Welding Technology

UNIT-5

Other Welding Process & Defects:

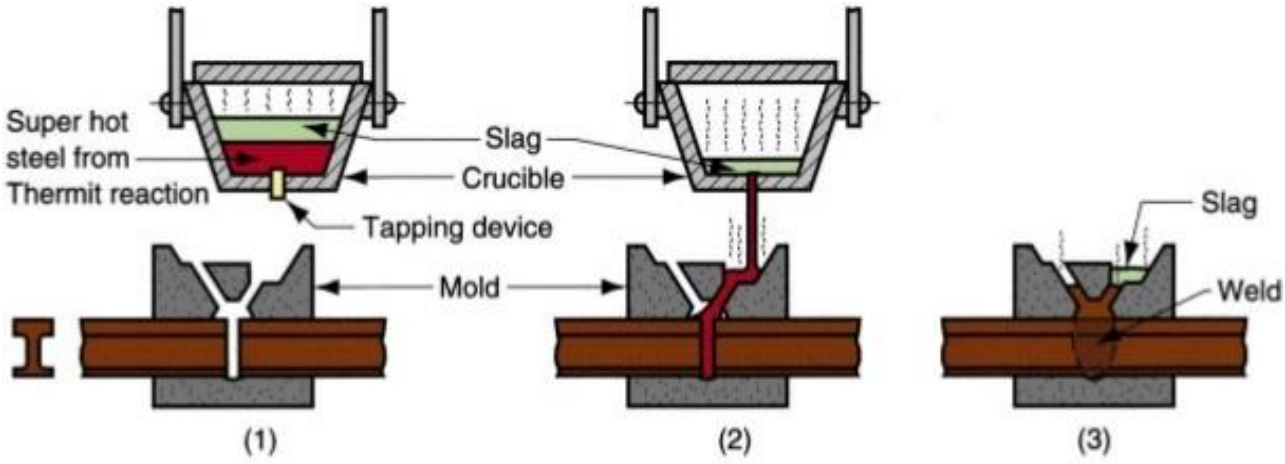
THERMIT WELDING

Principle:

- Thermit welding is a liquid state chemical welding process, in which joint formation takes place in molten state.
- Practically, it is combination of welding and casting process in which, the molten iron poured at the welding plates and allow solidifying to make a permanent strong joint. The molten state of iron creates without application of external heat or conventional furnace so this is taken as a welding process.
- In this type of welding, a mixture of aluminium and iron oxide is used in ratio 1:3 by weight. This mixture chemically reacts as follow:

$8\ Al + 3\ Fe_3O_4 \rightarrow 9\ Fe + 4\ Al_2O_3 + Heat$

- This reaction gives aluminium oxide and iron and also liberate a huge amount of heat which coverts this mixture into molten state.
- Because the molten iron has higher density compare to aluminium oxide so it remains bottom of the crucible. There is an opening at bottom of the crucible from where, this molten iron poured at the required plates where we want to create joint. This is basic principle of thermite welding.



Thermit welding: (1) Thermit ignited; (2) crucible tapped, superheated metal flows into mold; (3) metal solidifies to produce weld joint.

Equipment's:

Refectory Crucible:

The thermit mixture of iron oxide and aluminium reacts in a refectory crucible. This crucible is made by graphite or other suitable refectory materials, which can handle temperature around 3000 degree centigrade. There is a gate at bottom of the crucible for exit of molten metal. The slag form by aluminium oxide floats over molten metal due to density difference which is removed from there.

Thermite Mixture:

A mixture of aluminium and iron oxide in proper ratio known as thermite mixture. The ratio of aluminium to iron oxide is about 1:3 by weight. In the copper thermite welding copper oxide with aluminium mixture is used.

Mould:

In the thermite welding mould is created by either graphite or sand. Graphite moulds are permanent mould which is used to make various similar joints. Sand mould is used where the joint design is different every time. For making sand mould, wax pattern is used. This mould made around the part that needs to be welded. It receives the molten metal. The mould contains runner, riser, gating system, heat opening etc. same as used in casting.

Wax Pattern:

Wax pattern is used to make sand mould around the welding work pieces. The sand is rammed around the wax pattern to make sand mould. After proper ramming action, the mould is heated which removes the wax pattern by melting of it.

Moulding Flask:

The sand mould creates into the moulding flask. The wax pattern which is created around the weld cavity is placed at the middle of the flask. The moulding sand rammed into the flask to make sand mould.

Mould handle clamp:

This is a clamp which is used to fix moulding flask around the welding plates.

Ignite powder:

To ignite the thermite mixture, preheating of this mixture is essential, which is done by ignition of powder. It is highly inflammable powder which can achieve the maximum temperature of 1300 degree centigrade which is essential to start thermite reaction.

Working:

Now we know basic principle and essential parts of thermite welding. Thermite welding is similar like a casting process in which the molten state of metal is created by the chemical reaction. Its working can be summarized as follow.

- First both the work pieces which are needed to be weld, are cleaned.
- Now a wax pattern is created around the weld cavity.
- A moulding flask is fixed around the joint with the help of mould handle clamp. This wax pattern is situated at the middle of the flask.

- Now the moulding sand rammed around the wax pattern to create mould in which the molten metal will pour. This mould involves all necessary parts like runner, riser, pouring basin, gating system, opening for wax pattern etc. same as involves in casting.
- Now this mould is heated to remove wax pattern. The wax is melted and run off from the wax pattern outlet prepared at bottom of the sand mould.
- Now the thermite mixture is taken into the refectory crucible. The ignite powder is placed over the mixture. This mixture is ignited by a magnesium ribbon.
- This will start the thermite reaction which liberates a huge amount of heat. This reaction form molten state of iron which flows from crucible to sand mould.
- This molten metal fills the weld cavity and fuses the parent metal to make a permanent joint. This will allow to cool down. After proper cooling, flask is removed from the joint.
- After removing the flask, machining is done to remove the welding burr or other extra metal.

