UNIT IV OTHER WELDING PROCESSES

THERMO CHEMICAL WELDING PROCESSES

Thermochemical welding processes involve Exothermic Reactions.

Thermochemical welding processes discussed here are
1. Thermit welding.
2. Atomic hydrogen welding.

THERMIT WELDING

Definition- Thermit welding comprises a group of welding processes where in coalescence is produced by heating with superheated liquid metal and slag resulting from chemical reaction between a metal oxide and, aluminium, with or without the application of pressure. The liquid metal acts as filler metal too.

a. Thermite welding (TW) (sometimes called thermit welding) is a process which joins metals by heating them with super heated liquid metal from a chemical reaction between a metal oxide and aluminum or other reducing agent, with or without the application of pressure. Filler metal is obtained from the liquid metal.

b. The heat for welding is obtained from an exothermic reaction or chemical change between iron oxide and aluminium. This reaction is shown by the following formula:

$$8A1 + 3fe_30_4 = 9FE + 4A1_20_3 + Heat$$

The temperature resulting from this reaction is approximately 4500°F (2482°C).

c. The super heated steel is contained in a crucible located immediately above the weld joint. The exothermic reaction is relatively slow and requires 20 to 30 seconds, regardless of the amount of chemicals involved. The parts to be welded are aligned with a gap between them. The super heated steel runs into a mold which is built around the parts to be welded. Since it is almost twice as hot as the melting temperature of the base metal, melting occurs at the edges of the joint and alloys with the molten steel from the crucible. Normal heat losses cause the mass of molten metal to solidify, coalescence occurs, and the weld is completed. If the parts to be welded are large, preheating within the mold cavity may be necessary to bring the pats to welding temperature and to dry out the mold. If the parts are small, preheating is often eliminated. The thermit welding process is applied only in the automatic mode. Once the reaction is started, it continues until completion.

d. Themite welding utilizes gravity, which causes the molten metal to fill the cavity between the parts being welded. It is very similar to the foundry practice of pouring a casting. The difference is the extremely high temperature of the molten metal. The making of a thermit weld is shown in figure. When the filler metal has cooled, all unwanted excess metal may be removed by oxygen cutting, machining, or grinding. The surface of the completed weld is usually sufficiently smooth and contoured so that it does not require additional metal finishing

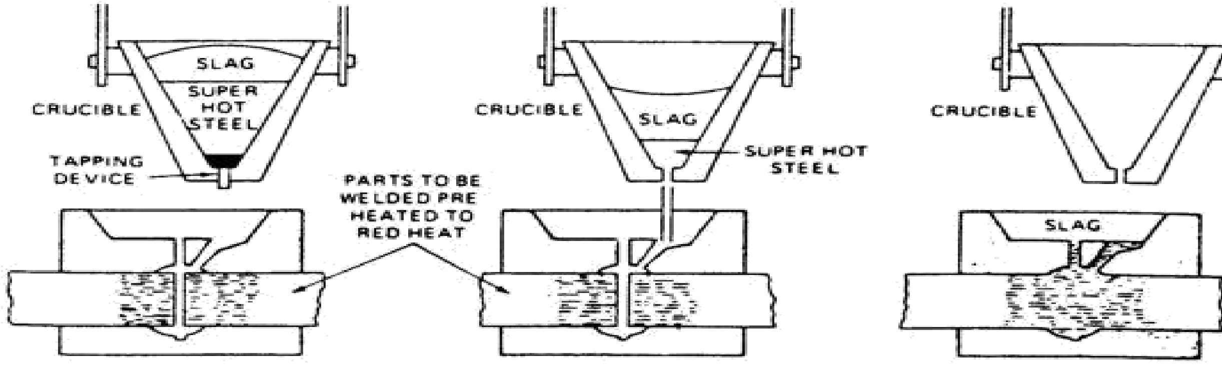
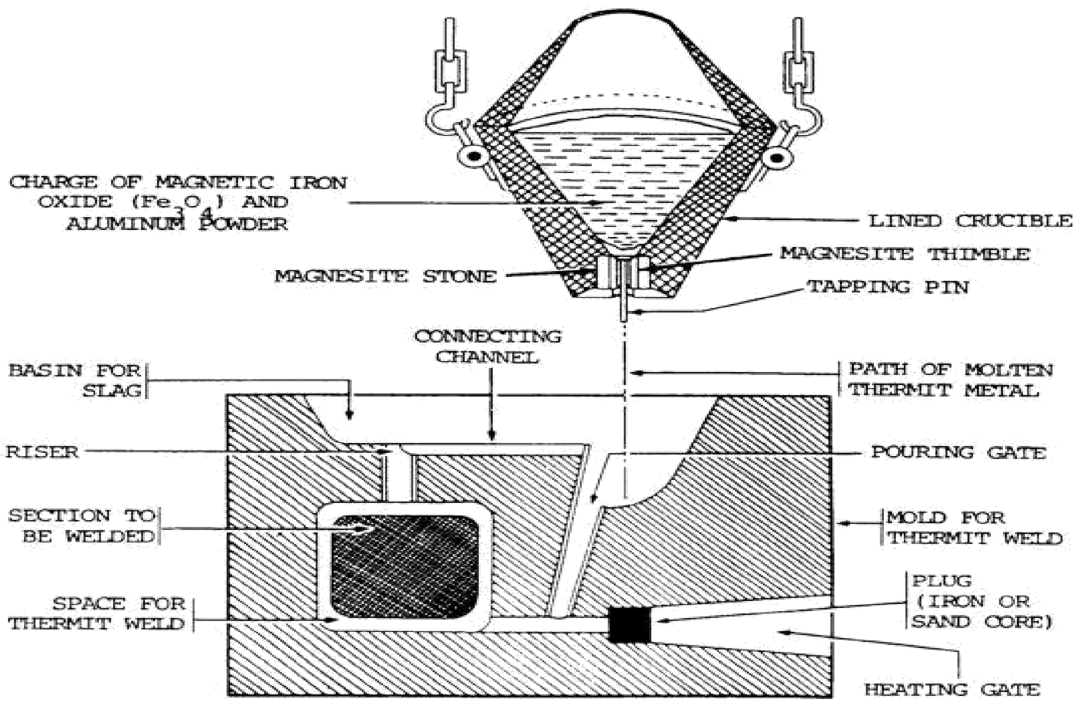


