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Comparative Analysis of Physical Characteristics of Some Welding Processes

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Abstract

Welding is a process of permanent joining of two materials (usually metal) through localized coalescence resulting from a suitable combination of temperature, pressure and metallurgical conditions. depending upon the combination of temperature and pressure from a high temperature with no pressure to a high pressure with low temperature, a wide range of welding processes has been developed.

The most common types of welding are oxyfuel gas welding (OFW), arc welding (AW) and resistance welding (R W).As a steel worker it is primary concern is gas and arc welding.

In chapter I, we have discussed about the introduction of welding. Welding is a joining process that produce coalescence of material by heating them to the welding temperature with or without the application of pressure or by the application of pressure alone, and with or without the use of filler metal.

In chapter II,it is discussed about the history of welding .In the year1800AD, Electric arc was in vented by Sir Humphrey Devy. In the last decade of 19th century, the resistance welding was developed.

In chapter III, it is briefly discussed about the arc,which constitutes a mechanism whereby the electrons are evaporated from the cathode, transferred through a region, ionized gas to th anode and there condensed street usually.

In chapter IV, the topic is discussed about the literature review.

Welding technology became advanced during the early of 20th century as world war I and world war II during them, several modern welding techniques were developed including manual methods like shielded metal arc welding.

In chapter V, we have investigated the different test of welded joints, several test of weld as tensile strength test is used to measure the strength of welded joint which is calculated by dividing the breaking load of the test piece by the original cross section area of the specimen, Guide bend test has been use to determine the quality of the weld metal at the face and root of the welded joints as well as the degree of penetration and fusion at the base metal. X-ray test has been conducted to reveal the presence and nature of internal defects in the weld. In this chapter comparative analysis of physical characteristics of arc welding with reverse polarity and the result of test shows that DCEN (Direct Current Electrode Negative) welded joint is more stronger as ultimate stress is more than 640 N/mm^2 where as the DCEP (Direct Current Electrode Positive) welded joint exhibited the ultimate stress less than 515 N/mm^2 has been also observed by the several test that the location of fracture in any case in parent metal than the welded parts.

In chapter VI, it gives the idea about discussion on result, conclusion and future scope of investigation and suggestions. Present thesis has undertaken detailed study of arc welding process and its results based on the observation was noted.

The data given in this investigation may be used for further research work. Hence it is suggested a further work varying the cooling rate of the joint.

Keywords: DCEN, DCEP, Tensile Test, Physics of arc, guide bend test.

Introduction

Welding is the best process to join the metals. It is a fabrication or sculptural process that joins materials, usually metals or thermoplastics,

by causing coalescence. This is done by melting the work piece and adding a filler material to form a pool of molten material that cools to become a strong joint with pressure in conjunction with or by itself. This is in contrast with soldering and brazing which involve melting a lower melting point. Between the work piece from a bond between them, without melting the work piece.

It is the only way to join permanently two or more pieces of metal to make them act as one piece.

Welding is a joining process that produces coalescence of material by heating them to the welding temperature, with our without the application of pressure or by the application of pressure alone, and with or without the use of filler metal.

Coalescence means the growing together or growth into one body of material being welded.

It is used to make welds which is a localized coalescence of metals or nonmetals produced by either by heating material to the welding temperature with or without application of pressure or alone and with or without the use of filler metals.

Welding is a method of joining metals by the application of heat, without use of solder or any other metals or alloy having a lower melting point than the metals being joined. Therefore, welding is a heat dominated technology.

So, welding is a process of joining two similar or dissimilar metals by fusion, with or without the application of pressure and with or without the use of filler metal.

Welding process can be classified as fusion welding and solid phase welding. When weld is occurred by using alone heat, it is called fusion welding.

Advantages of welding over other joints

- Building, bridges and structures can be built lighter and thus higher due to reduction in weight.
- These are cheap also due to reduction in weight and material cost.
- Addition joint strength can be obtained by using smaller structural member.
- Welded joints having high corrosion resistance compared to bolted and riveted joints.
- Welded joints are fluid tight for tank and vessels.
- Welded structure can be altered easily and economically
- Many different types of joints are possible in welded joints.

Other advantages

1. A large no. of metals/alloys both similar or dissimilar can be joined by welding.
2. A good weld is as strong as the base metal.
3. Welding permits considerable freedom in design.
4. General welding equipment are not costly.
5. Portably welding equipment are available.
6. Low manufacturing cost.
7. It is a good saving of material and reduced content of production.
8. It is also used as method for repairing broken, worn, or defective metal parts. Due to this, the cost of reinvestment can be avoided.
9. Welding is the must economic and efficient way to make permanent joint in metals.
10. Welding is the –
    a. Lowest lost joining method.
    b. Join all commercial metals.
    c. Can be used any where
    d. Provide design flexibility.

