproofing.

- **Copper:** It is available either as cold rolled or hot rolled sheets. It has good corrosive resistance. It conducts heat and electricity efficiently. Cost is high.

✓ Applications: electric works, automobile industries, expansion joints etc.

- **Aluminium:** It can not be used in pure form, but is used with a very small amount of Si, Cu, Fe & Mn. It is light in weight and highly resistance to corrosion.

✓ Applications: construction of refrigerator trays, lighting fixtures, window panels, airplanes , many transport and electrical items etc.

References

https://www.google.com/search?q=measuring+tools+in+workshop

https://www.google.com/search?q=sheet+metal+hand+tools

End

Welding Shop

Part-II: Gas welding

Prof. Sukhomay Pal
Department of Mechanical Engineering
IIT Guwahati

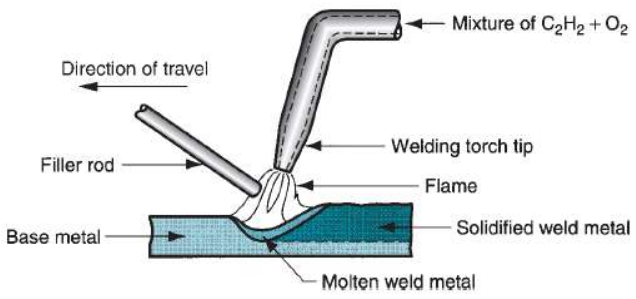
Gas welding / Oxyfuel gas welding

In this process, various fuels are mixed with oxygen and burnt to perform welding. Eg: Oxyacetylene welding

Oxyacetylene welding (OAW): In this case, welding is performed by a flame formed by the combustion of oxygen and acetylene. The flame comes from a torch.

A filler metal is sometimes added. It is typically in the form of a rod with diameters ranging from 1.6 to 9.5mm

Acetylene is a famous fuel because it is capable of generating a temperature of 3500°C.



Gas welding

In this process, various fuels are mixed with oxygen and burnt to perform welding.

Gas welding

- Usually refers to Oxy-Acetylene welding where the acetylene or the fuel is burnt with the addition of Oxygen to obtain a high temperature flame.
- The flame temperature obtained with 1 part of fuel and 2 ½ part of oxygen is around 3200 °C
- The fuel and oxygen are fed through a torch in the ratio 1:1. The remaining 1 ½ part of oxygen is taken from the surrounding air.
- The reaction is

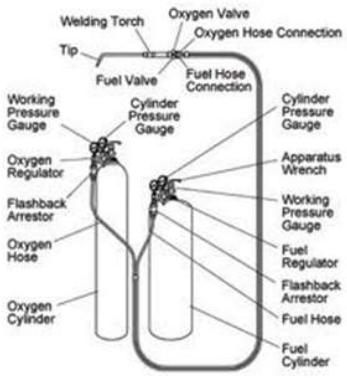
  $2\ C_2H_2 + 5\ O_2 \rightarrow 2\ H_2O + 4\ CO_2$ + heat (i.e. $\Delta H = 2518$ kJ/mol)
- Other fuel gases used are propane, natural gas, propylene, MAPP (methylacetylene propadiene).

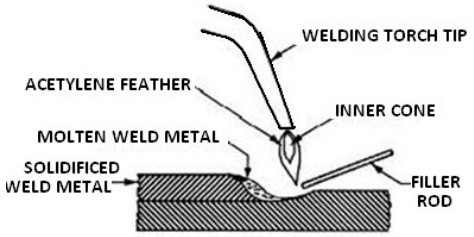
Equipment:

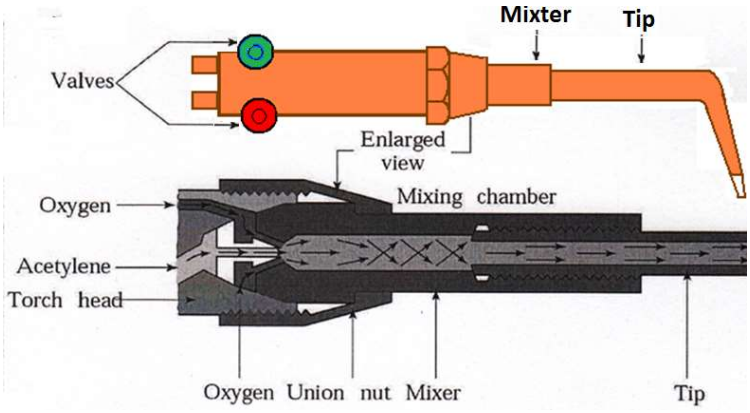
Torches: The welding torch is used to mix oxygen and fuel in the right proportions.
The tips are interchangeable and provide a variety of sizes to handle a wide range of metal thickness.

Acetylene cylinder pressure of 17 kg/cm^2. Dissolved in acetone which is absorbed by porous material like asbestos, corn pitch, wood, charcoal, etc. When stored in free state under pressure > 2.2 kg/cm^2, may dissociate by heat or shock resulting in explosion.

Oxygen cylinder pressure of 16 MPa at 21 °C







The acetylene valve is opened first; the gas lit with a spark lighter and then the oxygen valve is opened and flame adjusted. To ensure correct connections, all the threads on acetylene fittings are left handed while those of the Oxygen are right handed. Oxygen regulators are generally painted green and acetylene regulator painted red.