Figure 6-12. Steps in making a thermit weld.

Thermite material is a mechanical mixture of metallic aluminum and processed iron oxide. Molten steel is produced by the thermite reaction in a magnesite-lined crucible. At the bottom of the crucible, a magnesite stone is burned, into which a magnesite stone thimble is fitted. This thimble provides a passage through which the molten steel is discharged into the mold. The hole through the thimble is plugged with a tapping pin, which is covered with a fire-resistant washer and refractory sand. The crucible is charged by placing the correct quantity of thoroughly mixed thermit material in it. In preparing the joint for thermite welding, the parts to be welded must be cleaned, alined, and held firmly in place. If necessary, metal is removed from the joint to permit a free flow of the thermite metal into the joint. A wax pattern is then made around the joint in the size and shape of the intended weld. A mold made of refractory sand is built around the wax pattern and joint to hold the molten metal after it is poured. The sand mold is then heated to melt out the wax and dry the mold. The mold should be properly vented to permit the escape of gases and to allow the proper distribution of the thermite metal at the joint. A thermite welding crucible and mold is shown in figure.



Advantages

1. The heat necessary for welding is obtained from a chemical reaction and thus no costly power supply is required. Therefore broken parts (rails etc.) can be welded on the site itself.
2. For welding large fractured crankshafts.
3. For welding broken frames of machines.
4. For building up worn wobblers.
5. For welding sections of castings where size prevents there being cast in one piece.
6. For replacing broken teeth on large gears.
7. Forgings and flame cut sections may be welded together to make huge parts.
8. For welding new necks to rolling mill rolls and pinions.
9. For welding cables for electrical conductors.
10. For end welding of reinforcing bars to be used in concrete (building) construction.

Disadvantages

1. Low deposition rate with operating factor.
2. Its cannot weld low melting point.
3. This reduce risks to operators.
4. Extremely high level of fume.
5. It has slag inclusion.
6. It is high skill factor.

Applications

1. Thermit welding is used chiefly in the repair or assembly of large
2. For repairing fractured rails (railway tracks).
3. For butt welding pipes end to end.

ATOMIC HYDROGEN WELDING

Definition

It is a welding process wherein coalescence (fusion) is produced by heating the job with an electric arc maintained between two tungsten electrodes in an atmosphere of hydrogen, which also acts as a shielding gas. Filler rod and pressure mayor may not be applied depending upon job conditions.

The arc supplies the energy for a chemical reaction to take place, During the process, more heat is released due to exothermic reaction. The electric arc efficiently breaks up the hydrogen molecules which recombine with tremendous release of heat with the temperature from 3400 to 4000°C. Without the arc, an oxy-hydrogen torch can only reach 2800 degree C, It is the third hottest flame after di-cyano acetylene at 4987 ° C and cyanogen at 4525e degree C. An acetylene torch merely reaches 3300°C.This device is called an atomic hydrogen torch ornascent hydrogen torch or Langmuir torch. The process was also known as arc-atom welding. Filler rod may or may not be used during welding process.

The heat produced by this torch is sufficient to weld tungsten 3422°C and most of the refractory metal. Hydrogen gas acts as a heating element as well as it acts as shielded gas to protect the molten liquid metal from oxidation and contamination by carbon, nitrogen or oxygen which can severely damage the properties of many metals. It eliminates the need of flux for this purpose.

The arc is independently maintained for the workpiece or parts being welded. The hydrogen gas is normally diatomic (H_2) but where the temperatures are over 6000°C near the arc. When the hydrogen strikes a relatively cold surface, it will recombine into its diatomic form releasing the energy associated with the formation of bond. The energy in AHW can easily be varied by changing the distance between arc stream and workpiece surface. This process is being replaced by gas metal-arc welding mainly because of the availability of inexpensive inert gases.

In this process, arc is maintained entirely independent of the work or parts being welded. The work is a part of the electrical circuit only to the extent that a portion of the arc comes in contact with the work at which time a voltage exists between work and each electrode.

It differs from shielded metal arc welding in which the arc is independent of base metal making electrode holder as a mobile without arc getting extinguished. Thus, heat input to the weld could be controlled by manually to control weld metal properties.

The process has the following special features.

- High heat concentration is obtained.
- Hydrogen acts as a shield against oxidation.
- Filler metal of base composition could be used.
- Most of its applications can be met by MIG process. Therefore, it.is not commonly used.