Conventional Welding Proceses :-

Gas Welding

It is a method of Fusion welding in which a flame produced by a combustion of gases is employed to heat and melt the parent metal and filler rod of a joint. It can weld most of the common material.

Gas welding is a process in which the required heat to melt the surface is supplied by a high temp. Flame obtained by the mixture of two gases. The gases are mixed in proper proportion in a welding blowpipe (torch). For controlling the welding flame, there are two regulators on the torch by which the quantity of gas can be regulated. Usually the mixture of oxygen and acetylene is used for welding purposes. It produces temp. in the range of 3200-3300^0C.

Other gases used are MAPP (methyl acetate propediene) 2600^0-2900C), propylene (2500-2850^0C), propane (2450^0-2775^0C), natural gas/methane (2350^0C-2750^0C).

In gas welding, the two surfaces to be welded are properly prepared and placed near to each other. The important zone in fusion/gas welding are-

a. Fusion zone
b. Heat affected Zone
c. The unaffected original part.

The characteristics of fusion weld is that the metal being joined is actually melted and the union is produced and subsequent solidification.

Different gas welding processes are

A. Oxyacetylene Welding

In such welding the two gases are used for producing flame are oxygen and acetylene. Oxygene are used to support and intensely combustion Oxygen cylinders are painted black and acetylene cylinders are painted maroon. Each cylinder is connected to the blow pipe by flexible hoses. The chemical reaction for complete combustion of oxygen and acetylene is as follows:-

$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$$

(acetylene)(Oxygen) (Cargon dioxide) (water vapour)

Thus for complete combustion ratio of oxygen to acetylene is 2:1.

The temperature of flame is depend upon the relative proportion of the two gases. For normal welding, most suitable mixture is generally obtained by having equal proportion of oxygen and acetylene. This mixture produces a neutral flame which is neither oxidizing nor carburizing and is very suitable for welding under this condition the following chemical action takes place:-

$$C_2H_2 + O_2 \rightarrow 2CO + H_2$$
$$\underline{2CO + O_2 \rightarrow 2\,CO_2}$$

$2H_2 + O_2 \rightarrow 2\ H_2O$ (water vapour)

Neutral flame (is obtained my mixing equal quantities of acetylene and oxygen) which is used for all metals like ferrous material CU & Al alloys accept brass.

In carburizing flame (which is obtained by more quantity of acetylene), it is more suitable for welding steel as rate of welding is much faster than neutral flame. It is also used for depositing stellite. Oxydising flame is very suitable for cutting operation due to very high temp. and also for welding non-ferrous metals (brass & bronzes).

The oxyacetylene welding process can be used for welding almost all metals and alloys used in engineering Practice. The advantages of using acetylene with oxygen is that, it produces a comparatively higher temperature and also an inner gas envelop, consisting of CO_2 and water vapors , which prevents the molten metal from oxidation.

The use of an oxyacetylene flame is the mostly employed method of welding iron, steel, Al, C.I. & Cu and the equipment required being considerably cheaper and simpler than that needed for electric welding.

2. Oxyhydrogen welding

In this process, hydrogen is used in place of acetylene and the temperature of flame is very low 1980^0C. It is best suited for welding of thin sheets, low melting alloys and for brazing work and other advantage of this process are, no oxides are formed on the surface of the weld.

3. Air acetylene welding

This process is generally used for lead welding low temperature brazing and soldering operation.

In this case, lowest temperature is produced in comparison to all other types of gas welding processes. The acetylene is applied to the torch from a cylinder and air is drawn into the torch from atmosphere and its quantity can be adjusted for proper combustion by varying the opening of air inlet to torch.

Arc Welding

In this case, heat is liberated at the arc terminals and this heat is used to melt the metals to be welded at the points of contact and in such welding, different parts may be joined. A filler metal is also added to the surface of the metal and the temperature of the arc is of the order of 3600^0C. The parent metal and added metal are thoroughly mixed and refined so that after cooling, a sound joint is formed.

Arc is created by low voltage and high current supply and flux coated electrodes are used which form a gas shield around the electrode tip and molten weld pool. On cooling, the residue of this flux solidifies to form a slag on the surface of the weld.

