WELDING AND ITS TECHNIQUES

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ABSTRACT Welding is an essential component of manufacturing technology. New developments in welding are evolved in order to acquire extraordinary benefits. This study provides an update on recent developments of welding. This study presents theoretical background, process parameters etc. along with its application. Along with addressing advanced welding techniques under different headings. Our aim is to study and link all the progress in this field till now and look for future scope as well.

1. INTRODUCTION

Welding is a process which joins materials by using high heat to melt and fuse the parts together after allowing them to cool after melting the metal. It is different from other metal-joining techniques like brazing and soldering, because they do not melt the base metal.

Along with melting the base metal, a filler material in molten is also added to the joint for forming joint as it is cooled, moreover it can be stronger than the base material. In conjunction with heat or itself for producing a weld pressure can also be used. A kind of shield is required as well for protecting the filler metals from being contaminated or oxidized.

It also uses different energy sources, including gas flame, electric arc, laser, electron beam etc. It can be performed in many different environments like in open air, under water, and in outer space etc. It is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage etc.

Working of Welding

- **Joining Metals**

Welding melts the base material as it is a high heat process. Along with the addition of some filler material. A weld pool of molten material is formed after causing the heat at a high temperature for making the join as it is cooled, and that filler metal can be stronger than the parent metal. To produce a weld pressure can also be used, either along the heat or itself. A shielding gas can also be used to protect the melted and filler metals from being contaminated or oxidised.

- **Joining Plastics**

Heat is also used in plastics welding to join the materials and it can be done in three stages:

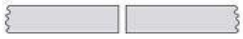
- Before applying heat and pressure surfaces are prepared.
- The joining methods can be separated into external or internal heating methods for welding plastics, depending on the exact process which is used.
- Finally the materials are allowed to cool so that they can create fusion.

- **Joining Wood**

Heat generated from friction is used to join the materials in wood welding. The materials which are to be joined are kept under high pressure before a linear friction movement which creates heat for bonding the workpieces together. This process allows wood to be joined without adhesives or nails within seconds.

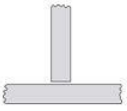
Common Joint Configurations

- **Butt Joint**



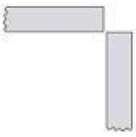
It is a connection between the ends or edges of two parts which makes an angle of 135-180° to one another in the region of joint.

- **T Joint**



It is a connection between the end or edge of one part and the face of the other part, which makes an angle of more than 5 up to and including 90° to one another in the region of the joint.

- **Corner Joint**



It is a connection between the ends or edges of two parts which makes an angle of more than 30 but less than 135° to one another in the region of the joint.

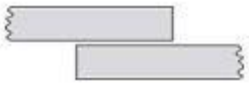
- **Edge Joint**

It is a connection between the edges of two parts which makes an angle of 0 to 30° to one another in the region of the joint.

- **Cruciform Joint**

It is a connection in which allows two flat plates or two bars to be welded to another flat plate at right angles and on the same axis.

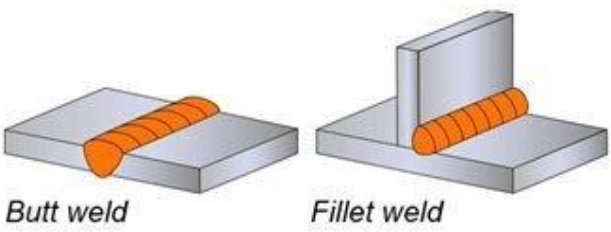
- **Lap Joint**



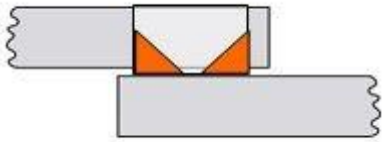
It is a connection which is formed by making an angle of 0-5° to one another between two overlapping parts in the region of the weld.

2. TYPES OF WELDING JOINTS

1. Based on Configuration

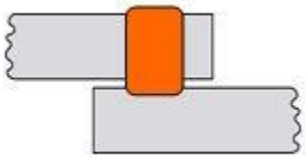


- **Slot weld**



It is a joint between two overlapping components which are made by depositing a fillet weld around the periphery of a hole in one component such that it makes a join with the surface of the other component exposed through the hole.

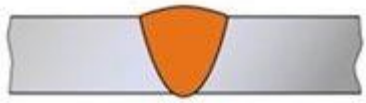
- **Plug weld**



It is a weld made by filling a hole in one component of a workpiece with filler metal such that it causes the joint in the surface of an overlapping component exposed through the hole.