Flames

Three distinct flames are Reducing or carburizing, neutral, and oxidizing

Acetylene flame is long and bushy. As the oxygen is turned on, the long flame reduces in size and a feathery inner cone appears producing a reducing flame.

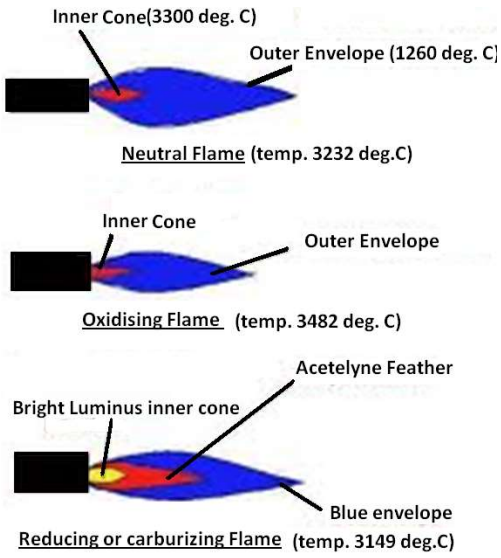
When oxygen proportions is further adjusted, the feathery white cone disappears and a rounded inner cone and outer envelope appears indicating a neutral flame

With further increase in Oxygen, the flame as a whole grows smaller and inner cone is reduced in size to produce an oxidizing flame.

Carburizing Flame: Welding H.C steels, hard facing and welding nonferrous alloys like Ni and Monel, silver brazing

Neutral flame: used for most welding operations

Oxidizing Flame: Fusion welding of Brass, Bronze. An oxidizing flame used on steel will cause the metal to foam and spark.



Advantages:

- The gas flame is generally more easily controlled and is not piercing as arc welding.
- Extensively used for sheet metal fabrication and repairs
- The gas mixture is very versatile. Can be used for heat treatment, preheating, brazing, post heating, forming, flame cutting, etc.
- The set up is portable and can be taken to any remote areas.

Disadvantages:

- Process is very slow compared to arc welding
- Harmful thermal effects are aggravated by prologed heat resulting in grain growth, distortion loss of corrosion resistance. Etc.
- Problem of safety during handling gases

Work Shop Practices (ME110)
L-T-P (0-0-3)

Lab 6: Demonstration of Assembling and disassembling of CNC machines

Dr. Sajan Kapil
Assistant Professor
Department of Mechanical Engineering
IIT Guwahati, Guwahati-781039

Presentation Layout

- Introduction of CNC Shop
- Advantages and Limitations of CNC Machines
- NC and CNC Machines
- CNC Machines Components

What will you learn in this section?

- **What are CNC Machines.**
- **Advantages and Limitations of CNC Machines.**
- **Assembly and Disassembly of CNC Machines.**

Introduction to CNC Shop

- Machining is one of the processes of manufacturing in which the specified shape to the work piece is imparted by removing surplus material. Conventionally, this surplus material from the workpiece is removed in the form of chips through interaction of the workpiece with an appropriate tool. This mechanical generation of chips can be carried out by single point or multi point tools.

- Modern precision manufacturing demands extreme dimensional accuracy and surface finish. Such performance is very difficult to achieve manually, if not impossible, even with expert operators. CNC machining is capable of meeting the tightest tolerances, and producing the most accurate, precise products over and over again.

Advantages of CNC Machines

- **Continuous Use:** Unlike manual labor, CNC machinery (barring any malfunction or maintenance issue) can work continuously over any period of time without a break. This greatly increases productivity and efficiency.
- **Consistency, Precision and Redundancy:** With computer software, the design of any given product only needs to be programmed once. The CNC machine can then perfectly replicate that design, for any order quantity.
- **Low Skill Requirement:** CNC machine operators require little training and skill when compared to manual machine operators.
- **Fewer Personnel:** Because computer software controls the machinery, fewer technicians are needed for operation and oversight, cutting overall expenses.
- **Flexibility:** The software can be reprogrammed quickly and easily to produce different parts, allowing operations to keep up with shifting customer demands.
- **Capability:** This technology uses computer precision to go beyond the limitations of manual capabilities. More complex and intricate operations are possible with CNC machining.

Limitations of CNC Machines

- **Cost:** CNC machines are more expensive and require a greater initial investment than machines that can be operated manually. However, as this technology becomes the standard, supply is increasing resulting in costs gradually decreasing. There is also a cost associated with training of the employees. As these machines heavily rely on softwares, often with every new version of the software, new training sessions are needed to updates the employees on new features and changes to old ones. Also softwares have licensing cost associated with them which make the overall cost even higher.
- **Skills Loss**: Automation decreases the need for manpower, and fewer laborers are hired. This could eventually lead to the complete loss of long-preserved skills.

NC and CNC Machines

- NC (Numeric Control) systems use fixed logical functions to handle a machine tool or the machining process. NC specifies the control of the machine movements and various different functions with the help of instructions represented as a sequence on punch cards. The electronic control systems drive these NC's. We cannot change the functions in the NC, meaning it is not programmable, due to the rigid wiring of the control logic and it is considered as hardwired.
- The CNC stands for Computer Numerical Control, it is generated by merging the computer with the Numerical control. It uses internal microprocessors (computers) which are comprised of memory registers. The memory registers stores various routines that can successfully manipulate logical functions.

CNC Machines Components

Part program

- A part program is a series of coded instructions required to produce a part. It controls the movement of the machine tool and on/off control of auxiliary functions such as spindle rotation and coolant. The coded instructions are composed of letters, numbers and symbols.