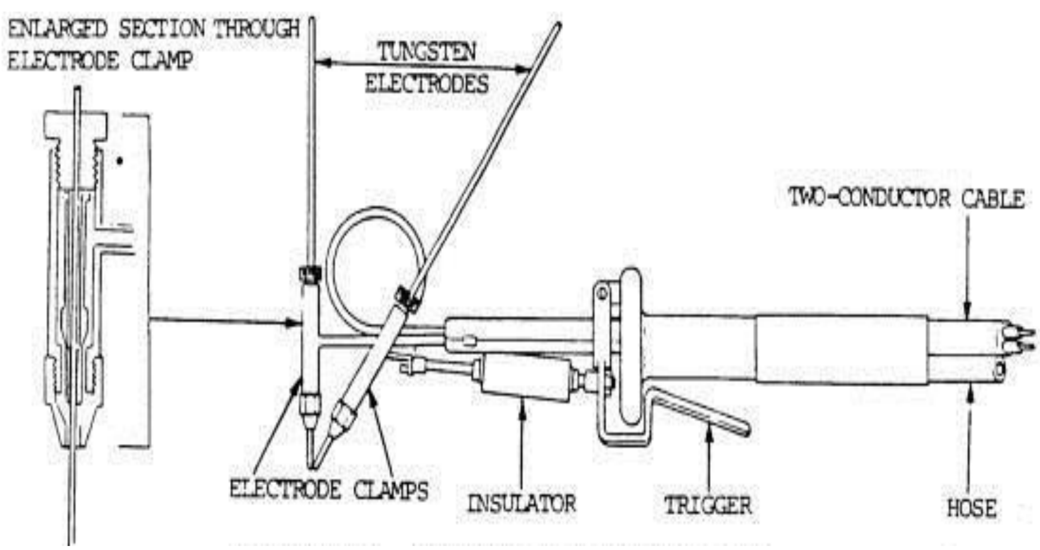
Working of Atomic Hydrogen Welding

The equipment consists of a welding torch with two tungsten electrodes inclined and adjusted to maintain a stable arc as shown in Figure 4.4. Annular nozzles around the tungsten electrodes carry the hydrogen gas supplied from gas cylinders. AC power source is suitable as compared to DC because equal amount of heat will be available at both electrodes. A transformer wjih an open circuit voltage c.f 300 Pis required to strike and maintain the arc.

The workpieces are cleaned to remove dirt, oxides and other impurities to obtain a sound weld. Hydrogen gas supply and welding cunent are switched ON. An arc is struck by bringing two tungsten electrodes in contact with each other and instantaneously separated by a small distance of 1.5 mm. Therefore, the arc still remains between two electrodes.

As the jet of hydrogen gas is passed through the electric arc, it disassociates into atomic hydrogen by absorbing large amounts of heat supplied by the electric arc.

H2aBH + H = 422 kJ (Endothermic Reaction)



Atomic Hydrogen Welding Equipments -
(a) Welding torch with tungsten electrodes and cable ,
(b) Hydrogen gas supply,
(c) AC power source (a transformer with an open circuit voltage of about 300 volts).
(if DC is used, an unequal amount of heal is available on the two electrodes, arc cleaning action is not proper, life of the two electrodes is not same, and frequent adjustment of the electrodes is necessary to maintain a stable arc.)

Advantages of Atomic Hydrogen Welding :

1. Due to high concentration of heat, welding can be carried out at fast rates (especially when filler metal is not needed) and with less distortion of the workpiece.
2. The job does not form a part of the electrical circuit. The arc remains between two tungsten electrodes and can be moved to other places easily without getting extinguished.
3. No flux or separate shielding gas is used; hydrogen itself acts as a shielding gas and avoids weld metal oxidation.
4. Welding of thin materials is also possible which otherwise may not be successfully carried out by metallic arc welding.
5. The process can be used to weld materials of specific chemical compositions for which coated electrodes may not be available.

Limitations of Atomic Hydrogen Welding :

1. The post of welding is high when compared to the other process.
2. Welding process is limited to flat positions only.
3. The process cannot be used for depositing large quantities of metals.
4. Welding speed is less when compared to metallic arc or MIG welding.

Applications of Atomic Hydrogen Welding: :

1. These welding processes are used in welding of tool steels which contains tungsten, nickel and molybdenum. .
2.They are used in joining parts, hard surfacing and repairing of dies and tools.
3. Atomic hydrogen welding is used where rapid welding is necessary in stainless steels, non-ferrous metals and other special alloys.

RADIANT ENERGY WELDING PROCESS

Radiant energy processes focus an energy beam on the work piece. The heat is generated only when the energy beam strikes the workpiece.
Radiant energy processes are
1. Electron Beam Welding.
2. Laser Beam Welding

ELECTRON BEAM WELDING

Though the development of the electron beam has evolved over the past three hundred years or so, the use of the electron beam in welding industry is quite new.
The need for electron beam welding developed after World War II, when it was required to obtain ultrahigh purity welds in reactive and refractory metals used in the atomic energy and rocketry field.