Application:

- It is mostly used to weld railroad at the site.
- It was used to weld thick plate before introduce **electroslag welding**.
- They are used to repair heavy castings.
- It is used to weld cable connectors of copper.
- It is used to make structure joints in large ships etc.
- It is used to joint pipe, thick plate etc. where power supply is not available.

Advantages and Disadvantages:

Advantages:

- It is simple and easy process.
- Low setup cost.
- Metal joining rate is high.
- Thermite welding can be done at site where casting is impossible.
- This can be used where power supply is not available.

Disadvantages:

- It is used for limited metals like iron and copper.
- It is uneconomical for welding light parts.
- Highly depends on environmental condition like moisture contain, work piece alignment etc.

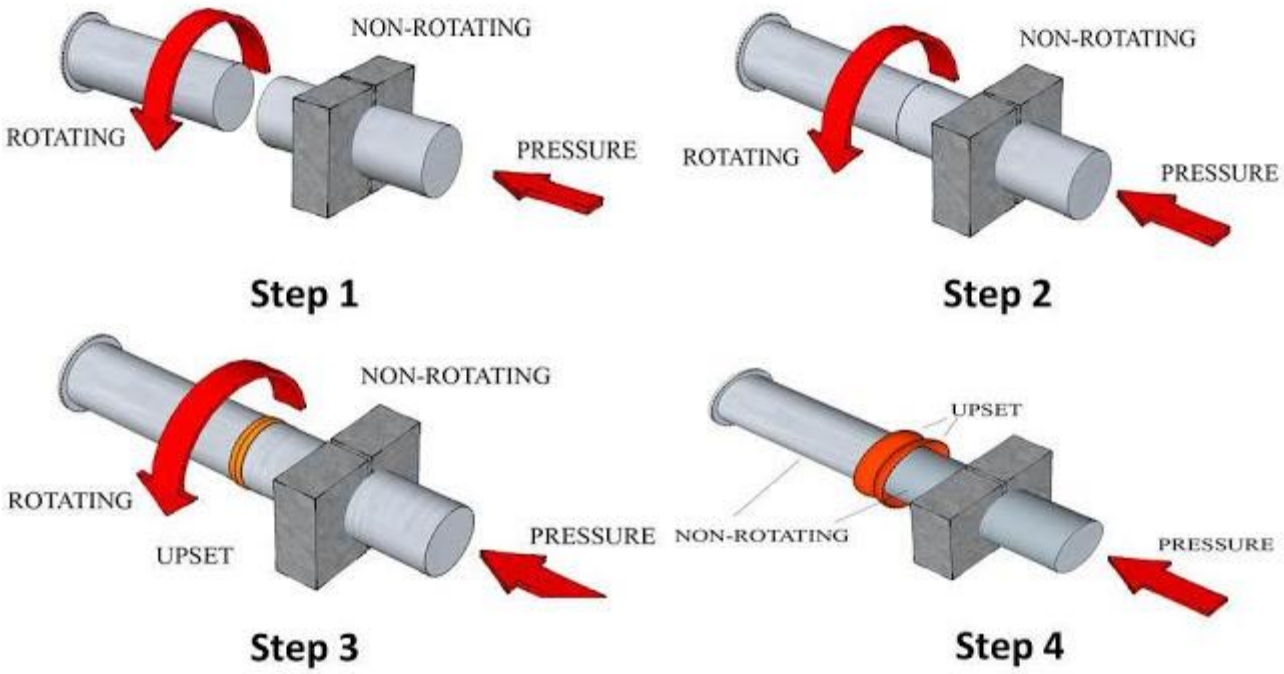
Friction Welding:

Principle:

- Friction welding works on basic principle of friction.
- In this welding process, the friction is used to generate heat at the interference surface.
- This heat is further used to join two work pieces by applying external pressure at the surface of work piece. In this welding process, the friction is applied until the plastic forming temperature is achieved.
- It is normally 900-1300 degree centigrade for steel.
- After this heating phase, a uniformly increasing pressure force applied until the both metal work pieces makes a permanent joint. This joint is created due to thermo mechanical treatment at the contact surface.

Working:

There are many types of friction welding processes which work differently. But all different these processes involves common a working principle which can be summarize as follow:



Friction Welding

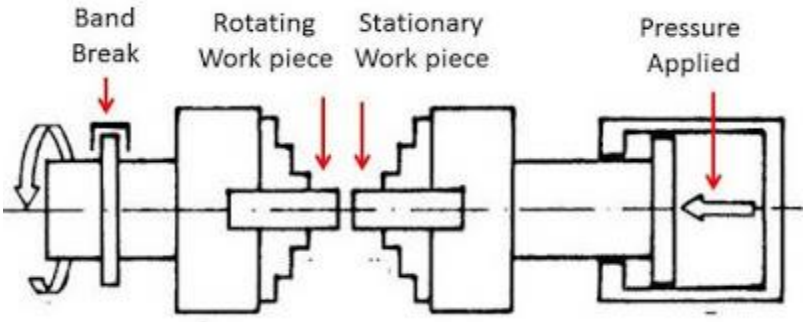
- First both the work pieces are prepared for smooth square surface. One of them is mounted on a rotor driven chuck and other one remains stationary.
- The rotor allows rotating at high speed thus it makes rotate mounted work piece. A little pressure force is applied on the stationary work piece which permits cleaning the surface by burnishing action.

- Now a high pressure force applied to the stationary work piece which forces it toward rotating work piece and generates a high friction force. This friction generates heat at the contact surface. It is applied until the plastic forming temperature is achieved.
- When the temperature is reached the desire limit, the rotor is stopped and the pressure force is applied increasingly until the whole weld is formed.
- This welding is used to weld those metals and alloys which cannot be welded by other method.