Machine Control Unit

The machine control unit (MCU) is the heart of a CNC system. It is used to perform the following functions:

- To read the coded instructions.
- To decode the coded instructions.
- To implement interpolations (linear, circular, and helical) to generate axis motion commands.
- To feed the axis motion commands to the amplifier circuits for driving the axis mechanisms.
- To receive the feedback signals of position and speed for each drive axis.
- To implement auxiliary control functions such as coolant or spindle on/off and tool change

CNC Machines Components (…Cont.)

Program input device

- The program input device is the means for part program to be entered into the CNC control

Drive System

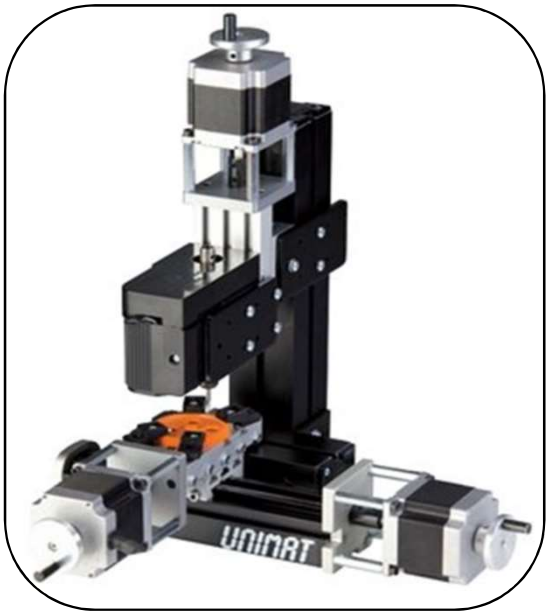
- A drive system consists of amplifier circuits, drive motors, and ball lead-screws. The MCU feeds the control signals (position and speed) of each axis to the amplifier circuits. The control signals are augmented to actuate drive motors which in turn rotate the ball lead-screws to position the machine table.

Machine Tool:

- CNC controls are used to control various types of machine tools. Regardless of which type of machine tool is controlled, it always has a slide table and a spindle to control the position and speed.

CNC Milling Machine

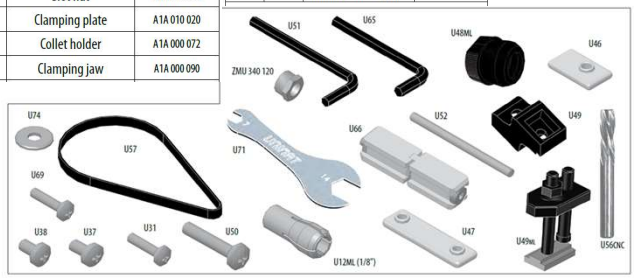
- The basic composition of the most universally favored CNC milling machine is the Knee type milling machine. On this equipment, the work piece travels on the X and Y axes and the tool on the Z axis.
- Increasingly CNC machining centers with 5-axis controls are being utilized. They are equipped with three linear axes (X, Y and Z) and two rotating axes (A, B, and/or C).

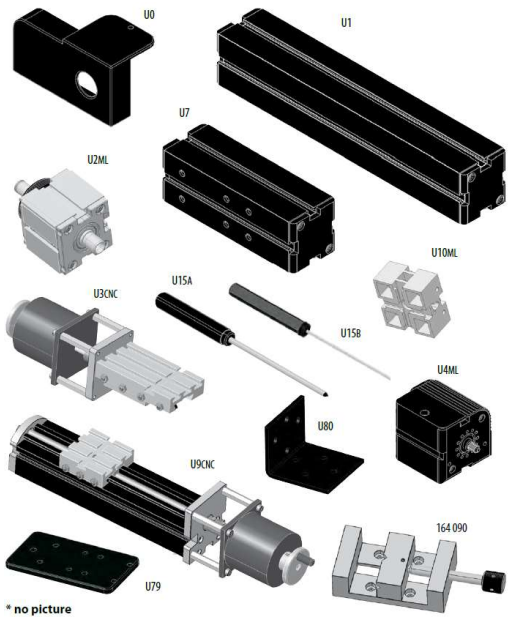


CNC Milling Machine: Part List

U0	1	Drivebeltcover	A1A 000 010
U1	1	machine bed, long	A1A 020 000 SW
U2ML	1	Countershaft	A1M 035 000
U3CNC	2	Cross slide CNC	164 060 CNC
U4ML	1	Motor	162 420 MH S
U7	1	Machine bed, short	A1A 010 00 SW
U9CNC	1	Longitudinal slide CNC	164 480 CNC
U10ML	1	Intermediate piece	A1M 000 100
U12ML	1	Collet 1/8"	164 460 1/8"
U15A	1	Screw driver #2	ZWZ 980 010
U15B	1	Screw driver allen key	ZWZ 980 075
U31	8	Screw M4x10	ZSR M40 410
U37	12	Screw M4x8	ZSR M40 408
U38	7	Screw M4x6	ZSR M40 406
U46	13	Slot nut	A1A 060 040
U47	7	Clamping plate	A1A 010 020
U48ML	1	Collet holder	A1A 000 072
U49	4	Clamping jaw	A1A 000 090
U49ML	2	Clamping jaw ML	A1Z 490 000
U50	1	Screw M4x70	ZSR M40 470
U51	1	Allen key 2mm	ZWZ 110 200
U52	1	Rod	ZST 110 345
U56CNC	1	Milling head 1.6 mm	F2470 1.60
U57	1	Drive belt (87)	ZRM 730 087
U65	1	Allen key 2,5mm	ZWZ 110 250
U66	5	Connection piece	A1A 000 ZIN SK
U69	4	Screw M4x12	ZSR M40 412
U71	1	7/14 mm straddle wrench	ZWZ 400 700
U74	18	Plain washer	ZSB 250 430
U79	3	Stabilizing plate small	A1Z 470 000
U80	2	Stabilizing angle	A1Z 480 000
	1	Locking nut M4	ZMU 340 120
	1	Wood mounting plate *	164 400
	4	Rubber buffer *	
	1	Unimat power supply *	161 312