Electron beam welding is now used to weld titanium, tungsten, molybdenum, stainless steel, aluminium and many of the more refractory metals.
In electron beam welding, the heat to melt the metals is generated not by a flame or arc but by a stream of highly accelerated electrons. The energy of electrons does not appear as heat, until the electrons hit the workpiece

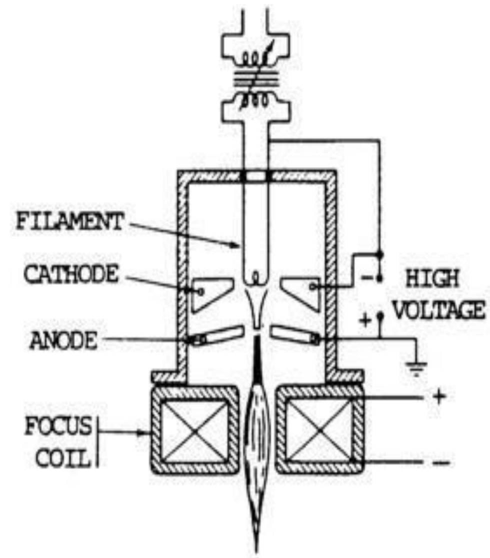
Electron Beam Welding Definition and Principle of Operations

Electron beam welding is defined as a fusion welding process wherein coalescence is produced by the heat obtained from a concentrated beam composed primarily of high velocity electrons. As the high velocity electrons strike the surfaces to be joined, their kinetic energy changes to thermal energy thereby causing the workpiece metal to melt and fuse.

Welding operation may be carried out in
(i) Hard vacuum,
(ii) Partial vacuum, and
(iii) Atmosphere
(i) Hard vacuum. When welding is to be carried out in hard or high vacuum, both the electron beam gun and the workpiece are enclosed in the same vacuum chamber. The pressure in the chamber is of the order of 10-4 torr.

(ii) Partial vacuum. In a partial vacuum welding system, the beam gun and the workpiece are contained in separate chambers. The gun chamber is pumped to 0.1 μ (micron), but the workpiece chamber is pumped only to a vacuum of 5 to 100 μ. An orifice permits electron beam to pass from gun chamber to work chamber but at the same time limits leakage from the work chamber to the gun chamber.

(iii) Atmospheric welding. In this case the workpiece is placed outside the vacuum chamber. The electron beam leaves the high-vacuum environment of the gun and passes into the atmosphere through orifice(s). Such a welding system contains high-capacity vacuum pumps to take care of the leakage through the orifice.



Electron Beam Welding Equipment

An electron beam welding equipment includes the following subsystems:

1. An electron beam gun with a high voltage power supply and controls (from 5 to 150 kV),
2. A vacuum pumping system.
3. Mechanical tooling fixtures, drives and motor controls, and
4. A beam alignment system, including optics, scanner, tape control and tracker.

Advantages of Electron Beam Welding

1. Welds produced are of high quality (free from porosity and atmospheric contamination) and can be made at high speeds.
2. The fusion zone and the heat affected zone are extremely narrow.
3. As the energy input is in a narrow concentrated beam, distortion is almost eliminated.
4. Edge preparation for welding usually consists of closely aligning the edges. Butt joints can be made in plates up to 6 mm without edge preparation
5. Welded joints surfaces are clean and bright having no oxide, scale or flux slags and thus need no cleaning up, after the weld is completed.
6. Electron beam welds have a highly desirable depth to width ratio. Much deeper penetration can be obtained in a single pass.
7. Small thin parts can be welded to heavy sections.
8. Edge and butt welds can be made in metals as thin as 0.025 mm.
9. This input power is small when compared to the power requirements of other electrical welding devices.
10. Precise control is possible welds can be made between components in remote locations

Disadvantages of Electron Beam Welding –

(i) Initial cost of equipment is high and portable equipment is rare.
(ii) Work is to be manipulated through vacuum seals.
(iii) Time and equipment is required to create vacuum everytime a new job is to be welded.
(iv) Precautions are needed to prevent damage from X-rays.
(v) Electron beam travels on a line of sight, therefore, obstructed joints cannot be welded.
(vi) Because of complexity of circuitry, very competent persons are required.

(vii) Workpiece size is limited by the work chamber dimensions. Moreover, the workpiece being in an evacuated chamber becomes inaccessible and thus need to be manipulated by some special device

Applications of Electron Beam Welding -

(i) For welding reactive"' and refractory"' metals used in the atomic energy and rocketry fields.

(ii) For welding other common similar"' * and dissimilar metal combinations [e.g. Invar (64Fe - 36Ni) and (12Mn -18 Cu -10Ni); stainless steel and Inconel, titanium, and copper, etc.].

(iii) For welding automobile, airplane, aerospace, farm and other types of equipment, where especially low distortion is desired.

(iv) Since arc length may be varied from very short to very long without changing the quality of welds, welds can be made even at those points that are virtually inaccessible for other welding processes

(v) Recently developed machines can make two parallel beads simultaneously with one gun and find applications in the mass production of type writer carriages.

LASER BEAM WELDING

Definition and Concept

Laser beam welding is defined as a welding process where in coalescence is produced by the heat obtained from the application of a concentrated coherent light beam impinging upon the surfaces to be joined. All light consists of waves.

In common light, these waves are incoherent and of varied lengths and frequencies that shoot off in numerous directions. The laser beam, on the other hand, is a coherent light i.e., the waves are identical and parallel.

The laser is a device for concentrating light waves into narrowly defined highly intense beam that can impart tremendous energy on a small area to produce fusion for welding purposes.