Arc initiation voltage is of the order of 60-100V and arc maintenance voltage is 25-40V power source may be A.C. or D.C.

i. A welding are has two electrodes, one being the welding rod & the other being work piece to be welded. If d.c. is used for are welding, there are possibilities one is d.c. straight polarity (DCSP) in which the work piece in connected to the terminal of welding m/c and the other in DCRP (d.c. reverse polarity) in which the work piece is made –ve.

ii. Penetration is deepest for DCSP because the electron stream flows to the work & less for A.C. & least for DCRP. In case of DCRP, good cleaning action is obtained due to less penetration in case of DCRP, it is best suited for them section of Al, tag and other hard weld mat. using tungsten electrode.

iii. Deposition rate of filler metal increases with current.

iv. In an arc welding process, using d.c. current about two third of arc heat appears at the anode and about one third at the cathode.

v. In A.C. welding, the welding heat will be distribute equally between the electrode rod.

Different types of arc welding processes are

i. Shielded metal arc welding (SMAW) :-

It is a manual arc welding methods used on coated electrodes. Since the electrode melts and joins the weld pool, it is classed under consumable arc welding method

This process is very versatile and flexible and can be used in difficult places.

It can be performed both on A.C. & D.C. source with drooping characteristics, highest current rating being about 600A and selection of proper electrode is essential for best results.

In D.C. welding, arc starting is easy and the arc is steady and smooth. Straight polarity (electrode-VE) is used for welding thin sheets and for plates with wide gaps. Reverse polarity (electrode +ve) produces maximum. Penetration and is used for root passes and out of position welding. Due to high voltage drop in cables, cable length should be short.

Principle of Operations

In this process, the arc is initiated by momentarily touching the electrode to the base metal. The heat of the arc melts the surface of the base metal to form a molten pool at the end of electrode.

The melted electrode is transferred across the arc into the molten pool and becomes the deposited metal. The arc and its area is evolved by an atmosphere of protective gas produced by the disintegration of electrode coating.

The investment for equipment is very small and most welders have the necessary skills to use the process.

2. Submerged Arc Welding

It is an automatic process developed for the production of high quality butt welds in thicker steel plates. It differs from other arc welding processes in a way, that a blanket of fusible, and granular material (flux) is used for shielding the arc and the molten metal.

SAW may be done with either A.C. or D.C. power in which D.C. gives better control of bead shape, penetration and welding speed and arc starting is easier with it.

Welds made by the SAW Process having high strength and ductility with low hydrogen or nitrogen content. Bead shape is usually best with D.C.

reverse polarity (electrode +ve) which provides maximum penetration, higher deposition rates and minimum penetration are obtained with D.C. straight polarity. A.C. minimizes arc blow and gives penetration between D.C.R.P & DCSP.

In this process, the welds are low in H_2 and thus excellent crack resistance and human error is minimized due to machine control of welding parameters and arc placement and it is possible to produce welds of the same size and quality repeatedly and there in maximum operator comfort and minimum fatigue.

SAW is mostly adopted for low carbon and alloy steels but sometimes non-ferrous metals are also welded.

Advantages

This process is used for manufacture of large boilers, heavy machine components, ship and large building, rail road or building, pipe manufacture in fabricating structural beams, girders etc. and nearly 100% deposition efficiency achieved. High welding speeds are possible.

Wire electrodes are in expansive. Entire welding takes place beneath a bath of molten flux, with spark, smoke or flash.

3. Tungsten inert gas welding or Gas tungsten Arc welding (TIG or GTAW)

In this process, welding uses a non consumable tungsten electrode to heat and melt the work piece. Filler metal can be fed and molten puddle is shielded from the atmosphere with on inert gas supply feeding from the torch cup.

In this process, the heat necessary to melt the metal is provided by a very intense electric arc which is struck between a virtually non-consumable tungsten electrode and metal work piece. The electrode does not melt and became a part of the weld. On joints, where filler metal is required, a welding rod is fed into the weld zone and melted with base metal in the same manner.

The major inert gases that are used are organ & helium.

Principle of TIG welding

During TIG welding, an are in maintained between a tungsten electrode and the W/P in an inert atmosphere i.e. he or Ar-He mixture.

In this Process, electrode is held in electrode holder and also ensures supply of inert gas around the electrode that creates an inert atmosphere around the arc cooling is done by the electrode holder with the supply of water or air. No filler metal is used in this Process.

It is used to join Al-alloys, cu-alloys, Mg-alloys & Ni-alloys etc. It is mostly used to weld thin section (like 2-6 mm.) of Stainless Steel and light metals Such as AL, Mg, & Cu alloys.

It is often used when quality welds are extremely important. Such as in bicycle, air craft and naval application.