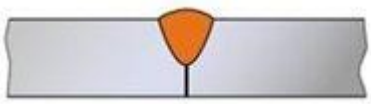
2. Based on Penetration

- **Full penetration weld**



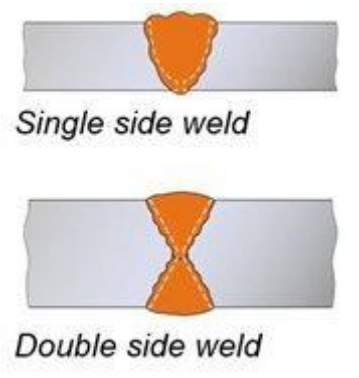
It is the welded joint where the joint is fully penetrated by the weld metal with complete root fusion.

- **Partial penetration weld**

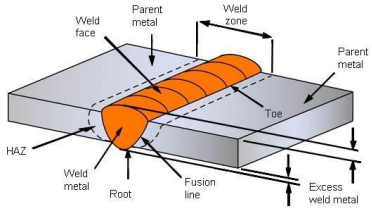


It is a weld in which the fusion penetration is kept less than the full penetration.

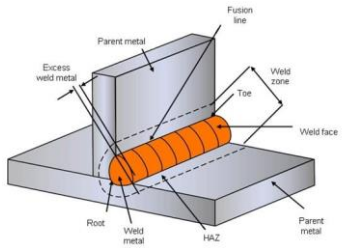
3. Welds Based on Accessibility



Features of Completed Welds



Butt weld



Fillet weld

- **Parent Metal**

It is the metal which is to be joined or surfaced by welding.

- **Filler Metal**

It is the metal which is added during welding.

- **Weld Metal**

The metals which are melted during the making of a weld and are retained in the weld.

3. HEAT AFFECTED ZONE (HAZ)

It is the part of the parent metal which is metallurgically affected by the weld, but is not melted.

- **Fusion Line**

It is the boundary between the weld metal and the HAZ in a fusion weld. It can also be termed as weld junction.

- **Weld Zone**

It is the zone which contains the weld metal and the HAZ.

- **Weld Face**

It is the surface of a fusion weld which is exposed on the side which has been welded.

- **Weld Root**

It is the zone which is on the side of the first run furthest from the welder.

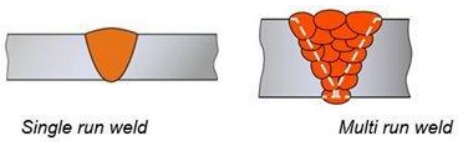
- **Weld Toe**

It is the boundary between a weld face and the parent metal or between runs.

- **Excess Weld Metal**

It is the weld metal which lies outside the plane joining the toes.

- **Run**



It is the metal which is melted or deposited during one passage of an electrode, torch or blowpipe.

- **Layer**

It is the stratum of weld metal which is consisting of one or more runs.

Energy Sources

Different processes can be determined by the energy source used for them, with different techniques which are available. Forge welding was the only method which was used in the past, but later new and advanced processes, such as arc welding etc. have been developed as well. Modern methods nowadays use gas flame, electric arc, lasers etc. for

welding. Proper care has to be taken with these processes as they can lead to burns, electric shock, damaged vision etc.

Welding Types and their applications

There are various different welding processes having their own techniques and applications in the industry, they include:

Arc

It includes a number of common manual, semi-automatic and automatic processes. These include metal inert gas welding, stick welding, tungsten inert gas welding which is also known as gas tungsten arc welding, gas welding, metal active gas welding, flux cored arc welding etc.

In these techniques a filler material is used and they are primarily used for joining metals including stainless steel, aluminium etc. Arc welding processes are widely used in the industries such as oil and gas, power etc.

C	N	AWS	Characteristics	Applications
Bare Metal Arc Welding	(113)	BMAW	It has a consumable electrode having no flux or shielding gas.	Historical
Carbon Arc Welding	(181)	CAW	Carbon electrode, historical	Copper, repair (limited)
Flux Cored Arc Welding	136 137	FCAW FCAW-S	Continuous consumable electrode filled with flux	Industry, construction
Gas Metal Arc Welding [3]	131 135	GMAW	Continuous consumable electrode and shielding gas	Industry
Gas Tungsten Arc Welding [4]	141	GTAW	Non consumable electrode, slow, high quality welds	Aerospace, Construction (piping), Tool and Die
Plasma Arc Welding	15	PAW	It has Non consumable electrode and has constricted arc	Tubing, instrumentation
Shielded Metal Arc Welding [3]	111	SMAW	It has a consumable electrode which is covered in flux and it can weld any metal as long as they include the correct electrode	Construction, outdoors, maintenance
Submerged Arc Welding	121	SAW	Automatic, arc submerged in granular flux	
Magnetically Impelled Arc Butt Welding	185	MIAB	It contains both tube ends as electrodes; no protection gas exists; arc rotates fast along edge due to applied magnetic field	Pipelines and tubes
Atomic Hydrogen Welding	(149)	AHW	Two metal electrodes in hydrogen atmosphere	Historical

Friction

In this welding technique mechanical friction is used. It can be performed in a various ways on different welding materials.