Types:

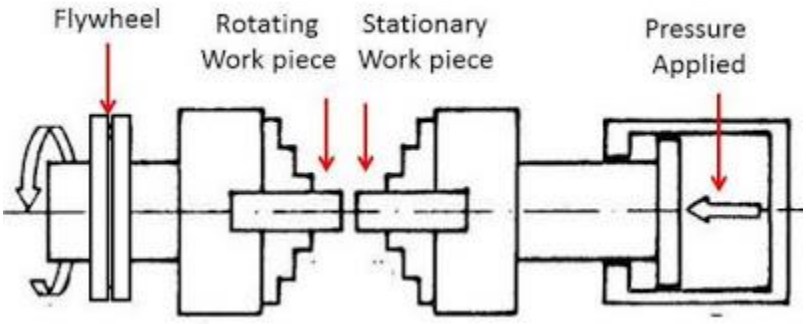
Continuous induce friction welding:

This welding is same as we discussed above. In this welding process, the rotor is connected with a band **brake**. When the friction crosses the limit of plastic temperature, the band brake comes into action which stops the rotor but the pressure applied on the work piece increasingly until the weld is formed.



Inertia friction welding:

In this type of friction welding the band brake is replaced by the **engine** flywheel and shaft flywheel. These flywheels connect chuck to the motor. In the starting of the welding, both flywheels are connected with one another. When the speed or friction reaches its limit, the engine flywheel separated from the shaft flywheel. Shaft flywheel has low moment of inertia which stops without brake. The pressure force is continuously applied to the work piece until the weld is formed.



Application:

- For welding tubes and shafts.
- It is mostly used in aerospace, automobile, marine and oil industries.
- Gears, axle tube, valves, drive line etc. components are friction welded.
- It is used to replace forging or casting assembly.
- Hydraulic piston rod, truck rollers bushes etc. are join by friction welding.
- Used in electrical industries for welding copper and aluminum equipment's.
- Used in pump for welding pump shaft (stainless steel to carbon steels).
- Gear levers, drill bits, connecting rod etc. are welded by friction welding.

Advantages and Disadvantages:

Advantages:

- It is environment friendly process without generation smoke etc.
- Narrow heat affected zone so no change in properties of heat sensitive material.
- No filler metal required.
- Welding strength is strong in most cases.
- Easily automated.
- High welding speed.
- High efficiency of weld.
- Wide variety of metal can be weld by this process.

Disadvantages:

- This is mostly used only for round bars of same cross section.
- Non-forgeable material cannot be weld.
- Preparation of work piece is more critical
- High setup cost.
- Joint design is limited.

Ultrasonic Welding:

Principle:

It works on the basic principle of energy of ultrasonic wave. Ultrasonic vibration creates a dynamic shear stress between the contacts of two work piece. Due to local plastic deformation and heat generate due to friction between contact surfaces, joint formation will take place at the interface.

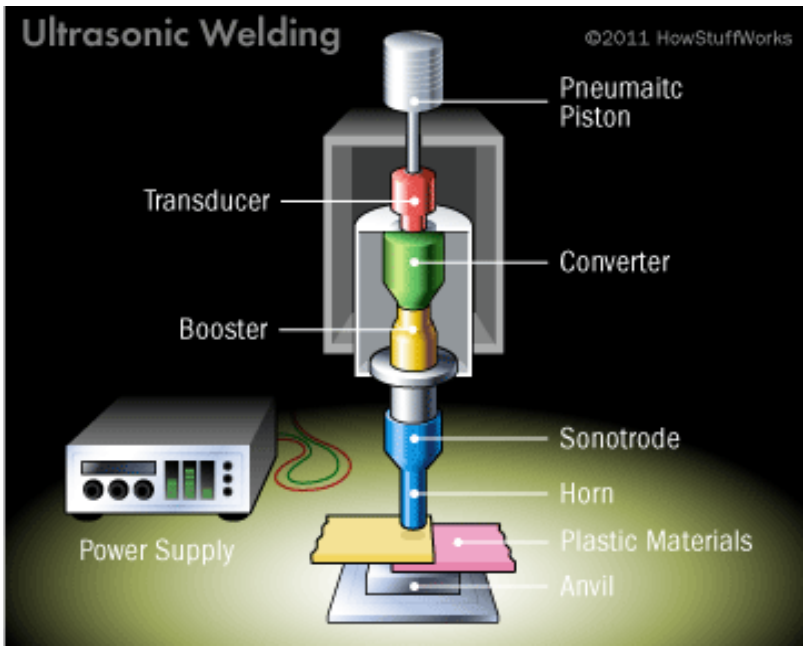


Diagram of Ultrasonic Welding

Equipment's:

Power Supply:

The ultrasonic welding needs high frequency and high voltage power supply. This power is needed by the transducer to generate vibrations.

Transducer:

Transducer is a device which can convert high frequency electric signal into high frequency mechanical vibration. This is connected with the welding head. The converter or piezoelectric transducer used in this welding process.

Booster and Horn:

The mechanical vibration created by the transducer is supplied to the booster which amplifies this vibration and supply to the horn. Horn is a device which supply this amplified vibration to the welding plates.

Fixture or clamping devices:

This device is essential in the ultrasonic welding. This uses either electrical, hydraulic, pneumatic or mechanical energy to hold the plates into desire location.

Working:

Now we know the basic concept of ultrasonic welding. This welding works as follow.

- At the start, high frequency current passes through a piezoelectric transducer. This transducer converts high frequency electrical signal into mechanical vibration.
- This vibration further supplied to the booster which amplify its frequency.

- The amplified high frequency vibration passes through horn which is in contact with welding plate.
- This welding creates lap joint. One plant of the weld is fixed into fixture and other one is in direct contact with horn. These plates are fixed under moderate pressure force.
- The horn supply high frequency mechanical vibration to the welding plate.
- Due to this vibration, oscillation shear force act at the interface between welding plates which result elestoplastic deformation at interface.
- It also create a localize temperature rise due to mechanical force and friction. This heat helps in plastic deformation at interface and makes a strong joint without melting of work piece or using filler metal.