A GTAW process utilizes suitable Power sources, a cylinder of organ gases, a welding torch having connection of cable for current, tubing for shielding gas supply and tubing for water/air for cooling the torch. Welding operation is done by striking an arc between the work piece and tungsten electrode in an atmosphere of inert gas such as Ar, He & Co_2

Application:-

i) It is extensively used in the manufacture of space vehicles.
ii) Also frequently employed to weld small diameter thin wall tubing.
iii) Often used make the welds for piping of various sizes.
iv) In maintenance and repair work, used to repair the tools and dies, especially components made of Al & Mg, because the weld Produces are highly resistant to corrosion and cracking over long time period.
v) It will make high quality welds in almost all metals and alloys.
vi) The are and weld Pools are clearly visible to the welder.
vii) Welding can be performed in all positions.
viii) There is no slag Produced.

Advantages

i. TIG welds are stronger, more ductile and more corrosian resistance than welds made with ordinary shield arc welding.
ii. Since no granular flux is required it is possible to use a wide variety of joint design than in conventional shield arc welding or stick electrode welding.
iii. There is a little weld metal splatter or weld spark that damage the surface of the base metal as in traditional shield arc welding.

Application

i. The TIG process to the welding of Al and its alloys, stainless steel, Mg alloys, nickel base alloys, cu base alloys, carbon steel & low alloy steel.
ii. TIG welding can be also used for the combining of dissimilar metals, hard facing and the surfacing of metals.

GTAW can be used to produce weld in the flat, horizontal, vertical and overhead position. But in GTAW process, a higher degree of operator skill is required.

Benefits

i. Superior quality welds.
ii. Welds can be made with or without filler metal.
iii. Free of spatter.
iv. Low distortion

Shielding gas Ar
Ar+H2
Ar/He

4. Metal Innert Gas welding or Gas Megal Arc Welding (GMAW

- This process is refinement of TIG process. In this process, the tungsten electrode is replaced with a consumable electrode. The consumable electrode acts as a source for the arc column as well as the supply for the filler material.

In this process, consumable electrode is fed through the electrode holder into the arc and at the

same speed the electrode is melted and deposited in the weld.

MIG welding

MIG (Metal inert gas) welding comes under the group of GMAW (Gas metal arc welding) Processes.

It is basically a fusion welding Process in which welding is completed in single Pass or in multiple Pass depending upon the material thickness and Joint design. It is a manual or automatic, continuous and consumable wire feed welding process. In such Process, the use of an inert gas requires the use of an active gas (i.e. Co_2 & O_2) in which Co_2 is more commonly used welding gas.

In this welding Process, electrode is in the form of continuous wire upto 2.4 mm dia that is fed into the arc and speed of the wire is controlled by an electric motor. The filler wire in generally connected to the positive polarity of a D.C. Power source and the work or job is connected to the negative polarity. An inert gas or gas mixture is supplied around the filler metal electrode in a smooth manner. Electrode holder feeds the wire and also ensures the supply of inert gas to the arc that creates an inert atmosphere for the arc. Since the electrode is continuous, welding speed are greater that SMAW. The inert gas shield eliminates slag and allows clean and stronger weld.

MIG welding is used on all thickness of steels, Al, Ni, Stainless Steel etc. This Process is suitable for both low and high alloys base material.

Advantages

i. It provides higher deposition rate.
ii. It is faster than SMAW due to continuous feeding of filler metal.
iii. Welds produced arc of better quality.
iv. There is no slag formation.
v. Deeper penetration is possible.
vi. The weld metal carries low H_2 content.
vii. More suitable for welding of thin sheets.

Application :-

i. Al commercially available metals can be welded by this method.
ii. It can be used for deep groove welding of plates & casting but it is more advantageous on light gauge metals where high speeds are possible.

In this welding process, electrode is in the form of continuous wire that is fed into the arc and speed of the wire is controlled by an electric motor.

A small adjustable speed motor arc used to remove wire, form a spool and fed it into the arc. and mixture of Co_2/organ are often used or shielding gases. Electrode used for MIG welding are quite small in dia (i.e. 0.13 to 0.15 mm) are average.

MIG welding is used on all thickness of steels, Al, Mi, stainless steel etc. This process is suitable for both low & high base mat.

A small adjustable speed motor is used to remove wire form a spool and feed it into the arc, and mixture of CO_2/Organ are often used as shielding gases for welding various types of carbon sheets and very little operator skills are required to obtain satisfactory welds.

Today MIG welding is commonly used in automobile industries due to its versatility and speed. In this welding, He is used for highly conducting metals like Cu & Ar is preferred for thin metals and also Ar being heavier than He, forms a shielding blanket easily,

Therefore a small amount of flow of Ar is sufficient. So often a mixture of Ar & He is used.