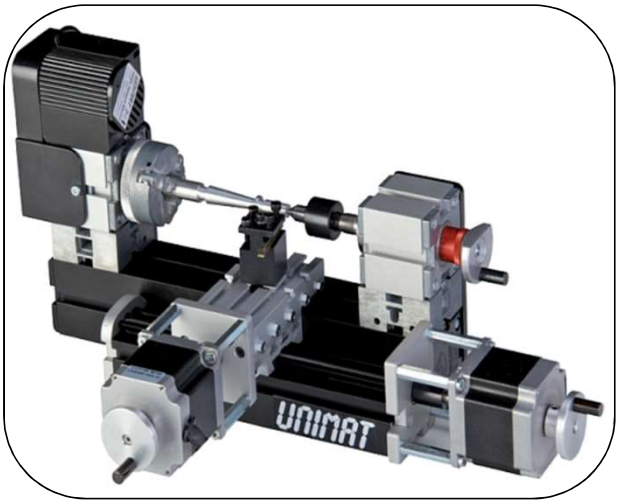
Optional
Steel Vice 164 090





CNC Turning Machine

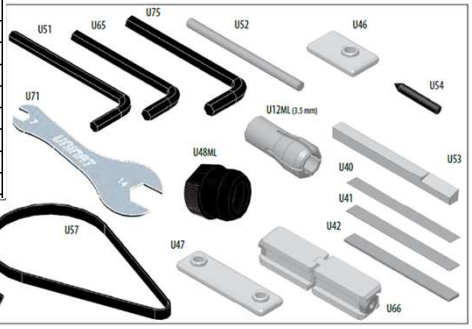
- CNC turning machines are in general turning machines (lathe) with axes (slide X,Z and the headstock spindle C) that are moved by a servo or stepper motors and controlled via storable programs.
- In production mainly multi-spindle turning machines are used (lathes with powered tools and powered tailstock). As tool holder, a turret tool post, movable in X- and Y direction, is used. The powered tools allow for the complete finishing of a work piece in one go.

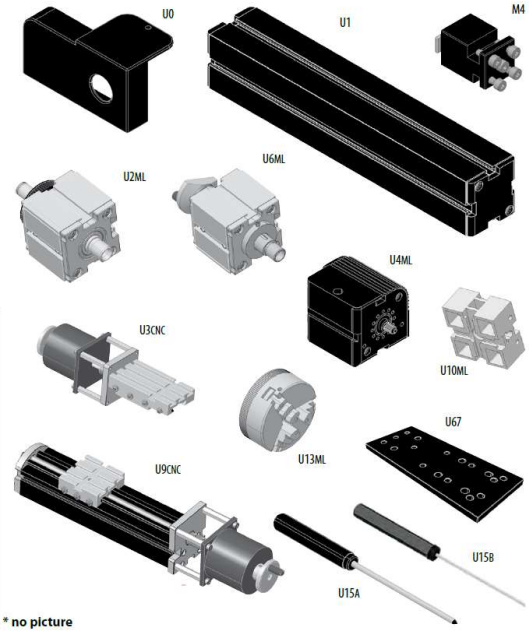


CNC Lathe Machine: Part List

U0	1	Drivebeltcover	A1A 000 010
U1	1	Machine bed, long	A1A 020 000 SW
U2ML	1	Countershaft	A1M 035 000
U3CNC	1	Cross slide CNC	164 060 CNC
U4ML	1	Motor	162 420 MH 5
U6ML	1	Tailstock	A1M 040 000
U9CNC	1	Longitudinal slide CNC	164 480 CNC
U10ML	2	Intermediate piece	A1M 000 101
U12ML	1	Collet 3.5 mm	164 460 35
U13ML	1	3 jaw chuck	164 430
U15A	1	Screw driver #2	ZWZ 980 010
U15B	1	Screw driver allen key	ZWZ 980 075
U31	8	Screw M4x10	ZSR M40 410
U37	4	Screw M4x8	ZSR M40 408
U38	3	Screw M4x6	ZSR M40 406
U40	2	Small part 0,1mm	A1A 000 170
U41	2	Small part 0,4mm	A1A 000 190
U42	2	Small part 1,0mm	A1A 000 180
U46	8	Slot nut	A1A 060 040
U47	2	Clamping plate	A1A 010 020
U48ML	1	Collet holder	A1A 000 072
U51	1	Allen key 2mm	ZWZ 110 200
U52	2	Rod	ZST 110 345
U53	1	Tool for outside turning	A1A 000 080