Advantages and Disadvantages:

Advantages:

- This welding can be easily automated and fast.
- This produces high strength joint without applying external heat.
- This is clean and provides good surface finish after welding.
- Ultrasonic process used to weld wide variety of dissimilar metal.
- It does not develop high heat so there is no chance of expel molten metal form joint.

Disadvantages:

- It does not weld thick harder metal. The thickness of welds about 2.5 mm for aluminum.
- Tooling cost for fixture is high and they also need special design.
- The vibration generates through transducer, can damage electronic component.
- Applications:
- This welding is used in fabrication of nuclear reactor components.
- It is used in automotive industry for key, head lamp parts, button and switches etc.
- Ultrasonic is used in electronic industries like armature winding, switches etc.
- This is clean welding process so it is used in medical industries to make parts like filters, masks etc.

Friction Stir Welding (FSW):

Principle:

- Friction stir welding works on same principle of friction welding. In this process, friction is used to generate heat at interface surface.
- This heat starts **diffusion** process at the mating surface.
- A high pressure force applied at these mating surfaces which accelerates metal diffusion process and form a metal to metal joint. This is basic principle of **friction welding**.
- In friction stir welding, a rotating tool is used to applied friction and pressure force at the plates. This tool rotates at its own axis and move longitudinally at the plates interface which generates heat by friction between rotating tool and work piece.

This heat deformed the interface surface and diffuses the two piece of work piece into one another by applying a high pressure force.

- This joint is created due to thermo mechanical treatment at the interface surface. One big advantage which makes it versatile welding process is that, it can be easily automated and gives higher metal joining rate. It is mostly used to join aluminium alloy.

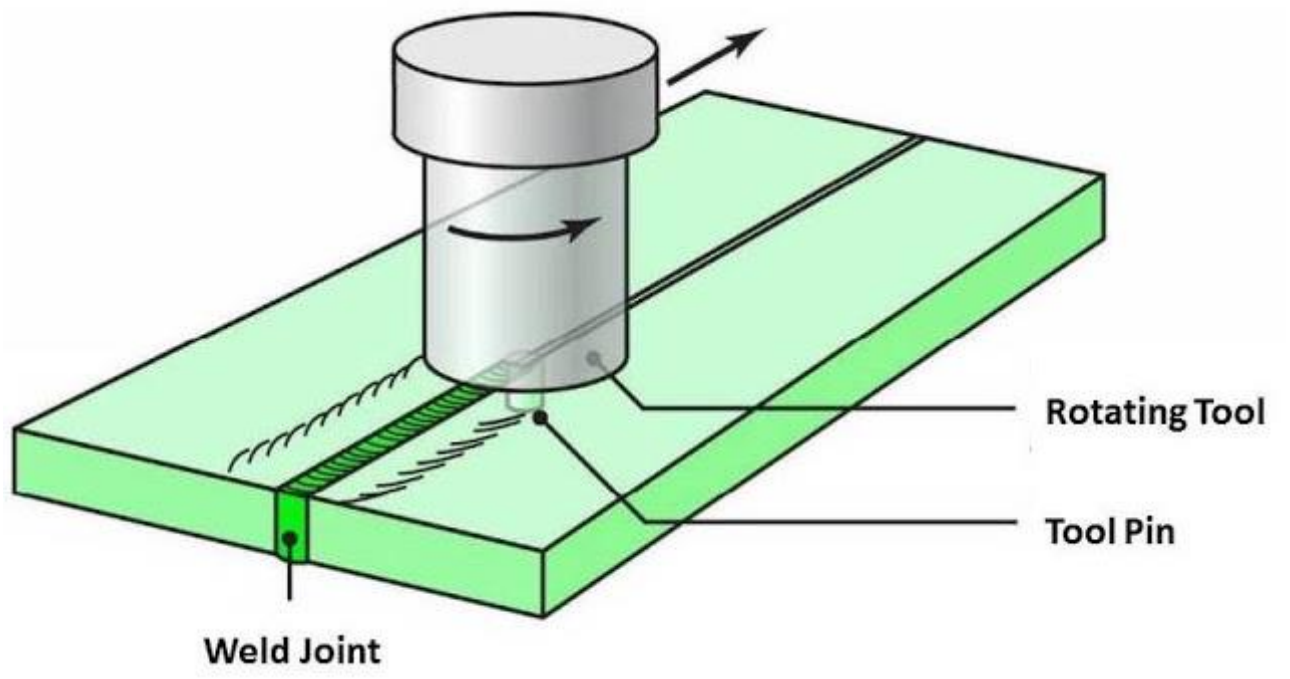


Diagram of FSW

Working:

The working process of friction stir welding can be summarized as follow.

- First both the work plates are clamped together same as in butt joint. These both plate's weld able surfaces are in contact with one another.
- Now a rotating tool pin is inserted into work pieces at the interface surfaces until tool shoulder touched the work piece. This will deform the material plastically due to heating by friction force. This is state of the joining process in which, inter molecular diffusion will deform the material plastically due to heating by friction force.
- Now the rotating tool is move forward along the joint line. This will form a joint behind the tool.
- The tool continuously move unlit the whole weld is form. After the joining process, tool is separated from the work piece. The hole created by tool pin remains in the welding plates.
- Its working can be clearly understood by following video.

Application:

- FSW is mostly used in aircraft industries for welding wings, fuel tanks, aircraft structure etc.
- Used in marine industries for structure work.
- Used in automotive industries to weld wheel rims, chassis, fuel tanks and other structure work.
- It is used in chemical industries for joining pipelines, heat exchanger, **air conditioner** etc.
- Friction stir welding is also used in electronic industries for joining bus bar, aluminum to copper, connectors and other electronic equipment's.
- It is widely used in fabrication industries.

Advantages and Disadvantages:

Advantages:

- It is a solid state welding so does not use flux, filler metal etc.
- FSW can be used to weld both similar and dissimilar metals.
- Fine grain size and quality weld can be obtain by this process
- Lower power consumption due to absence of external heating.
- Highly automated.
- Little maintenance required.
- Large welding joint design available and it can weld in all direction.
- Easy to operate and does not involve any environmental pollution.