Laser Beam Welding Principle and Theory of Operations

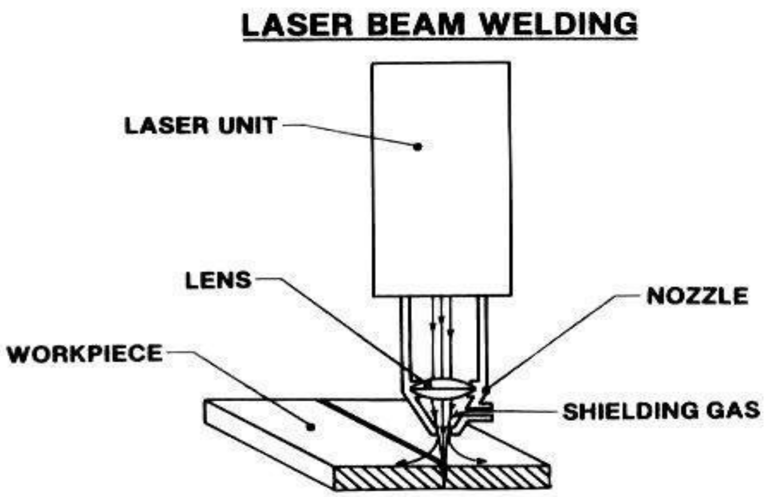
Laser welding system consists of,

A man made cylindrical by crystal. Ruby is aluminium oxide with chromium dispersed throughout it, forming about 1/2000 of the crystal, which is less than a natural ruby contains. The ends of the crystal are silvered to form mirrors internally, while one end has a tiny hole in the silver layer, through which the laser beam emerges.

Around the outside of the crystal is placed flash tube containing inert gas xenon. The flash tube is designed for operation of a rate of thousands of flashes per second. Flash tube converts electrical energy into light energy.

The capacitor bank (storage) stores electrical energy. It is charged by a high voltage power supply. It energises the flash tube by an appropriate triggering system. When subjected to electrical discharge from the capacitors, xenon transforms a high proportion of the electrical energy into white light flashes. The flash has a duration of about 1/1000 second. As the ruby is exposed to the intense light flashes, the chromium atoms of the crystal are excited and pumped to a high energy level. These chromium atoms immediately drop to an intermediate energy level with the evolution of heat, and eventually drop back to their original state with the evolution of a discrete quantity of radiation in the form of red fluorescent light.

As the red light emitted by one excited atom hits another excited atom, the second atom gives off red light which is in phase with the colliding red light wave. In other words, the red light from the first atom is amplified because more red light exactly like it is produced.



The effect is enhanced because the parallel ends of ruby rod are mirrored so that the red light that is produced reflects back and forth along the length of the crystal. The chain reaction collisions between waves of fluorescent red light and chromium atoms become so numerous that finally, the total energy bursts over a threshold and escapes from the small hole in the mirror at one end of the ruby crystal as the laser beam.

This narrow laser beam is focused by an optical focusing lens to produce a small intense spot of laser (light) on the job. Optical energy as it impacts the workpiece is converted into heat energy. The temperatures generated can be made sufficient to melt (and vaporize) the materials to be welded or cut.

Since most of the power output of a laser source is lost as heat, cooling system is used to carry away the same. Both gas and liquid cooling is used, the latter being more common.

The laser welding machine has an optical reflective cavity which reflects and focuses high-intensity radiation from the flash lamps on to the ruby (crystal) rod.

There are two techniques for laser welding. One is to move the workpiece so fast that a complete joint passes by and is welded by one burst. The other, and more common method, is to fuse a series of spots, commonly overlapping.

In laser welding, a minute puddle is melted and frozen in a matter of microseconds. Since this time is very short, no chemical reaction between the molten metal and atmosphere takes place and hence in laser welding no protection (shielding etc.) is needed against atmospheric contamination.

Advantages of Laser Beam Welding -

(i) Welds can be made inside transparent glass or plastic housings.

(ii) A wide variety of materials can be welded, including some formerly considered as unweldable combinations.

(iii) As no electrode is used, electrode contamination or high electric current effects are eliminated.

(iv) Areas not readily accessible can also be welded.
(v) It permits welding of small, closely spaced components with welds as small as a few microns in diameter.
(vi) Surface contaminants such as oxides and organic materials make little, if any, difference in the quality of the weld.
(vii) Unlike electron beam welding it operates in air, no vacuum is required.
(viii) Laser beam being highly concentrated and narrowly defined produces narrow size of the heat affected zone.

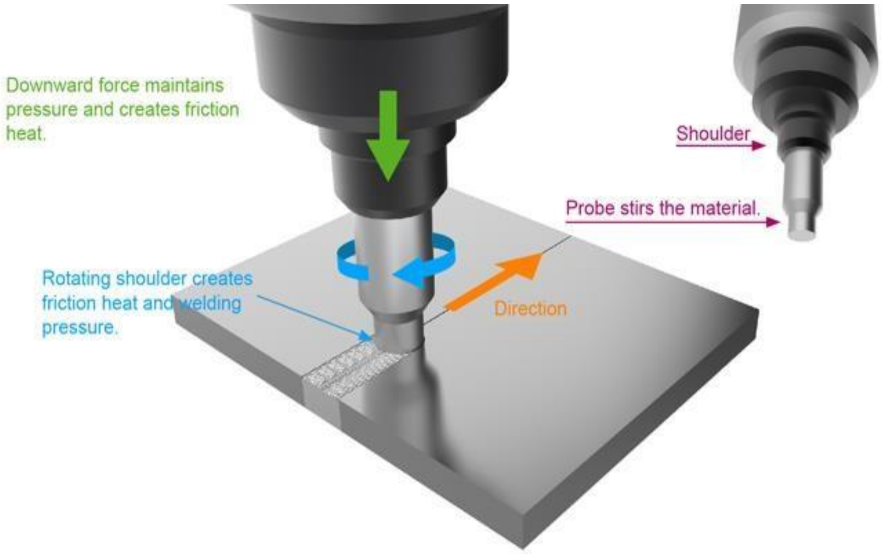
Disadvantages of Laser Beam Welding -
(i) The major drawback to laser beam welds is the slow welding speeds (25 to 250 mm/min.) resulting from the pulse rates and puddle sizes at the fusion point.
(ii) Laser welding is limited to depths of approximately 1.5 mm and additional energy only tends to create gas voids and undercuts in the work.
(iii) Materials such as magnesium tend to vaporize and produce severe surface voids.