Benefits :-

i. All position capability
ii. Higher deposition rate than SMAW.
iii. Long welds can be made without starts or stops.
iv. Minimum post weld cleaning in required.

Advantages :-

i. It provided higher deposition rate.
ii. It is faster than SMAW due to continuous feeding of filler metal.
iii. Welds produced are of better quality.
iv. There is no slag formation.
v. Deep penetration is possible.
vi. The weld metal carries low hydrogen content.
vii. More suitable for welding of thin sheets.

Application :-

i. All commercially available metals can be welded by this method.
ii. It can be used for deep groove welding of plates and casting but it is more advantageous on an light gauge metals where high speeds are possible.

NON- CONVENTIONAL WELDING PROCESS :-

- **Electron beam welding** :- In this process, the metals to be joined together are brought close together and a concentrated stream of high energy electron is directed into the gap between the metal causing fusion to take place. The operation is performed in a vacuum to prevent the reduction of electron velocity.
- The K.E. of the electron is converted into heat energy when the electrons are absorbed by the metal piece, producing deep penetration weld with a depth., with very little distortion and a small width of the heat affected zone.
- This process employs an electron gun in which electrons are emitted by a hot filament of tungsten or tantalum connected to a 12V supply.
- The electrons emitted from filament by thermionic emission accelerated to a high vel. to the anode fed with a high voltage supply at 10 KV to 150 KV.
- The fast electron then move through a diaphragm whose opening determines the beam width and the beam is then focused by magnetic lens (consisting of powerful electromagnets) on the work piece to be welded.
- This process allows fusion weld of great depth with a minimum width since the beam can be focused and magnified.

Advantages

i. Clean and sound welds.
ii. Energy conversion efficiency is high, about 65%.

iii. The speed may be as fast as 2500 mm/min and it will weld or cut any metal or ceramic, diamond or thick as 150 mm.
iv. Many of the more costly fabrication method could be replaced by electron beam process. Due to 100 operating cost & low power uses.
v. The narrow beam reduces the distortion of w/p and making the replacement of costly jigs and fixtures.

Application

Welding of automobile, airoplane, aerospace, form & other types of equipment including ball bearing over 100mm.

2.Plasma are welding :-

Plasma is defined as a gas heated to atleast partially ionized condition and enabling it to conduct an electric current.

Plasma arc refers to a constricted electric arc which is achieved by passing the arc through a water cooled copper orifice. Its aim is to obtain high power density of the arc stream.

The main function of plasma gas is shielding the body of torch from the extreme heat of cathode. Plasma arc consists of an electronic arc plasma gas in forced through the torch, surround the cathode.

The main function of plasma gas in shielding the body of torch from the extreme heat of cathode. Plasma arc consists of an electronic arc plasma gas, and gases used to shield the jet column.

The equipment necessary for plasma arc welding includes a convention D.C. Power supply with a drooping volt amp. Output and with 700 open line volts.

.**Advantages:-**

i. Due to greater penetration greater depth/width ratio is possible with less distortion.
ii. It involves lower heat input and requires less filler metal.
iii. There is less time for embrittlement of stainless steel due to formation of carbides.
iv. No edge preparation is needed and it requires few passages.
v. Possibility of human error is minimized.
vi. It has directional stability.
vii. weld uniformity in possible due to complete penetration.

APPLICATION

I. It is widely used for welding stainless steel, nickel alloys, refractory, metals in aerospace industries.
ii. It is very well suited for refractory metal coating and coating of refractory material like Aluminia on graphite nozzles for rockets.

3. Laser beam welding

The laser beam welding process is the focusing of a monochromatic light into extremely concentrated beams. It employs a focused beam of light that concentrates tremendous amount of energy on a small area to produce fusion.

The laser welding system comprises the following parts –

a. Electrical storage unit.
b. Capacitor bank
c. Triggering device
d. Flash tube (wrapped with a wire)
e. Lasing material
f. Focusing lens mechanism
g. Work piece with Work table

Advantages

1. This process can be used to weld dissimilar metals with varying physical properties.
2. No electrode is required since the laser is simply a beam.
3. Welds can be made with a high degree of precision.
4. It holds a minimum shrinkage.
5. High depth to width ratio of weld.
6. Welding can be done in inaccessible location.
7. High production rate.
8. Work cells can be made to cut and trim parts in addition to welding.
9. Welds can be made in air or with shielding gas.

4. Ultrasonic welding :-

In such welding the welding equipment consist of two units:-

a. A power source of frequency convertor which converts 50 cycle line power into high frequency electrode Power.
b. A transducer which changes the high frequency electrode Power into vibrator energy.

