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Comparison Study of Mechanical Properties on Butt Weld and Lap Weld Joints

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ABSTRACT: Welding is a fabrication process whereby two or more parts are fused together by means of heat, pressure or both and formed as a joint. The strengths of these joints are of great concern as in today's world these joints find a very crucial place in growths of structures and machine parts and it is the strength of such joints and welding which decides the service life of such structures and thus prevent from loss whether be it human loss, economic loss or the any such losses.
In this project we have taken few special and most commonly joints i.e lap joint and butt joint which are joined together by using Arc Welding. In this project ,we investigate the mechanical properties of individual joints through Tensile Test and Hardness Test and compare the mechanical properties of lap joint and butt joint.
KEYWORDS: Arc Welding ,Lap Joint ,Butt joint and Mechanical Properties

I. INTRODUCTION

1.1 Definition of Welding
Welding is a manufacturing process that uses heat, pressure, or both to fuse two or more parts together to form a joint as the parts cool.

1.1.1 Advantages of Welding:

i. Light, Strong and Permanent Joint: The welding joints are normally lighter than bolted or riveted joints. A good welded joint is stronger as the base metal. It produces a permanent joint.
ii. Cheap, Portable and Easily Available Equipment:The welding equipment's are cheaper, portable and everywhere available.
iii. Provides Maximum Efficiency:The welding joint provides maximum efficiency (up to 90-95%) among other related joints.

1.1.2 Disadvantages of Welding:

(i) Possibility of Distortion, Cracks and Residual Stresses:Due to uneven heating and cooling during fabrication, the possibility of distortion, cracks and residual stresses are powerful.
(ii) High Degree of Skill and Supervision:The welding process requires a high degree of skill and supervision to produce a good welding job.
(iii) Edge Preparation and Cleaning:The welding process requires edge preparation and cleaning of work piece before being weld.
(iv) Jigs and Fixtures:The welding process requires jigs and fixtures to hold and position the parts to be welded.
(vi) Needs Heat Treatment:A welded joint, needs stress-relief heat treatment. (vii) Harmful to Human Health:The welding process produces the harmful radiations, fumes, gases, spatter, which adversely affects the human health.

1.1.3 Applications of Welding:
Welding plays an important role in engineering industries. It is a major tool for fabrication and repairing of metal products. Welding has proved its ability in manufacturing, construction, fabrication and maintenance.
A Few Important Applications of Welding are Listed Below:

(i) Automobile Applications:
- Automobile frames.
- Trucks and trailers.
- Arc welded car wheels.

(ii) Aircraft Applications:
- Aircraft engine assembly.
- Turbine frames for jet engine.
- Rocket fuel tanks.

(iii) Bridge Applications:

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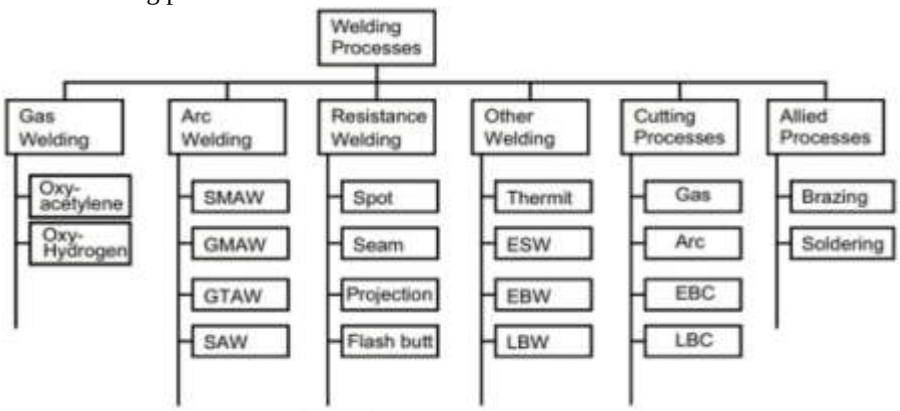
- Pillar construction.
- Truss assembly.
- Frames.

(iv) Building Applications:
- Doors and windows etc.
- Erection of column.
- Trusses.

(v) Storage Tank Applications:
- Oil tanks.
- Gas tanks.
- Gas cylinders.
- Water storage tanks etc.