Disadvantages:

- Complicated or special **fixture** arrangement required.
- It creates a visible hole in welding plates.
- High initial or setup cost.
- It is less flexible compare to **arc welding process**.
- FSW cannot make filler joints.
- Non Forgeable material cannot be weld.

Laser Beam Welding

- **Laser Beam Welding** is a fusion welding process in which two metal pieces are joined together by the use of laser.
- The laser beams are focused to the cavity between the two metal pieces to be joined.
- The laser beams have enough energy and when it strikes the metal pieces produces heat that melts the material from the two metal pieces and fills the cavity. After cooling a strong weld is formed between the two pieces.
- It is a very efficient welding process and can be automated with robotics machinery easily. This welding technique is mostly used in automotive industry.

Working Principle

It works on the principle that when electrons of an atom gets excited by absorbing some energy. And then after some time when it returns back to its ground state, it emits a photon of light. The concentration of this emitted photon increased by stimulated emission of radiation and we get a high energy concentrated laser beam.

Light amplification by stimulated emission of radiation is called laser.

Main Parts

The main parts or equipment of laser beam welding are:

1. **Laser Machine:** It is a machine that is used to produce laser for welding. The main components of laser machine are shown below.
2. **Power Source:** A high voltage power source is applied across the laser machine to produce laser beam.
3. **CAM:** It is a computer aided manufacturing in which the laser machine is integrated with the computers to perform welding process. All the controlling action during the welding process by laser is done by CAM. It speeds up the welding process to a greater extent.
4. **CAD:** It is called as Computer aided Design. It is used to design the job for welding. Here computers are used to design the workpiece and how the welding is performed on it.
5. **Shielding Gas:** A shielding gas may be used during the welding process in order to prevent the w/p from oxidation.

Also Read: Electron Beam Welding Process – Equipments, Working Principle with Diagram

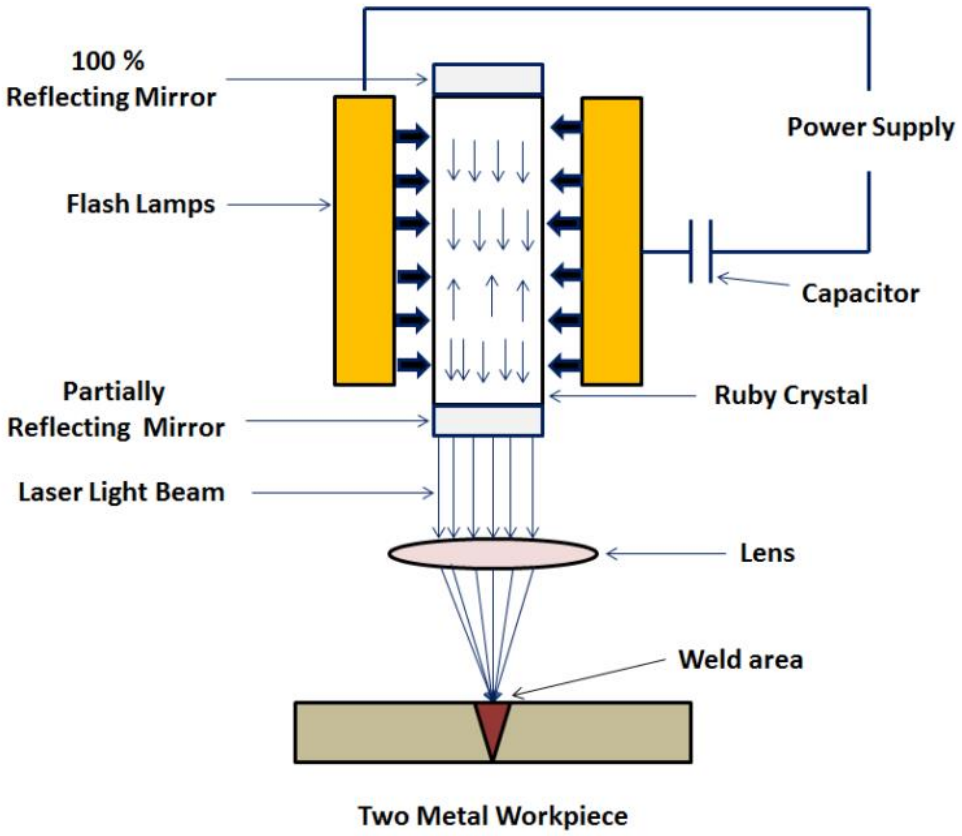
Types of Laser Used

1. **Gas lasers:** It uses mixtures of gases as lasing medium to produce laser. Mixtures of gases such as nitrogen, helium and co_2 are used as lasing medium.
2. **Solid-state laser:** it uses several solid media such as synthetic ruby crystal (chromium in aluminum oxide), neodymium in glass (Nd:glass), and neodymium in yttrium aluminum garnet (Nd-YAG , most commonly used).
3. **Fiber laser:** The lasing medium in this type of laser is optical fiber itself.

Characteristics of Laser Beam Welding

1. The power density of laser beam welding is high. It is of the order 1 MW/cm^2. Because of this high energy density, it has small heat-affected zones. The rate of heating and cooling is high.
2. The laser beams produced are coherent (having same phase) and monochromatic (i.e. having same wavelength).
3. It is used to weld smaller sizes spot but the spot sizes can vary from .2mm to 13 mm.
4. The depth of penetration of the LBW depends upon the amount of power supply and location of the focal point. It is proportional the amount of power supply. When the focal point is kept slightly below the surface of the workpiece, the depth of penetration is maximized.
5. Pulsed or continuous laser beams are used for welding. Thin materials are weld by using millisecond-pulses and continuous laser beams are used for deep welds.
6. It is versatile process because it is capable of welding carbon steels, stainless steel, HSLA Steels, aluminum and titanium. Due to high cooling rate, the problem of cracking is there when welding high-carbon steels.
7. It produces high quality weld.
8. This welding process is most popular in automotive industry.