U54	1	center	A1A 000 130
U54RO	1	Live center	164 450
U57	1	Drive belt (87)	ZRM 730 087
U65	1	Allen key 2,5mm	ZWZ 110 250
U66	7	Connection piece	A1A 000 ZIN SK
U67	2	Stabilizing plates	A1Z 470 010
U71	1	7/14 mm straddle wrench	ZWZ 400 700
U74	9	Plain washer	ZSB 250 430
U75	1	Allen key 3,0mm	ZWZ 110 300
M4	1	2 position tool post	A1M 000 091
	1	Wood mounting plate *	164 400
	4	Rubber buffer *	
	1	Unimat power supply *	161 312





* no picture

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[1] S. K. H. Choudhury, A. K. H. Choudhury and N. Roy, Elements of Workshop Technology, Volume I: Manufacturing Processes, Media Promotors, 2008

Thank you

Workshop–I (ME-110)

Welding Shop

Pankaj Biswas (PhD)
Department of Mechanical Engineering
IIT Guwahati

Introduction

❑ **Welding: In general, it is a process of joining two material plate and make an integrated one where the entire structural continuity exist.**

- ✓ The large bulk of materials that are welded are metals and their alloys. The welding is also applied to the joining of other material such as thermoplastics.
- ✓ Welding joins different metals/alloys with the help of different welding processes in which heat is supplied either electrically or by a gas torch.
- ✓ The most essential requirement is ***Heat*** but in some processes ***Pressure*** is also employed.
- ❖ The use of welding in today's technology is extensive. It is a phenomenal rise since about 1930; this growth is faster than the general industrial growth.

Types of Welding

❑ **Different welding techniques name (depending on source of heat):**

(i). Arc welding

- Carbon arc (CAW)
- **Metal arc (SMAW)**
- Tungsten inert gas(TIG/GTAW)
- Metal inert gas (MIG/GMAW)
- Plasma arc (PAW)
- Submerged arc (SAW)
- Electro-slag (ESW)
- Electro gas(ESW)

(ii). Gas Welding

- Oxy-acetylene
- Air-acetylene
- Oxy-hydrogen
- Pressure gas

(iii). Resistance Welding

- Butt
- Spot
- Seam
- Projection
- Percussion
- Flash Butt

(iv) Thermo-chemical welding process

- Thermit welding
- Atomic hydrogen welding

(v) Mechanical energy welding process

- Friction
- Ultrasonic
- Diffusion
- Forge
- Roll
- Explosive

(vi) Radiant energy welding process

- Electron-beam (EBW)
- Laser (LBM)

Types of electric discharges

ELECTRIC DISCHARGE

High Voltage (kV) Very Low Current (μA)	Medium Voltage (100sV) Low Current (mA)	Low Voltage (10sV) High Current (Amps)
Spark Discharge	Glow Discharge	Arc Discharge
		
NON SUSTAINABLE	SUSTAINABLE	SUSTAINABLE

Power Sources

❑ **POWER SOURCES** are apparatuses that are used to supply current and voltage that are suitable for particular welding processes.

❑ Arc Welding Power Sources

- ❖ Arc welding requires that an electric arc be established between an electrode and the workpiece to produce the heat needed for melting the base plate.
- ❖ Because utility energy is not delivered at the proper voltage and current, it must be converted to the required levels by the welding power source.
- ❖ Arc power sources convert the customary 220 or 440 V alternating current (ac) utility power to a range from 20 to 80 V and simultaneously increase the current proportionately.
- ❖ Motor- or engine-driven welding generators are wound to deliver the correct voltage and current directly; therefore, no transformer is necessary.

Categories of Power Sources

❑ **The conventional welding power sources (**based on power supply**):**

Power Source	Supply
(i) Welding Transformer	AC
(ii) Welding Rectifier	DC
(iii) Welding Generators	AC or DC (Depending on generator)
(iv) Inverter type	DC

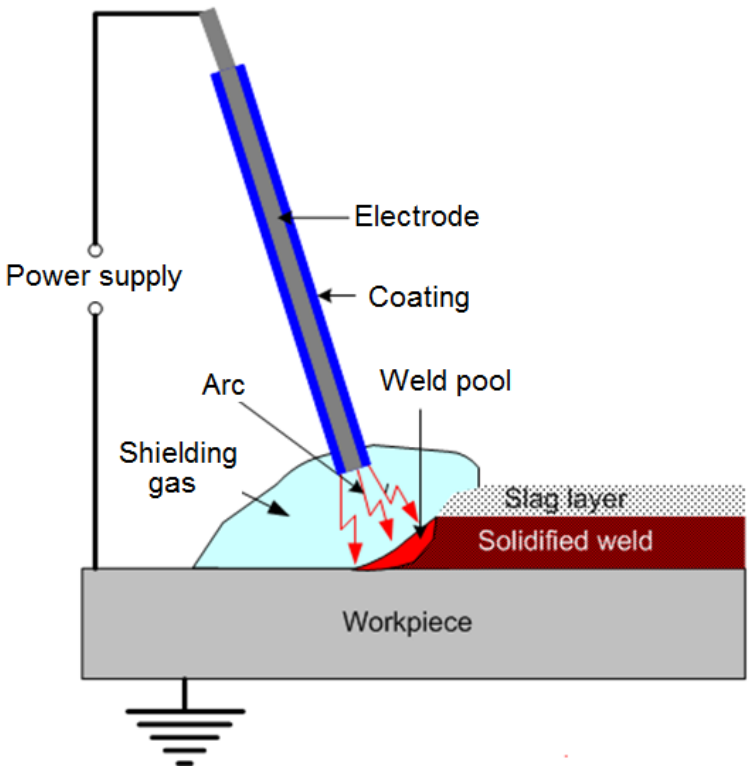
Note: The open circuit voltage normally ranges between 70-90 V in case of welding transformers while in case of rectifiers it is 50-80 V.