(vi) Repair and Maintenance Applications:
- Tools and dies.
- Gears.
- Press and machine tool frames tec.

1.2 Classification of Welding process



1. Gas welding
- Oxy-acetylene
- Oxy-Hydrogen

2. Arc welding
- Shielded metal arc welding (SMAW)
- Gas metal arc welding (GMAW)
- Gas tungsten arc welding (GTAW)
- Submerged-arc welding (SAW)

3. Resistance welding • Spot welding
- Seam welding
- Projection welding
- Flash butt welding

4. Thermit welding
5. Electroslag welding (ESW)
6. Electron-beam welding (EBW)
7. Laser beam welding (LBW)

1.3 Weld joint:
A weld joint is an area where faying surfaces of two or more materials are joined together by a welding process with or without addition of filler material. Pressure may or may not be used when making a weld at weld joint.

1.4 Types of weld joints:

1. Butt joint:
A butt joint or butt weld is a joint where two pieces of metal are placed together in the same plane and the side of each metal is joined by welding.
- Square
- Single bevel
- Double bevel
- Single J
- Double J
- Single U
- Double U
- Single V
- Double V

2. Lap joint:
Lap welding joints are essentially a modified version of the butt joint. They are formed when two pieces of metal are placed in an overlapping pattern on top of each other.
- Fillet welding
- Spot welding
- Plug welding
- Slot welding
- Bevel groove welding
- Flare bevel groove welding
- J-groove welding

3.Edge joint:
In this, both the metal plate surfaces are placed together, that they are adjacent and generally parallel in position at the point of welding. It is known as edge joint welding.
- U-groove
- V-groove
- J-groove
- Corner-flange
- Bevel-groove • Square-groove

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4.Corner joint:
The corner joint welding is used to join two members that are located at approximately right angle to each other in the form of a "L".

- Fillet weld
- Closed
- Half-open • Fully open

5.T-joint:
T-joint is formed, when the two metal plates are intersected to an angle of 90 degree with on plate is lie on the center of the other plate like a "T" shape.

- Fillet welding
- Plug welding
- Slot welding
- Bevel groove welding
- Flare bevel groove welding
- J-groove welding

1.5 Welding positions:

a. Flat position
b. Horizontal position
c. Vertical position
d. Over head position
e. Inclined

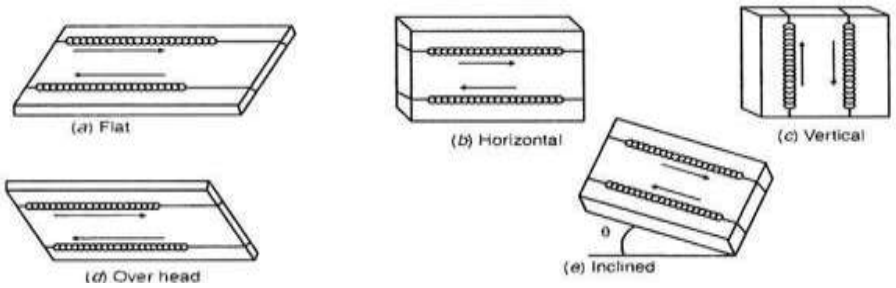

Fig. 1.5 welding positions

1.6 Terminology to be used with various welded joints

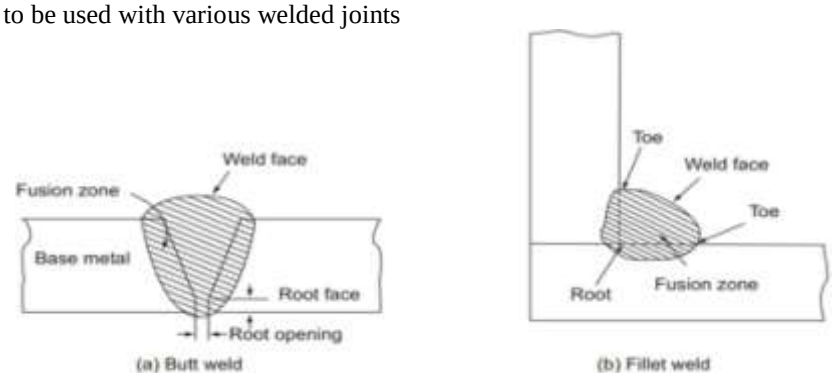

Fig. 1.6 various weld joints

Bade metal: The metal to be joined or cut is termed as the base metal.
Bead or weld bead: Bead is the metal added during a single pass of welding.
The bead appears as a separate material from the base metal.
Deposition rate: The rate at which the weld metal is deposited per unit time is the deposition rate and is normally expressed as kg/h.
Root: It is the point at which the two pieces to be joined by welding is nearest.
Weld face: It is the exposed surface of the weld, as shown in Fig.