Working



- First the setup of welding machine at the desired location (in between the two metal pieces to be joined) is done.
- After setup, a high voltage power supply is applied on the laser machine. This starts the flash lamps of the machine and it emits light photons. The energy of the light photon is absorbed by the atoms of ruby crystal and electrons get excited to their higher energy level. When they return back to their ground state (lower Energy state) they emit a photon of light. This light photon again stimulates the excited electrons of the atom and produces two photons. This process keeps continue and we get a concentrated laser beam.
- This high concentrated laser beam is focused to the desired location for the welding of the multiple pieces together. Lens are used to focus the laser to the area where welding is needed. CAM is used to control the motion of the laser and workpiece table during the welding process.
- As the laser beam strikes the cavity between the two metal pieces to be joined, it melts the base metal from both the pieces and fuses them together. After solidification we get a strong weld.
- This is how a laser Beam Welding Works.

Advantages

- It produces high weld quality.
- LBW can be easily automated with robotic machinery for large volume production.

- No electrode is required.
- No tool wears because it is a non-contact process.
- The time taken for welding thick section is reduced.
- It is capable of welding in those areas which is not easily accessible.
- It has the ability to weld metals with dissimilar physical properties.
- It can be weld through air and no vacuum is required.
- X – Ray shielding is not required as it does not produce any X-Rays.
- It can be focused on small areas for welding. This is because of its narrower beam of high energy.
- Wide variety of materials can be welded by using laser beam welding.
- It produces weld of aspect ratio (i.e. depth to width ratio) of 10:1.
- Disadvantages
- Initial cost is high. The equipment used in LBW has high cost.
- High maintenance cost.
- Due to rapid rate of cooling, cracks may be produced in some metals.
- High skilled labour is required to operate LBW.
- The welding thickness is limited to 19 mm.
- The energy conversion efficiency in LBW is very low. It is usually below 10 %.

Application

The laser beam welding is dominant in automotive industry. It is used in the area where large volume production is required.

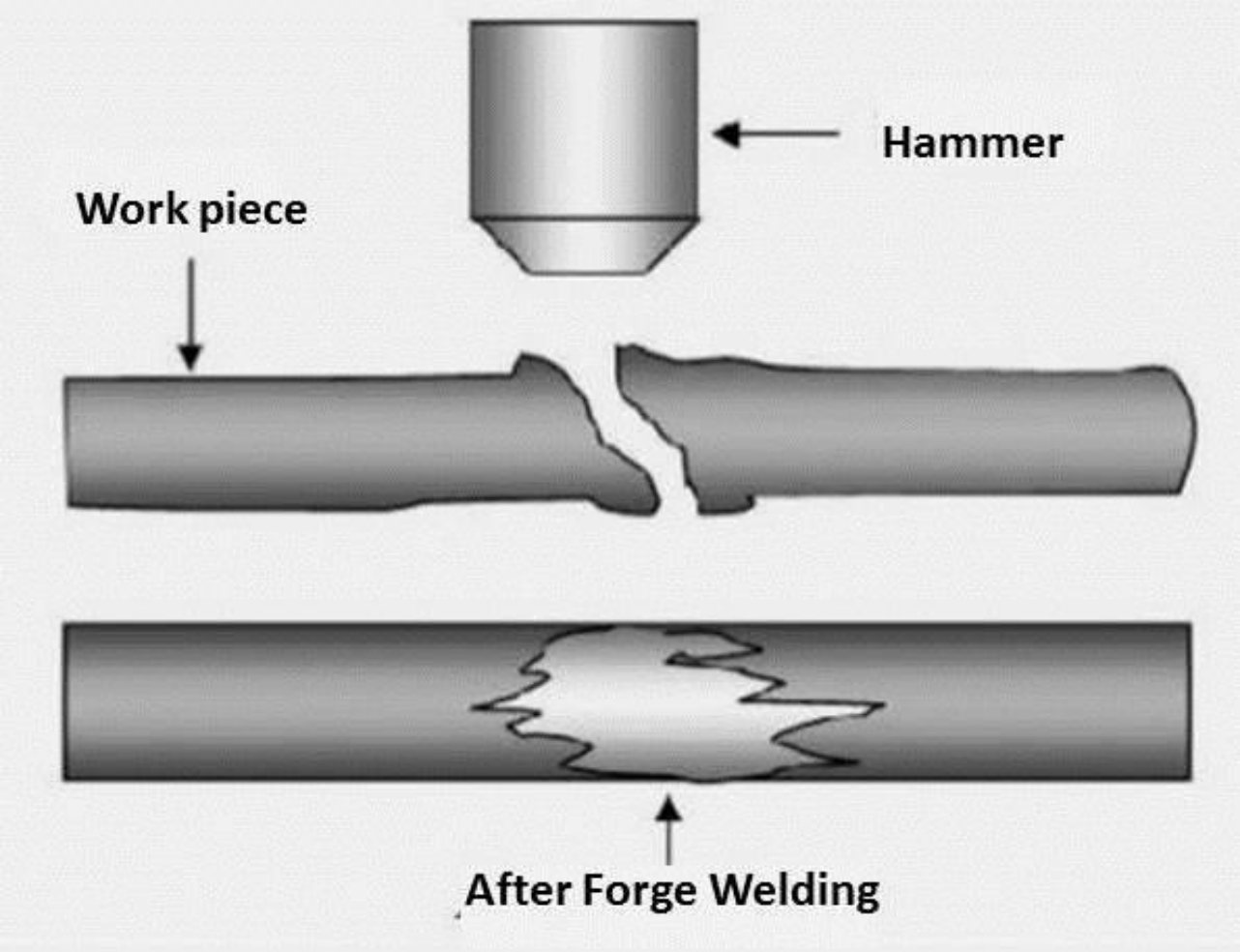
Forge Welding:

Principle:

- Forge welding is a solid state welding process in which both the plates are heated quite below its melting temperature.
- This heating deforms the work pieces plastically. Now a repeated hammering or high pressurize load is applied on these plates together.
- Due to this high pressure and temperature, inter-molecular diffusion takes place at the interface surface of the plates which make a strong weld joint. This is basic principle of forge welding.
- One of the basic requirement of this **types of welding**, is clean interface surface which should be free from oxide or other contaminant particles.
- To prevent the welding surface from oxidation, flux is used which mixes with the oxide and lower down its melting temperature and viscosity. This allow to flow out the oxide layer during heating and hammering process.