✓ However, welding voltages are lower as compared to open circuit voltage of the power source.

- In this shop the Shielded Metal Arc Welding (SMAW) is used for practicing purpose. So the subsequent slides provides the **details of the SMAW process.**

Principle of the SMAW Process

- Heat required for welding is obtained from the arc struck between a coated electrode and the workpiece.
- The arc temperature and thus the arc heat can be increased or decreased by employing higher or lower arc currents.
- A high current arc with a smaller arc length produces a very intense heat. The arc reaches temperatures of around 10,000°F. The arc melt the electrode and the job.

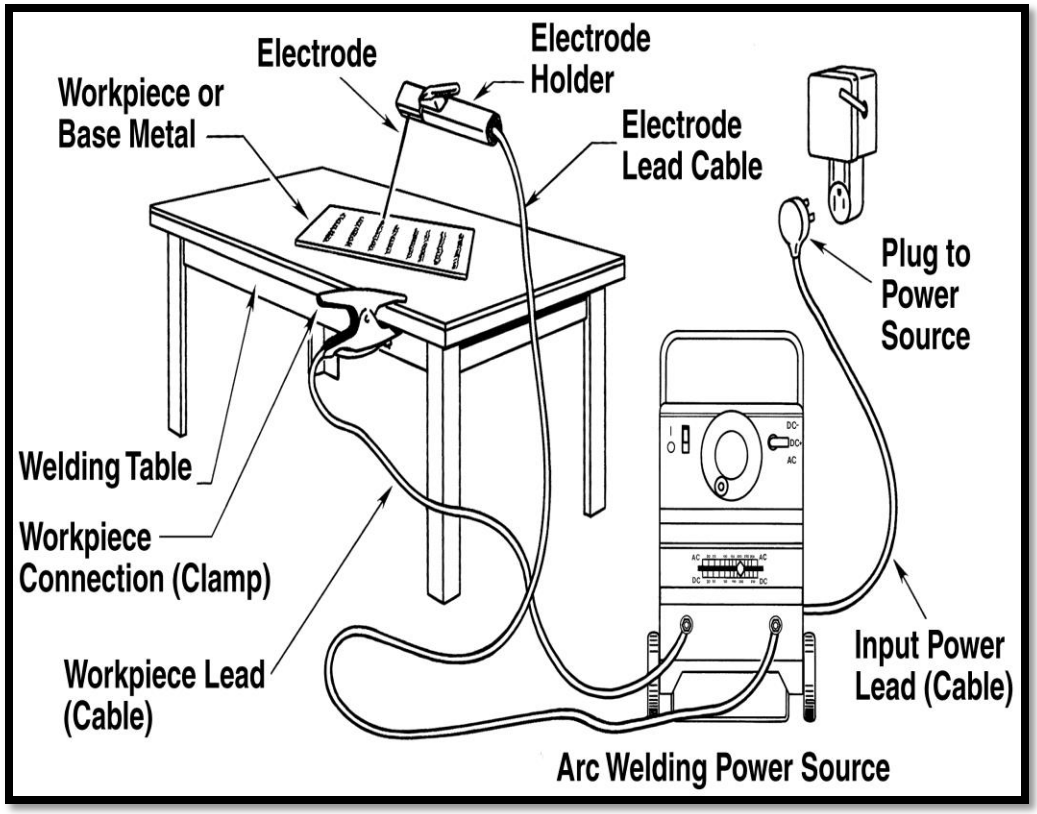


- Material droplets are transferred from electrode to the job, through the arc and are deposited along the joint to be welded.
- The flux coating melts, produces a gaseous shield and slag to prevent atmospheric contamination of the molten weld metal.

Shielded Metal Arc Welding Set up

❑ SMAW Set up

- ✓ Arc welding Power source
- ✓ Electrode
- ✓ Workpiece
- ✓ Electrode holder
- ✓ Electrode lead cable
- ✓ Welding table
- ✓ Workpiece lead (cable)
- ✓ Input power lead (cable)