Weld metal: The metal that is solidified in the joint is called weld metal. It may be only base metal or a mixture of base metal and filler metal.
Weld pass: A single movement of the welding torch or electrode along the length of the joint which results in a bead is a weld pass.
Penetration: It is the depth up to which the weld metal combines with the base metal as measured from the top surface of the joint.
Toe of weld: It is the junction between the weld face and the base metal
Fillet weld: The metal fused into the corner of a joint made of two pieces placed at approximately 90 degrees to each other.

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Puddle: The portion of the weld joint that melted by the heat of welding is called puddle.
Track weld: A small weld, generally used to temporarily hold the two pieces together during actual welding, is the tack weld.
Torch: In gas welding, the torch mixes the fuel and oxygen and controls its delivery to get the desired flame.
Crater: In arc welding, a crater is the depression in the weld metal pool at the point where the arc strikes the base metal plate

Backing: It is the material support provided at the root side of a weld to aid in the control of penetration.

1.7 Gas welding
In this welding process a high temperature flame is produced by the combustion of gas and it is used to melt the work pieces to join an external filler material for proper welding.

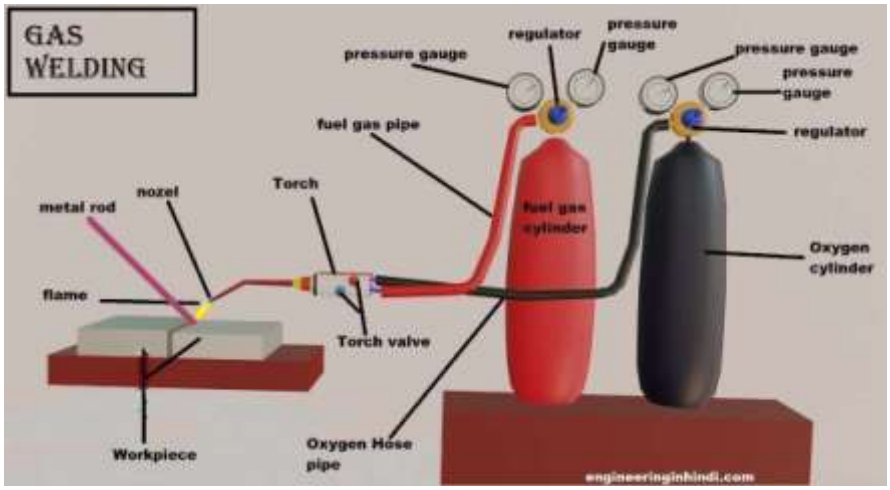

Fig. 1.7 Gas welding

1.8 Arc welding
In this welding process an electric power supply is produced an arc between electrode and metal piece to join the material, so that work piece metals melt at a point of two metals. Welding should be only done by power supply for arc welding process.

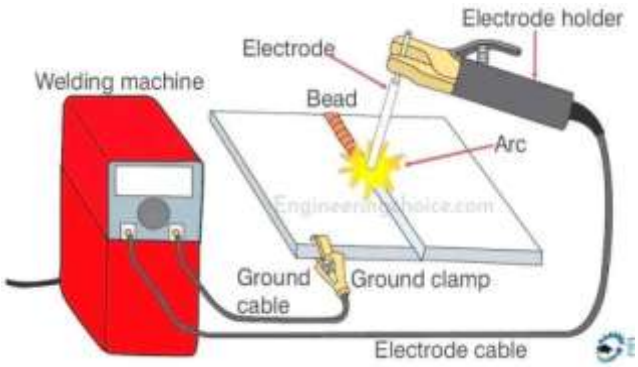

Fig.1.8 Arc welding

1.9 Resistance welding : In this welding, heat is generated due to passing of high amount current. Although this resistance caused by the contact between two metal surfaces.