Working:

Forge welding was one of the most applied welding method in ancient time. This is a fundamental welding process of all solid state welding. Its working can be summarized as follow.



- First both the work plates heated together. The heating temperature is about 50 to 90% of its melting temperature. Both the plates are coated with flux.
- Now manual hammering is done by a blacksmith **hammer** for making a joint. This process is repeated until a proper joint is created.
- For welding large work pieces, mechanical hammering is used which is either driven by electric motor or by using hydraulic mean. Sometime dies are used which provides finished surface.

Application:

- It is used to join steel or iron.
- It is used to manufacture gates, prison cells etc.
- It is widely used in cookware.
- It was used to join boiler plates before introduction of other welding process.
- It was used to weld weapon like sword etc.
- Used to weld shotgun barrels.

Advantages and Disadvantages:

Advantages:

- It is simple and easy.
- It does not require any costly equipment for weld small pieces.
- It can weld both similar and dissimilar metals.
- Properties of weld joint is similar to base material.
- No filler material required.

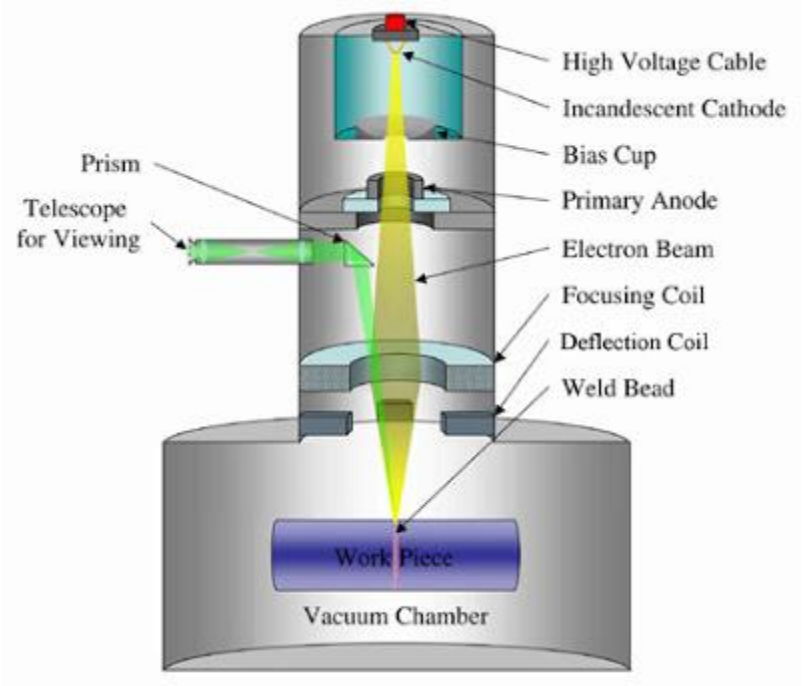
Disadvantages:

- Only small objects can be weld. Larger objects required large press and heating furnaces, which are not economical.
- High skill required because excessive hammering can damage the welding plates.
- High **Welding defects** involve.
- It cannot use as mass production.
- Mostly suitable for iron and steel.
- It is a slow welding process.

Electron Beam Welding:

Principle:

- This welding works on same principle of **electron beam machining**.
- This process uses kinetic energy of electrons to produce heat. This heat is further used to weld two welding plates.
- When a high jet of electrons strike at welding plates, its kinetic energy converts into heat energy. This heat energy is sufficient to fuse two metal plates together to form a weld joint.



Equipment's:

Power Supply:

This process uses a power source to supply continuous beam of electrons for welding process. The voltage range of welding is about 5 – 30 kV for low voltage equipment's or for thin welding and 70 – 150 kV for high voltage equipment's or for thick welding.

Electron Gun:
It is heart of electron beam welding. It is a cathode tube (negative pole) which generates electrons, accelerate them and focus it on a spot. This gun is mostly made by tungsten or tantalum alloys. The cathode filament heated up to 2500 degree centigrade for continuous emission of electrons.

Anode:
Anode is a positive pole which is just after the electron gun. Its main function is to attract negative charge, (in this case electron) provide them a path and don't allow them to diverge from its path.

Magnetic Lenses:
There are a series of magnetic lenses which allows only convergent electrons to pass. They absorb all low energy and divergent electrons, and provide a high intense electron beam.

Electromagnetic lens and deflection coil:
Electromagnetic lens used to focus the electron beam on work piece and deflection coil deflect the beam at required weld area. These are last unit of EBW process.

Work holding device:
EBW uses CNC table for hold work piece which can move in all three direction. The welding plates are clamped on CNC table with the use of suitable **fixtures**.

Vacuum Chamber:
As we know, whole thisprocess takes place in a vacuum chamber. Vacuum is created by mechanical or electric driven **pump**. The pressure ranges in vacuum chamber is about 0.1 to 10 Pa.

Working:
Its working can be summarized as follow.

- First the electron gun, which is a cathode, produces electrons. These electrons move towards anode which is positive charged and placed right after electron gun.
- The anode accelerates the electrons and form a electron jet which is further move towards magnetic lenses.
- The magnetic lenses are a series of lenses which are used to absorb low energy electrons and does not allow to divergent electron to passes through it. It provides a high intense electron jet.
- Now this electron beam passes through electromagnetic lens and defecting coil which are used to focus and deflect the electron beam at the required spot. This unit direct high velocity electron beam to the weld cavity where its kinetic energy converts into heat energy due to collision. This heat energy is used to create weld by fusion. This whole welding process carried out in a vacuum chamber otherwise the electrons collides with air particle in the way and loses its energy.