Here heat is generated by the mechanical friction to soften the materials that mix to create a bond after they cool down.

In this welding filler metals, flux or shielding gas are not required.

To bond wood without the use of adhesives or nails friction processes are also being explored.

Gas welding

In the gas welding process is oxyfuel welding is most common, it is also known as oxyacetylene welding. Being one of the oldest and most versatile welding processes it still has become less popular in industrial applications in recent years, but it is still widely used for welding pipes and tubes, as well as repair work etc.

Name	N	AWS	Characteristics	Applications
Air acetylene welding	(321)	AAW	Chemical welding process which is not popular	Limited
Oxyacetylene welding	311	OAW	It includes combustion of acetylene with oxygen which produces high-temperature flame	Maintenance, repair
Oxygen/Propane welding	312		Gas welding is done with with oxygen or propane flame	
Oxyhydrogen welding	313	OHW	Combustion of hydrogen is done with oxygen to produce flame	Limited
Pressure gas welding		PGW	It includes gas flames heating surfaces and pressure to produce the weld	Pipe, railroad rails (limited)

Electron Beam

This process uses a beam of high velocity electrons to weld materials. The kinetic energy of the electrons transforms into heat upon impact with the workpieces causing the materials to melt together.

Electron beam welding is performed in a vacuum to prevent the beam from dissipating.

There are many applications for it, as it can be used to join thick sections as well. Which says it can be applied across many industries from aerospace to nuclear power and so on.

Laser

It is used for joining metals or thermoplastics, in this process a laser is required for providing concentrated heat which is ideal for barrow, deep welds etc. It is perfect for high volume applications, like within the automotive industry due to it being easily automated and its high welding speed at which this process can be performed.

This welding can be performed with electron beam joining in air rather than in a vacuum.

Resistance

This is a process which is used in the automotive industry. It can be split into two types which are resistance spot welding and resistance seam welding.

- Spot welding uses the heat delivered between the electrodes for applying it to a small area due to the workpieces being clamped together.
- Seam welding is just similar to spot welding except that it replaces the electrodes with rotating wheels for delivering a continuous leak-free weld.

Name	N	AWS	Characteristics	Applications
Resistance spot welding	21	RSW	It has two pointed electrodes to apply pressure and current to two or more thin workpieces	Automobile industry, Aerospace industry
Resistance seam welding[a]	22	RSEW	It includes two wheel-shaped electrodes which roll along workpieces for applying pressure and current	Aerospace industry, steel drums, tubing
Projection welding	23	PW	It has welds which are localized at predetermined points.	
Flash welding	24	FW		
Upset welding	25	UW	It has butt joint surfaces which are heated and brought together by force	

Name	N	AWS	Characteristics	Applications
Electroslag welding	72	ESW	It welds thick workpieces quickly and has a continuous consumable electrode	Heavy plate fabrication, construction, shipbuilding
Flow welding (previously cast welding)			In this process distortion is minimized and the thermal cycle is relatively gentle.	Joining rails in situ by liquid metal
Induction welding	74	IW		
Laser-hybrid welding			It combines LBW with GMAW in the same welding head it is able to bridge gaps up to 2mm.	Automotive, Shipbuilding, Steel work industries
Percussion welding	77	PEW	In this process pressure is applied following an electrical discharge for forging the materials together	Components of switch gear devices
Thermite welding	71	TW	It experiences an exothermic reaction between aluminium powder and iron oxide powder	Railway tracks
Electrogas welding	73		Continuous consumable electrode, vertical positioning, steel only	Storage tanks, shipbuilding
Stud arc welding	78		It welds studs to base material by the use of heat and pressure	

4. FUTURE SCOPE

Welding being a basic manufacturing technology, in the future may experience the growth rate of approximate 8% per year along with shipments for welding equipment which are expected to more than double in the upcoming years. It is expected that all of the different welding processes may experience sufficiently shared growth rate. Employment of welders, cutters, solderers etc. is expected to grow 3% from present to upcoming years. The infrastructure of the nation will require the expertise of welders, cutters, solderers etc. highways, buildings etc. in future as well due to aging. As the welding has been continuously advancing and hence for this much growth and advancement in future as well this industry requires more and more better and reliable welding methods.

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