Applications of Laser Beam Welding -
(i) Laser is a high energy light beam that can both weld and cut the metals.
(ii) For connecting leads on small electronic components and in integrated circuitry in the electronic industry.
(iii) To weld lead wires having polyurethane insulation without removing the insulation. The laser evaporates the insulation and completes the weld.
(iv) To join hard high melting point metal alloys.
(v) In space and aircraft industry for welding light gauge materials.

FRICTION STIR WELDING

Friction stir welding (FSW) is a solid-state joining process that uses a non-consumable tool to join two facing workpieces without melting the workpiece material. Heat is generated by friction between the rotating tool and the workpiece material, which leads to a softened region near the FSW tool. While the tool is traversed along the joint line, it mechanically intermixes the two pieces of metal, and forges the hot and softened metal by the mechanical pressure,

Friction stir welding is a cylindrical shouldered tool with a profiled probe. A pin or nib is used. Friction is created between the metal being worked, the nib and the shoulder.



Principle:

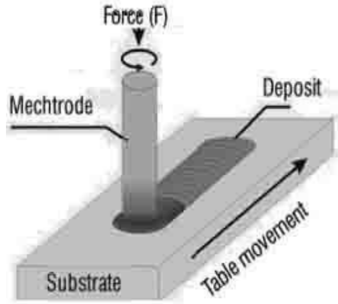
The adjacent metal sheets are joined by a tool that is a non-consumable tool and is made up of a pin and a shoulder. The non-consumable tool used in friction stir welding performs two functions first it heats the workpiece to raise its temperature sufficiently to the stage at which it is not molten but plastically melted and second it moves along the edges of the workpiece to weld it or to make a joint. The heating is achieved by friction between the tool and the workpiece and because of the plastic deformation of the workpiece. The localized heating softens the material around the pin and shoulder. The tool rotation leads to the movement of material from the front of the pin to the back of the pin. And this completes the welding and a strong solid-state joint is ready.

Working Process of Friction Stir Welding (FSW)

1. Firstly clamp the workpiece in a heavy-duty setup, so that it does not move or shake at the time of welding.
2. Workpiece should be abutting i.e. both parts should be kept side to side at a particular distance from each other.
3. Now insert a blunt or probe tool till the whole pin gets inserted in the abutting edges.
4. Now the shoulder gets in touch with the abutting edges.
5. The tool starts rotating within contact with the job.
6. Due to contact of the workpiece, friction is applied and as a result of it, heat is generated.
7. This heat makes the metal plastically melt.
8. When the metal gets plasticized the high downward forces or pressure makes a strong, clean and solid-state weld.

Friction Surfacing

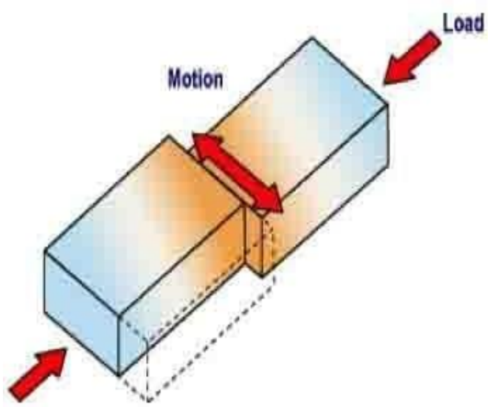
Friction Surfacing



Friction surfacing is a surface coating process. The coating material is Mechtrode, which is rotated under pressure over the substrate

Linear friction welding

In linear friction welding an oscillating chuck is used. It is applied to non-round shapes as compared to spin welding. The material welded has to have high shear strength.



Advantages:

1. Can produce high quality welds in a short cycle time.
2. No filler metal is required and flux is not used.
3. The process is capable of welding most of the common metals. It can also be used to join many combinations of dissimilar metals. Friction welding requires relatively expensive apparatus similar to a machine tool.
4. Easy to operate equipment
5. Not time consuming

6. Low levels of oxide films and surface impurities
7. When compared to resistance butt welding creates better welds at lower cost and higher speed, lower levels of electric current are required
8. Small heat affected zone when comparing the process to conventional flash welding.
9. When compared to flash butt welding, less shortening of the component.
10. No need to use gas, filler metal or flux. No slag that can cause weld imperfections.

Disadvantages:

1. Process limited to angular and flat butt welds.
2. Only used for smaller parts.
3. Complicated when used for tube welding.
4. Hard to remove flash when working with high carbon steel.
5. Requires a heavy rigid machine in order to create high thrust pressure.