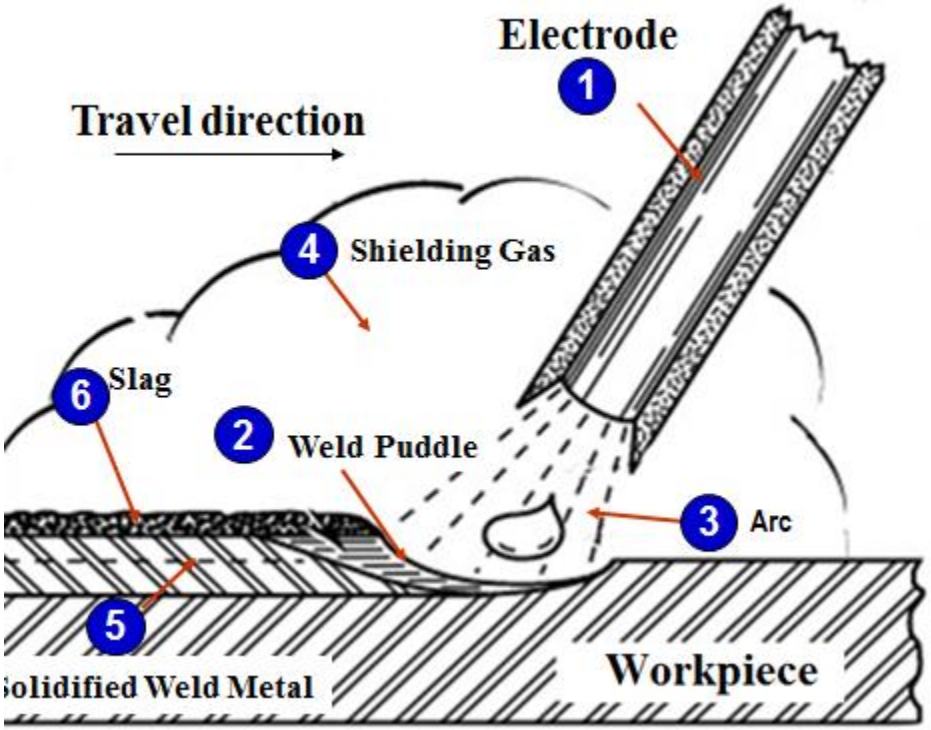


- ❖ Current flows through the electrode cable, to the electrode holder, through the electrode, and across the arc.
- ❖ On the work side of the arc, the current flows through the base material to the work clamp and back to the welding machine.

Details of SMAW Process

❑ Different constituents of a SAMW process:

1. Electrode
2. Weld puddle
3. Arc
4. Shielding gas
5. Solidified weld metal
6. Slag



❑ Power Source used in SMAW

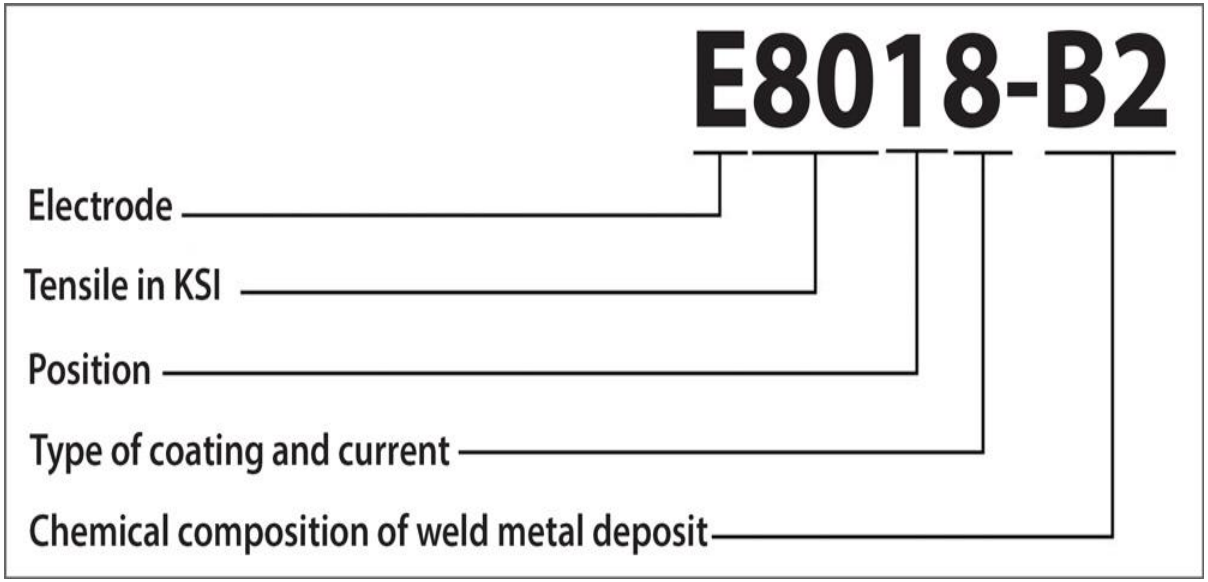
✓ Can be operated with AC and DC power supplies.

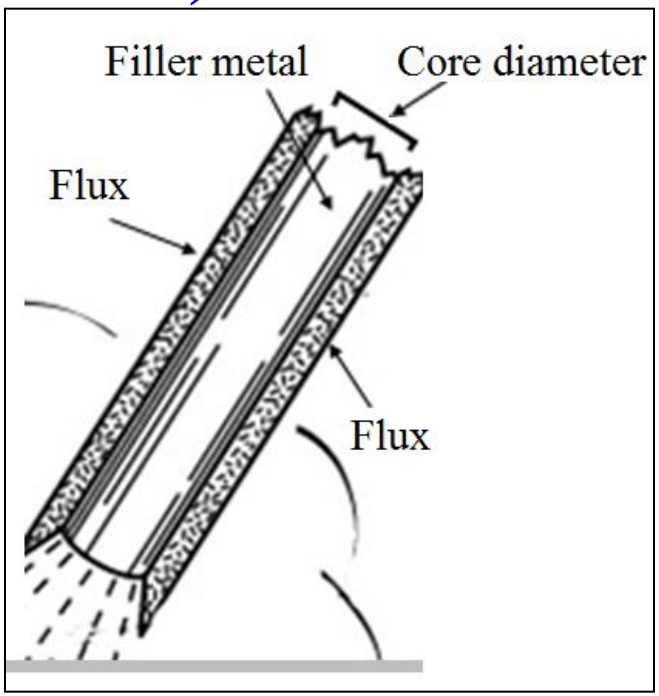
✓ A constant-current power source is preferred

Electrodes

- SMAW electrodes are basically composed of a metal core and a flux cover. The metal core acts as a the electrode as well as filler rod.