- Either spot type weld or continuous seam welds can be made for the thickness from 0.000425mm (Al foil) to 0.25mm)
- Thicker sheet and plate can be welded if the m/c is specially designed for them.
- High strength bonds are possible both in similar and dissimilar metal combination.

Advantages :-

i. High productivity
ii. Thin pieces can be welded to thicker pieces.
iii. Welds are free from foreign inclusion.
iv. Post cleaning of weld is not necessary.
v. Very little preparation required for the weld, usually it involves degreasing.

Application :- It is adaptable for :-

i. Joining electrical & electronic components.
ii. Thermatic sealing of material & devices
iii. Splicing metallic foil.
iv. Welding of Al wire & sheets.
v. Fabricating nuclear fuel elements.

The other advantages are no grain growths, no gas absorption, no porosity, and inbrittlement is at minimum.

5. Thermit welding

It is the only welding process employing an exothermal chemical reaction. The heat of “thermit” reaction is utilized to bring the surfaces of metal to be welded into plastic state and mech. Pressure is then applied to complete the weld.

It is based upon the chemical reaction between Al & iron oxide which equation is given below

$$8Al + 3fe_3\ 0\ 4 \rightarrow 9\ fe + 4AlO3$$

During the reaction, oxygen from iron oxide separates from it and combines with Al to form aluminium oxide. During the reaction a very high temperature of the order of 3000^0c is developed which is nearly twice the temperature of the melting

temperature of steel. The reaction is non-explosive and requires 30 seconds to complete. Handling and storing of mixture is dangerous, since an initial temperature of 1100^0c is needed for ignition.

The thermit mixture is kept dry because if it becomes wet or damp, it can't be restored to original state.

Advantages :-

i. Low setup cost.
ii. Not a highly skilled operation.
iii. Most suitable for welding of thick section.
iv. It can be used any where

Application :

i. It is applicable in the repair of heavy parts such as tracks, spokes of driving wheel, broken motor casting.
ii. Connecting rods and specially in the welding of pipes.
iii. The process is widely used in shiping, steel and railroad industries.

The thermit welded joints have an average tensile strength of 5000kg/cm^2 with the yield strength of about 2500kg/cm^2 and elongation from 35% to 0%.

It is a economical and fast process welding joint made by this process is also very stronger. The surface of the completed weld is usually smooth and does not require additional metal finishing.

ized the flux and shielded the base material from impurity

Joints Formed In The Case Of Arc & Gas Welding

Tensile Strength Test

This test is used to measure the strength of a needled joint. The tensile strength, which is defined as stress in Pounds/Sq. inch. Which is calculated by dividing the breaking load of the test Piece by the original cross section area of the specimen. The tensile test specimen in mounted in a machine that will exert enough Pull on the Piece to break the Specimen. The testing machine may be either a stationary or a Portable type.

4.3 Welding Test Procedures

Types of joint to be welded – Fillet joint
Welding Process- MAG (135) (Manual Are Gas Welding)
Parent mat. Group & Sub-group - 1-1
Parent Metal thickness – 2.7 mm
Threat thickness – 3.9 mm.
Single run/multi run – Single run.
Outside dia (mm) – 300 mm.
Filler mat. Designation – SFA 5.18 as per ASME IIC
Filler mat. Make – super wire industries.
Filler mat. Size – 0.8mm
Gas/ Flux – Shielding – CO_2 (99.9%)
Baking – N.A.
Gas flow rate – shielding – 15 LPM
Baking – N.A
Welding Current – DLEP
Mode of Metal transfer – Globular
Heat input – 740-805 5/mm
Welding Position – PA
Preheat temp. – Room temp.
Other information – Soaking temp. ($900\text{-}93^0$c)
Soaking time – 2 min and
Cooling – still air

Joint design

Welding Sequence - Single Pass

Welding Details

Run – Single run
Process – MAG
Size of filler metal – 0.8
Current – 450-480
Voltage – 27-28
Type of current/ Polarity – DCEP
Wire feed speed (mm/min) – 2180
Travel Speed (mm/min) – 940
Heat input – 740-805
Stand off distance – 20mm
Torch angle – 90^0 to the Horizontal axis

Tensile Test :-

Specimen		TT_1	TT_2
Width	-	19.10	19.10
Thickness	-	14.25	14.28
Area	-	272.18	272.75
Ultimate Total Load (KN)	-	139.5	140.0
Ultimate unit Stress (Kg/mm2)	-	513.00	513.00
Type of failure and location	-	Broken at Broken at Parent metal parent metal	

Tensile Test (Polarity changed) DCEN Electrical characteristics.