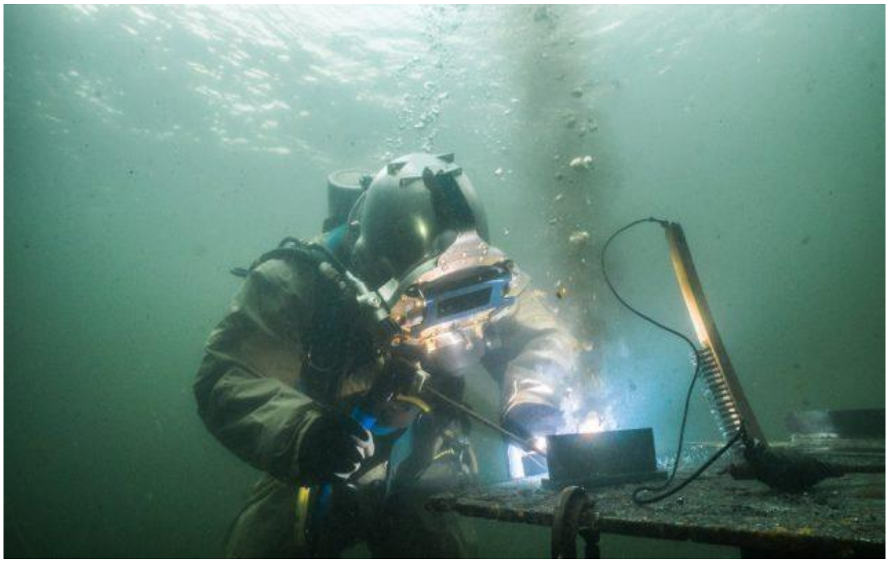
Application:

1. Used in shipbuilding companies to weld big parts of the ship.
2. Mostly used in aerospace industries to join or weld the bigger parts like wings etc.
3. It is used in automotive industries to held many parts.
4. Used in railways.
5. It is also used in fabrication work of metals

WET UNDERWATER WELDING

Wet underwater welding directly exposes the diver and electrode to the water and surrounding elements. Divers usually use around 300–400 amps of direct current to power their electrode, and they weld using varied forms of arc welding. This practice commonly uses a variation of shielded metal arc welding, employing a waterproof electrode.

Wet underwater welding employs a waterproof electrode. Other processes that are used include flux cored arc welding and friction welding. In each of these cases, the welding power supply is connected to the welding equipment through cables and hoses. The process is generally limited to low carbon equivalent steels, especially at greater depths, because of hydrogen-caused cracking.



Wet Welding

Underwater welding also called as hyperbaric welding Well, if we perform a hyperbaric welding process in the wet surrounding or the wet environment then, it is referred to as the underwater welding. A lot of people often confuse between the words underwater welding and hyperbaric welding. A hyperbaric welding process can be called as the underwater welding if and only if it is carried out in the environment where water is present.

It is evident that welders mostly use Shielded Metal Arc Welding (SMAW) as it is the most effective and affordable welding method. Shielded Metal Arc Welding is also called as Stick Welding. With the help of the Stick Welding, an electric arc is generated between the electrode and the base metal. In most of the cases, the base metal is often of copper or aluminium.

In the wet underwater welding process (WUW), drivers have to be very attentive and they must follow various certain rules. Here, the most important thing that welder should do is keeping the electrode very clean.

Usually, when the welders are ready, they alert their respective team to pass the current when the electrode is in touch with the base metal.

Which type of current is used during wet welding? In the wet welding process, direct current is used. Direct current is very safer to use in underwater conditions than the alternating current.

The wet underwater welding process takes place in the following manner:

- The work that has to be welded is attached at one end of the electric circuit while a metal electrode is attached at the other side.
- The electric arc is formed due to the supplied current. Then, bare metal is welded and the formation of weld pool takes place.
- Due to the heat generation, the electrode melts and projection of the metal droplets takes place into the projected area. At the same time, the flux which is coated on the electrode melts to form the shielding gas. This shielding gas is used for stabilizing the arc column.

Requirements of the wet underwater welding process:

- **Power supply:** 300 to 400 amps of current. Motor generators or DC generators.
- Gas manifolds
- Power converter
- Welding generator
- Power converter

Advantages of WUW

- Low cost:
- The most important benefit of the wet underwater welding is that it is very affordable as compared to the dry underwater welding.
- It is also versatile to carry out
- The WUW process is easier to carry out. We can do at a very faster rate with more effectiveness.
- Can Weld in the Complicated Areas:
- Minimum Equipment is Required:

Disadvantages of Wet Underwater Welding:

- Less Strength:
- Low efficiency:

Applications

It is the key technology for repairing marine structure.

Welding is directly performed under water is directly exposed to the wet environment.

Increased freedom movement makes more effective, efficient and economical.

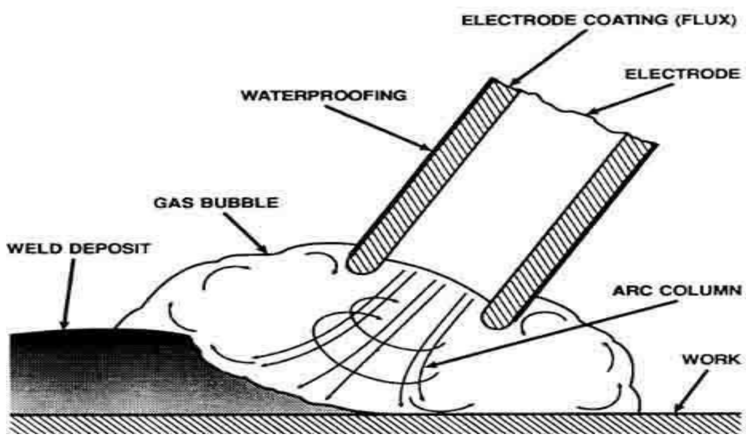
Supply is connected to the welder, driver via cables or hoses.