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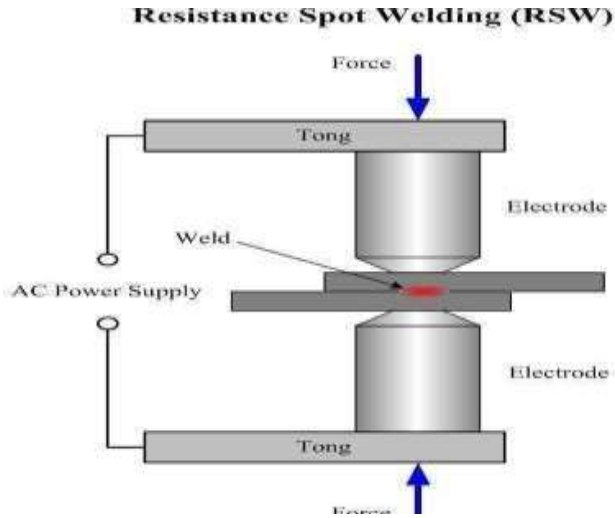

Fig.1.9 Resistance welding

II. METHODOLOGY AND PROBLEM STATEMENT

1Methodology

4.2Problem Statement

To know the hardness of the weld joint at different groove angles at various amperages. There is need know about different weld joints and different groove angles. It is important to know the mechanical properties of weld pool. Especially hardness and tensile strength by testing the weld joint.

4.3Objectives

The key objectives are mentioned in below.

i. To know the hardness of weld pool.

ii. Develop various steps included in finding the hardness.

4.4Time Line

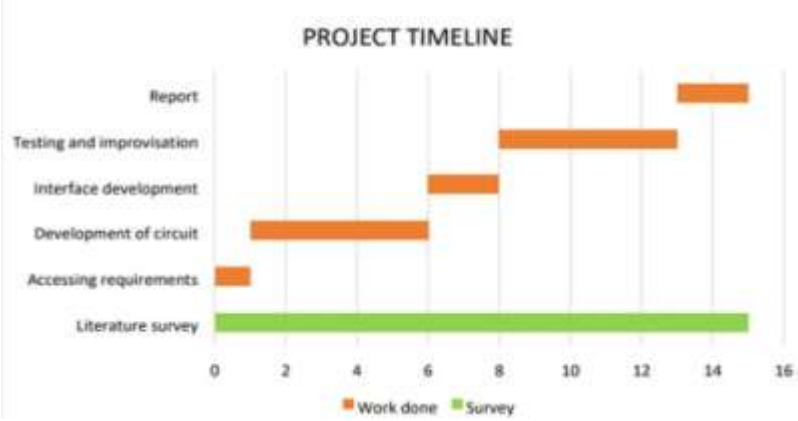

Fig.4.1 Time line

4.5Design and Development

4.5.1Material Selcetion

Mild steel plates of sizes 150x50x6 mm3 were selected as base material because this material is widely used for the engineering applications in the industries. Mild steel has the excellent weld ability. The metal is mostly used for the fabrications work and building of structures. This metal is also widely used in constructional field, automobile field etc., due to its excellent weld ability.

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Element	%
Carbon	0.20
Manganeous	1.60
Sulphur	0.045
Phosphorous	0.045
Silicon	0.045

Fig.4.5.1 Chemical composition of base material

4.5.2Electrode Material

A flux coated consumable electrode is used for the Arc welding because it acts as shield to avoid atmosphere gases and oxidation on the weld pool. It also acts as cleaning agent by avoiding or removing impurities from the weld pool. Generally flux is made from calcium carbonate, magnesium carbonate, calcium fluoride , silicate materials and few other shielding compounds.

The Electrode used in this experiment is E6013.

- E6013 welding rod is considered one of the most commonly-used rods for beginners. Hence, it is also known as 'sheet metal rod', 'beginners' rod' or 'easy rod'.
- E stands for electrode.
- 60 stands for tensile strength which is almost 60,000 pounds per inch.
- 1 stands for position of electrode. This welding rod can be used for all four positions – flat, horizontal, vertical and overhead.
- 3 stands for the type of slag(Titania potassium), flux composition and power supply. This welding rod can be used for AC or DC power supply.