Application:

- It is used in aerospace industries and marine industries for structure work
- It is used to join titanium and its alloy.

- This **type of welding** is widely used to join **gears**, **transmission system**, **turbocharger** etc. in automobile industries.
- It is used to weld electronic connectors in electronic industries.
- This process is also used in nuclear reactors and in medical industries

Advantages and disadvantages:

Advantages:

- It can weld both similar and dissimilar metals.
- It provides high metal joining rate.
- Low operating cost because no filler material and flux are used.
- It provide high finish welding surface.
- It can used to weld hard materials.
- Less **welding defects** occur due to whole process carried out in vacuum.

Disadvantages:

- High capital or set up cost.
- High skilled labor required.
- Frequently maintenance required.
- Work pieces size is limited according to vacuum chamber.
- It cannot do at site due to vacuum.

Welding Defects : Types, Causes and Remedies

Types of Welding Defects:

After welding some defects are found which make the strength of joint weak. Such defects are called welding defects. Some welding defects are given below.

Porosity:

- It is common type. In this defect, air bubbles or gases are present in the weld zone.
- The distribution of air bubbles in weld zone is random.
- Porosity caused by gases release during melting of the weld area but trapped during solidification, chemical reaction during welding or by contaminants.
- This **defect can be minimized by** the proper selection or electrode, filler material, improve welding Technics, more attention to weld area during welding preparation and slower speed to allow gases time to escape. The effect of porosity on performance depends on quality, size and orientation to stresses.

Spatter:

- Metal drop expelled from the weld that sticks to surrounding surface is known as spatter.
- Spatter can be minimize by correcting the welding condition and should be eliminated by grinding.

Causes:

- Welding current too high.
- Arc is too long.
- Incorrect polarity.
- Insufficient gas shielded.

Remedies:

- Reduce welding current and arc length.
- Use correct polarity according to the welding condition.
- Increase torch to plate angle and use correct gas shielding.

Slag inclusions:

- Slag inclusions are compound such as oxides, fluxes and electrode contains material that is trapped in the weld zone.
- These defect are commonly associated with undercut, incomplete penetration and lack of fusion in weld.
- Insufficient cleaning between multi-pass welds and incorrect electrode and current can leave slag and unfused section along the weld joint.
- Slag inclusion not only reduces cross section area strength of joint but also may serve as initiation point for serious cracking.
- This defect can only be repaired by grinding down or gouging out and re-welding.

Incomplete fusion:

- In this types of welding defect gap is not totally filled by molten metal. It is due to inaccuracy of the welder so pre solidification of welding metal.

Causes:

- Heat input is too low.
- Weld pool is too large and running ahead of the arc.
- Joint included angle is too low.
- Electrode and torch angle is incorrect.
- Unfavorable bead position.

Remedies:

- Increase welding current and decrease the travel speed.
- Reduce deposition rate.
- Increase joint include angle.
- Position electrode or plate angle such a way so the plate edges will melt.
- Position bead in such a way that the sharp edges with other bead or plate are avoided.

Incomplete Penetration:

It is occurs when the depth of the welded joint is insufficient.

Under cutting:
This defect occurs when base of metal melts away from the weld zone and the consequent generation of a groove is in the shape of sharp recess or notch. It reduces the fatigue strength of the joint.

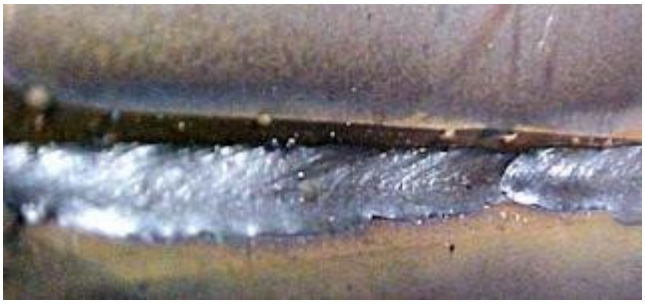
Causes:

- Arc voltage too high or arc too long.
- Incorrect electrode use or incorrect electrode angle.
- The electrode is too large.
- High electrode speed.

Remedies:

- Lower arc voltage or reduce arc length.
- Apply electrode angle form 30 degree to 45 degree with the standing leg.
- Use a smaller diameter electrode.
- Reduce travel speed.

Under filling:
Under filling occurs when the joint is not filled with the proper amount of molten metal.



Inclusion:

- It is a defect in which several passes are made along a V-joint when joining thick plate using flux cored or flux coated rods and the slag covering a run is not totally removed every pass before following pass.

Lamellar tears:

- This is mainly a problem with low quality steel. It occurs I plate that has a low ductility in the thickness direction which causes by non-metallic inclusions like sulphides, oxides that have been elongated during the rolling process.
- Lamellar tearing can occur in both fillet and butt welds but the most affected joints are T and corner joints where the fusion boundary is parallel to the rolling plane.

Cracks:

- Cracks may occur in various location and direction in the weld area.
- The typical types of cracks are longitudinal, transverse, crater, under bead and toe cracks.
- When joint is at elevated temperature then a crack occurs and it is known as hot crack. When it occurs after solidifying weld metal, it is known as cold crack.

Causes:

- It is due to the welding ended far too abruptly. The cracks begins at a void in welding crater, caused by the solidification shrinkage.

Remedies:

- When finishing move back the electrode to fill up the crack.
- With root pass welding, quickly move the arc form welding pool to the plate edge.
- Increase crater fill time by power source.

Arc blow:

Causes:

- Arc deflection as a result of magnetic effects into the opposite direction of the earth lead clamp.
- Arc deflection as a result of magnetic effects in the direction of heavy part of work piece especially at corner and edges.

Remedies:

- Use AC electrode where possible.
- Try welding away from earth clamp connection. Try splitting the earth clamp and correct to both side of the joint.
- Keep arc as short as possible.