Current AC or DC	-DC
Polarity	-DCEN
Amp. Range	-83-98
Volts	-10-14
Tungsten electrode type	-2.4 mm dia
Welding Process	-GMAW
Weave Bead	-Weave bend (max- 3 times of filler wire dia)
Orifice of gas cup size	-6mm & 10mm
Initial & interpass cleaning	-Brushing, grinding & chipping.
Multiple or single Pass	-Multiple
Multiple of Single electrode	-Single
Edge Preparation	-Machining/ Grinding
Weld finish	-As welded (start – stop point to be grinded to merge to weld contour)

Tensile Test

Joint Design

Welding Sequence = Double run.
Run – 1st & 2nd run
Process – SAW
Size of filler metal (mm) – 3.2
Current (A) = 490-530
Voltage (v) = 27-28
Polarity = DCEP
Wire feed Speed (mm/min) = 2180
Travel Speed (mm/min) = 1255
Heat input = 632-709
Filler metal classification & make
= SFA 5.17, EL8 (as Per ASM E11 C)

ADOR welding Ltd.

Gas/Flux – shielding – Flux – F7AZ –EL8 Baking – 250^{0}c for 2 Hrs.
Preheat temp. = Room temp.
Interpass temp. – 300^{0}c
Stand off distance = 18mm
Torch angle = 90^0 to the horizontal axis
Post weld heat treatment – Normalizing
Time, temp. – Soaking time – 2 min temp – (900-930^{0}c)
Heating & Cooling rats – Cooling – still air
Test Results – Tensile Test (As per EN 895)

Type no.	Re N/mm2	Rm(N/mm2)		A%	onZ%	Fracture location
TT_1	-	502	-	-		BOW
TT_2	-	510	-	-		BOW
Required Value (min)				410		

TT – Transverse Tensile
BOW- Broken out of weld

Bend Test (As Per EN – 910)

Type /no	Bend angle	Elongation	Result
Root (2Nos.)	180^0	-	Satisfactory
Face (2Nos.)	180^0	-	"

Former dia. – 4t (4times)
Macro examination – no. of samples = 2PC separated by 90^0 a part.

Mechanical Test

Particulars	Tensile Test on weld TT_1	Tensile Test weld TT_2
Width in (mm) (W)	25.0	25.0
Thickness in mm (T)	2.84	2.82
Area in sq. mm A = WxT	71.0	70.5
Gauge length 5.65 area	-	-
Yield load kg. f	-	-
Ultimate load kg f	3460	3670
Final length in mm	-	-
Elongation		
Yield strength		
Ultimate Tensile	502	510
Position of fracture	BOW	BOW

Analysis

Case (I) - Tensile Test

Polarity -DCEP (Direct Current electrode +ve) When we apply different specification and different data like current (450-480), voltage (27-28), heat input (740-805), terch angle- (90^0 to the horizontal axis) Process is MAG (manual automatic gas) and thickness with different specimen like TT1 & TT2 – 14.25 & 14.28, width is 19.10 & 19.10, Area is 272.18 & 272.75, load in (kn) – 139.5 & 140.00 and ultimate unit stress (Kg f/mm^2) is 513.0 & 513.0 and location of failure occurs at Parent metal.

Analysis :-

Case II (Tensile Test)

When Polarity – DCEN (Direct Current Electrode –ve)

When we take different specification and different data for this test, there is only some change such as location of fracture occurs at base metal and for this test, we take the different data's like current (DC), Amp. Range (83-98), voltage- (10-14) welding Process in GTAW, specimen is TT1 & TT2, width is 19.02, thickness is 4.92, Area 93.58, ultimate load in KN is 61.2 and ultimate tensile strength in N/mm^2 is 642 and when testing done with this data, location of fraoture occurs at base metal.

Case-III- (Tensile Test)

For this test we take the Process SMAW (Shielded metal are welding) and during this test, we take the Polarity DCEN (Direct current electrode –ve), and current variation is 110 to 130, voltage variation is 20 to 25, speed in (mm/min) is 50-90 and type of electrode is E-6013, with size in (mm) 3.15 and we apply the load (on specimen i.e transverse tensile 1 & 2) like 77.0 to 77.8. KN and ultimate tensile stress in N/mm^2 is 521.0 to 523.0 and thickness of the metal is 7.77 and 7.80 and width in mm is 18.95 and 19.16. When we apply the load with different data then, fracture or failure of location occurs at Parent metal.

Case-IV- When load is changed.