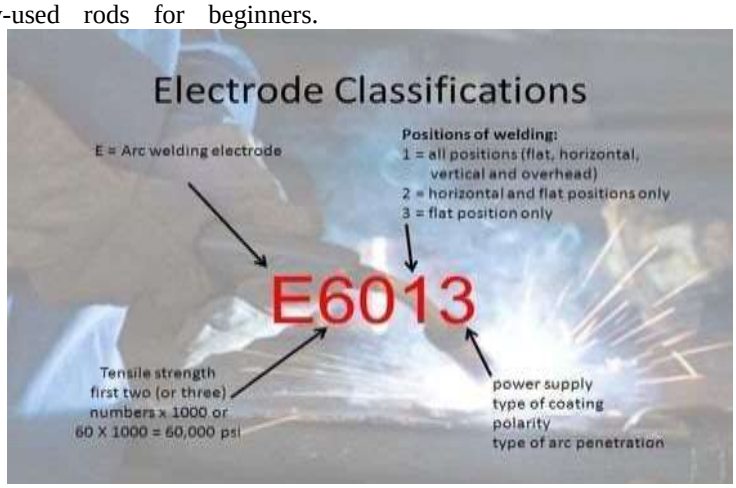

Fig. 4.5.2 Electrode Classification

4.5.3Selection of joints

The important aspect of welding include the joint selection. Among all joints (Butt joint, Lap joint, Tee joint ,Edge joint) butt joint and lap joint are used . In butt joint the two metals are placed side by side to do weld whereas in lap joint the two metals are overlapped to weld.

Fig.5.5.3 Butt joint and lap joint

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4.5.4Slection of Groove angle

Selection and preparation of weld groove is an important step in the fabrication of a welded joint. Selection of a correct joint design of a welded member leads to perform within load service, corrosive resistant atmosphere and safety. The weld joint which we use to join the welded members should have the required load bearing capacity when the load is applied in any direction. This should have good surface finish to make a sound weld joint. It should be designed in such a way that it will produce minimum distortion and residual stresses in the weldment as well as it should be economical. Since the distortions and residual stresses are main causes for the failure of weld joints. Based on thickness and width of the base plate 45°,60°,75° groove angles were selected. Then the three specimen were bevelled to the required angles with a hand grinding machine. In this procedure the mild steel plates were held fixedly in the bench vice. Then the grinding wheel was allowed to bevel the edges of the plates to the required angles. The spatters formed on the surfaces of the steel plates are also removed to make a smooth surface. The grinding process being performed is shown below.