DRY WELDING OR HYPERBARIC WELDING

In the dry welding process, a special type of chamber is used as a welding environment. Here, the welding is done in the same way as that of the regular welding process. But, a seal-like structure is created around the area which is to be welded. A mixture of gases like helium and oxygen is present in such an area.

In the dry welding done under the water, following four dry welding methods are used:

- Habitat Welding: In the habitat welding, welders use the room-sized chamber having the same pressure outside it.
- Dry Spot Welding: Dry spot welding is usually performed for the chambers that are smaller in size. Here the chamber size is as small as that of the head of the person. The welder has to insert the electrode inside the chamber.



- Pressure Welding: In pressure welding, the pressure of 1 atmosphere is usually present.
- Dry Chamber Welding: In the dry chamber welding, the size of the chamber is usually bigger than the size of it inside the dry spot welding.

Process

- Use a pre-job meeting to do a job safety analysis. Get the crew together at the beginning of the job to review the hazards and plan. (use the Job Safety Analysis – JSA format)
- Use an adequate size DC welding generator using straight polarity. Straight polarity is obtained by connecting the negative lug to the torch and the positive to the ground lead. Never use AC for burning or welding in the water. The electrical shock caused by AC current prevents voluntary relaxation of the muscles that control the hands. If electrocuted a diver may be unable to let go if his body or equipment accidentally enters the electrical circuit. If you use a rectifier machine, use a modern one that has up to date technology

- Divers should wear insulated gloves at all times when burning or welding.
- Attach the ground lead of the generator as close to the worksite as practical so that the diver is never between the electrode and the ground.
- Make sure there is a positive operating disconnect switch on the torch side of the current. When the diver is changing burning rods or doing anything other than burning, the disconnect switch must be in the open position (as shown). It is important that the opening and closing of the switch be directed by the diver. Each command should be confirmed by the diver using the terminology “make it hot,” or “make it cold.”
- Polarity can be checked by immersing the rod tip and ground clamp into a bucket of saltwater 2″ apart. Energize the rod by closing the safety knife switch. A stream of the bubble should rise from the rod tip. If not reverse the polarity and retest.
- After the diver enters the water, the first task is to clean a spot for the ground clamp. The spot should be in a position in front of the diver, as close as practical to the weld joint and should be scraped or wire brushed shiny clean. For diver safety, only C-type clamps should be used as grounding clamps for underwater cutting or welding operations. The clamp must be firmly secured to the workpiece and the cable should have
  sufficient slack to prevent it from being pulled loose. The diver may elect to lightly tack weld the clamp in place when there is a possibility of it working loose. The ground should always be kept in the diver’s forward line of vision.
- The diver should make a test weld to check the “heat” at working depth.
- When the electrode has been consumed to within 3″ of the torch, stop the cut and signal to “make it cold.” before attempting to change electrodes. Maintain the torch in the cutting position until the tender acknowledges “make it cold” or “switch off.”
- It is not safe to operate the welding torch without the flash arrestor in place.
- Never speed up the cutting by creating a fire or inferno deep inside the metal. Such a situation can lead to an explosion.
- Do not cut non-ferrous metals underwater since they do not oxidize and have to be melted. Cutting non-ferrous metals can result in an explosion.
- Ignition should not occur underwater when the oxygen pressure is low. This will result in the cable to burn inside itself, possible blowing holes through the cable, a situation that can result in injury.
- A diver risks electrical shock when welding or cutting when partially immersed in water.
- Acetylene is very unstable at pressures above 15 psi and is not used for underwater cutting.
- The hand should never be closer than 4″ from the electrode tip.
- The diving tender should always maintain a written record of the following in order to repeat what worked during the next welding or cutting session:
    - The welding amperage as read from the tong meter.
    - Both open and closed-circuit voltage as read from the voltmeter.
    - Electrode diameter, type, manufacturer and waterproofing material.
    - Electrical polarity.
    - Length of welding cable.
    - Depth of work site.

Advantages of Dry Underwater Welding:

- Safety of the welder:
- Non-destructive testing can be easily carried out in the dry environment and after the dry underwater welding process.
- Excellent Quality Weld.

Special reason behind the production of the quality weld

1. First of all, as the water is not present inside the chamber or during this process, weld doesn't get quenched easily.
2. The second reason is the less presence of the hydrogen near the weld area.
3. During the dry underwater welding (DUW), the surface can be monitored easily. That means we can usually inspect the joint, alignment of the pipe without any hassle

Disadvantages of the Dry Underwater Welding:

- Complex Habitat:
  Here, we use a chamber as a habitat. For building this chamber, a lot of complex things have to be done. Also, various precautions are must be taken for creating the entire habitat where we can do to the welding without any issue.
- Costlier Process:
  The important drawback of the dry underwater welding is that this process requires a lot of money. For producing a single weld, we require $80000. This amount is very large. Also, a used chamber cannot be reused for doing welding at different locations inside the water.
- Here, the cost of the process is directly proportional to the depth of the welding zone under the water. So, if you want to implement this welding at very high depth then, a large capital has to be invested.
- High Voltage Required:

Applications:

- Offshore construction for tapping sea resources,
- Temporary repair work caused by ship's collisions or unexpected accidents.
- Salvaging vessels sunk in the sea
- Repair and maintenance of ships
- Construction of large ships beyond the capacity of existing docks.