➢SMAW electrode specification (AWS Classification):





Electrodes *cont.*

❑ Primary function of flux cover:

- ❖ Shielding weld pool and metal transfer from the electrode tip to the weld pool from atmosphere.
- ✓ Gases generates as the coating decomposes under the arc heat.

❖ The gas is not enough for proper shielding

- The flux coating burns and produces a protective slag
  - ✓ Keeps the molten weld metal shielded from atmospheric contamination.
- The molten slag has a lesser density,
  - ➢ Floats above the molten metal

❖ **Note:** The layer of slag thus forms not only prevents the deposited metal from atmospheric contamination but also slows down the cooling rate and produces a more ductile weld deposit.

Electrodes *cont.*

❖ The flux composition serves the following purpose:

- ➢ Induce easier arc starting
- ➢ Arc stability
- ➢ Improve weld bead appearance and penetration
- ➢ Reduce spatter

❖ **Types of electrodes based on the type of flux covering:**

✓ There are three distinct types of electrodes are used in SMAW, usually termed:

1. Cellulosic Electrodes

2. Rutile Electrodes

3. Basic Electrodes

Electrodes (*cont.*)

1. Cellulosic Electrodes

- ❑ Cellulosic electrodes are coated with flux rich in cellulose $(C_6H_{10}O_5)_n$.
- ✓ This burns to produce hydrogen and carbon monoxide, provides shielding to the arc.
- ✓ Suitable with DC power and electrode-positive polarity.
- ✓ Presence of these gases in the arc with high ionization potentials results in a high arc voltage and therefore a high arc energy.
- ✓ Results in a deeply penetrating arc and a rapid burn-off rate calling for high welding speeds.
- ❖ Makes the electrode suitable for all position welding

Electrodes (*cont.*)

1.Cellulosic Electrodes

❖Basic features of Cellulosic Electrodes:

- ✓ Deep penetration in all positions.
- ✓ Suitable for vertical down welding.
- ✓ Reasonably good mechanical properties.
- ✓ High level of hydrogen generated-risk of cracking in the heat affected zone.

❖Application:

✓ Pipelines, tanks, pressure vessels, structural and field work where deep penetration is necessary. Specially suited for pressure pipelines which cannot be welded from inside.

Electrodes (*cont.*)

2. Rutile Electrodes

- ❑ Rutile electrodes contains high proportion of titanium oxide (rutile) in its coating.
- ✓ Titanium oxide promotes easy arc ignition, smooth arc operation, low spatter. This is classified as general purpose electrodes.
- ✓ Because of rutile and the ionizers in the coating, these electrodes can be used with either polarity and all positions.
- ✓ Rutile electrodes are specially suitable for fillet welding in horizontal and vertical position.

Electrodes (*cont.*)

2. Rutile Electrodes

❖ Basic features of Rutile Electrodes:

- ✓ Moderate weld metal mechanical properties.
- ✓ Good bead shape produced because of viscous slag.
- ✓ Positional welding possible with a fluid slag.
- ✓ Easy slag removal.

❖Application:

✓ Storage tanks, gear blanks, machinery, steel furniture, truck bodies, foundry equipment, shaft build-up, etc.

Electrodes (*contd.*)

3. Basic Electrodes

- In basic electrodes the coating contains a high proportion of calcium carbonate and calcium fluoride.

  - ✓ Referred to as low hydrogen electrodes.
  - ✓ Makes the slag more fluid than that at the rutile coatings.
  - ✓ Slag is of fast-freezing type.
  - ✓ Suitable for vertical and overhead position.

Common Welding Base Material

❑ **Metals can be classified as:**

1. Ferrous
2. Non-ferrous Material

1. Ferrous materials (Main composition is Iron) finding day-to-day welding application are:

i) Wrought Iron (Less than 0.035% Carbon)
ii) Cast Iron [Carbon and Silicon % are: **2.3 to 4.5%** and **0.5 to 3%** respectively)
iii) Carbon Steel [Low (0.05–0.3%), Medium (0.30–0.59%) and High (0.6–1.5%)]
iv) Cast Steels [Carbon content between **0.2 to 2.1%** by weight, depending on the grade, also other alloying elements manganese, chromium, vanadium, and tungsten]
v) Stainless steel [More than **11.5%** chromium], etc.

2. Non-ferrous material are not Iron-based. Non-Ferrous materials finding day-to-day welding application are:

i) Aluminium and its alloys
ii) Copper and its alloys
iii) Magnisium and its alloys
iv) Nickel and its alloys
v) Zinc and its alloys, etc

General Advantage of Welding

- A good weld is as strong as the base metal.
- General welding equipment is not very costly.
- Portable welding equipments are available.
- Welding permits considerable freedom in design.
- A large number of metals/ alloys both similar and dissimilar can be joined by welding.
- Welding can join workpieces by spots, as continuous pressure tight seams, end-to-end and in a number of other configurations.
- Welding can be mechanized.

General Disadvantage of Welding

- Welding gives out harmful radiations (light), fumes and spatter.
- Welding results in residual stresses and distortion of the workpieces.
- Jigs and fixtures are generally required to hold and position the parts to be welded.
- A skilled welder is a must to produce a good welding job.
- Welding heat produces metallurgical changes. The structure of the welded joint is not same as that of the parent metal.
- A welded joint, for many reasons, needs stress-relief heat-treatment.

End