Same test is done when load is changes. In Previous test, load was taken 77.0 to 77.80 and UTS was taken 523.0 and 521.0 when ever in this test, we apply the wad 61.2 and 59.8 and UTS (Ultimate terrible Stress) in N/mm^2 is 654 and 644 and gauge dimension in mm is 19.02 x 4.92t and 18.76 x 4.95t and area of cross section in (mm^2) is 93.58 and 92.86 then metal is broken in weld metal when load is 61.2 KM and metal is broken at Parent metal when load is 59.3 KN.

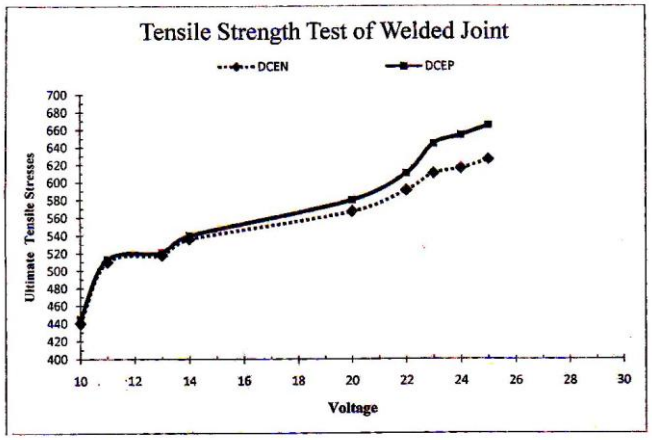
Analysis

Case V- (Tensile Test)

Process – Submerged are welding (SAW) Polarity – DCEP (Direct current electrode +ve)

When we go for this test, we take the different data like size of filter metal (mm) – 3.2, current = 490-530, voltage = 27-28.

Wire feed Speed in (mm/min) = 2180, heat in put was taken 632-709. and gas/flux– shielding (flux) baking – 250^{0}c for 2 hrs. and stand off distance = 18mm, and torch angel = 90^0 to the horizontal axis and during the test, soaking time = 2 min and temp. was 900- 930^{0}c and load was given in terms of (UTS) ultimate tensile stress in N/mm^2 = 502-510 for which required value is 410 min. and the result is broken out of weld.



4.4 Discussion On Result',Conclusion And Future Scope Of Further Investigation And Suggestions

Discussion on Results –

Welding is a joining process of polycrystalline work pieces usually metals by heating them to the welding temperature, with or without the application of pressure or by the application of pressure alone and with or without the use of filler metals. In chapter 2, details of the history of joining the metals goes back several millennia, with the earliest example of welding from the Bronze age and Iron age in Europe and the middle east, the modern welding process used today began just before the end of last century including resistance welding. During the middle of the century , many new welding processes were invented as submerged Arc welding, Gas Tungsten Arc welding , shielded metal Arc welding etc. Resent development in welding including the different energy recourses used for it as a gas flame, an electric Arc, a laser and an electron beam, friction and ultrasonic.

In chapter – 5, Several tests of weld as tensile strength test is used to measure the strength of welded joint which is calculated by dividing the breaking load of the test piece by the original cross section area of the specimen, Guide bend test has been used to determine the quality of the weld metal at the face and root of the welded joints as well as the degree of penetration and fusion of the base metal. In chapter – 6, comparative analysis of physical characteristics of arc welding with reverse polarity and the results of test shows that DCEN (Direct current Electrode Negative) Welded joint is more stronger as ultimate stress is more than 640 N/mm^2 where as the DCEP (Direct current Electrode positive) Welded joint exhibited the ultimate stress less than 515 N/mm^2

Conclussion on Result

This test leads to draw the following observations

1. DCEN Welded joint is more stronger than DCEP.
2. Current required for welded joint in DCEP is higter than DCEN.
3. Guide bend test shown in DCEN the satisfactory result in Root bend as well as Face bend position. Where as in DCEN Root bend is not satisfactory for some cases
4. Heat input required for weld in DCEP is more than the DCEN .
5. The microstructure of welded by X-RAY test shows that the DCEN weld has less impurities than the DCEP.

In has been also observed by the several tests that the location of fracture in any case is parent metal than the welded part.

Future Scope of Investigation And Suggestion

Present thesis has under taken detailed study of arc welding process of Arc welding and its results based on the observation was noted. The other welded joints as incase of Gas, TIG, MIG welding should be tested for different welding parameters done for one or more specific parameters and comparative study should be done. The data given in this investigation may be used for further research work. The cooling rate of the welder joint decides the micro structure form at the joint. The strength of the joint depends on the type of micro structure formed. Hence it is suggested a further work varying the cooling rate of the joint.

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