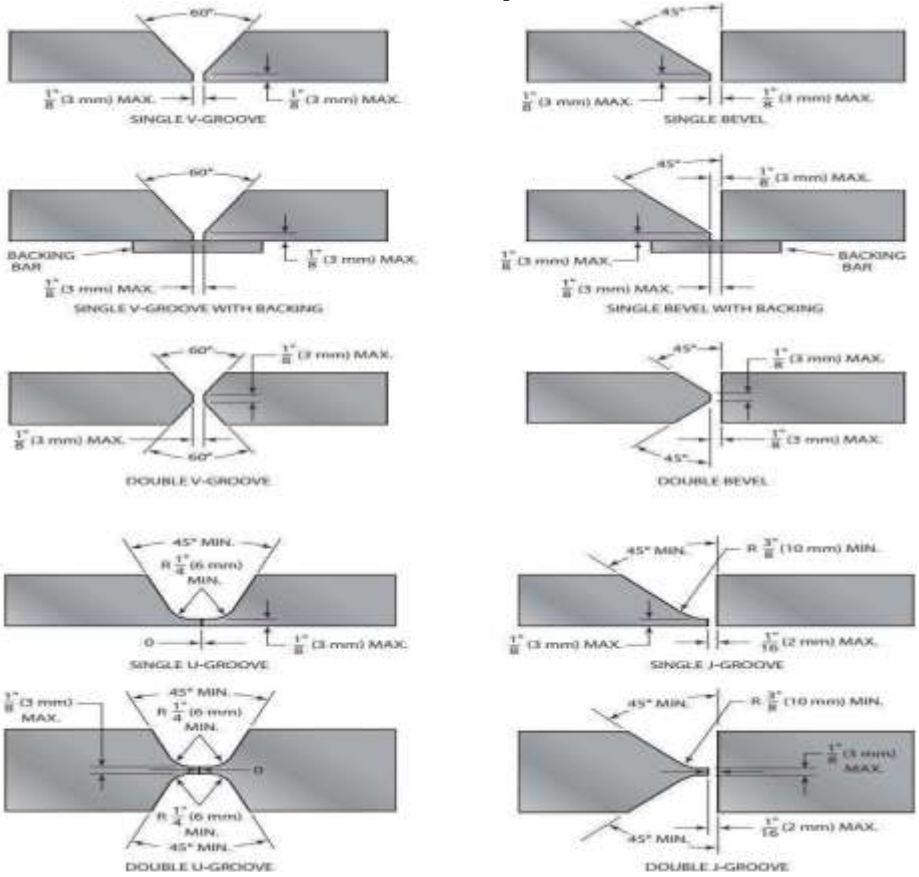

Fig.4.5.4 Selection of groove angle

4.5.5Selection of Current

The current effects upon the penetration of the weld is the current increases the depth of weld also increases at same time is the current decreases the depth of weld also decreases.

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Size	Dia Length	2.0	2.5	3.2	4.0	5.0
		250	350	350	400	400
Current range	F	30-60	50-90	90- 140	120- 170	160- 230
	V,OH	30-60	50-90	90- 140	100- 160	120- 200

Fig.4.5.5 Selection of current

4.5.6Welding Procedure

The welding process is done using Shielded Metal Arc Welding process. The DC rectifier having welding current rating of 450Amps with 60% rated duty cycle was used as a power source for the welding process. The butt and lap weld were made in following steps.

Step1: In this step a supporting plate was taken and a notch was made exactly near the groove.

The notch was made by grinding it on a fixed grinding machine.

Fig . 4.5.6.1 Grinding Process

Step2: Here the E6013 electrode was taken and tack welds were kept on each side of the steel plate. Then tack welds were allowed to cool for a while. The tack welds being made are shown inthe figure below.

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Fig 4.5.6.2 Welding

Step 3: The supporting member was also attached such that the notch on the supporting one was exactly above the groove. Then this joint was also allowed to cool.

Fig 4.5.6.3 Deburring

Step 4: Following the third step, three welding passes were made. The first one is called the Root pass (pass1), the second one as the hot pass (pass2) and the third one as the capping pass

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Fig 4.5.6.4 Welding

This is the joint after completing the entire process.
The welding parameters used for different passes is shown in the table below.

Pass no.	Size of the electrode used	Current used (Amps)
Root pass	3.15mm	90A
Hot pass	3.15mm	100A
Capping pass	3.15mm	100A

III. TESTING AND RESULT

To know the weld defects and mechanical properties of weld can be determined by testing basically testing can be done by breaking or without breaking material.

5.1. Non- Destructive Testing

This process can be done without breaking the welded material. In this process the weld defects can be evaluated. Basically non-destructive testing are Liquid penetration test, Visual inspection test, Magnetic particle test, Radiograpy test, Ultrasonic test, Eddy current test, Leak test. We preferred Liquid penetration test. The basic requirements of LPT are penetrant removal, developer, dye penetrant.

Fig 5.1.1 Equipment of LPT Steps included in LPT are:

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Pre cleaning: This can be done by using cotton waste or brush.
Appilication of penetrant: The dye penetrant can be sprayed on the weld pool and wait for some time. This time is known as dwell time.
Penetrant removal: By using penetrant removar we can remove the penetrant from the work piece.
Applying of Developer: Developer can be sprayed on the work piece and dwell time can acts under observation.
Observation: Some weld defects can be evaluated on the work piece.
Post cleaning: During this process developer is removed and work piece can be cleaned.

Fig 5.1.2 Observation of Defects

The weld defects such as spatter, porosity, slag inclusion, lack of penetration, lack of fusion can be observed and evaluated.

5.2. Destructive Testing:
In this process the work piece can be break to know the mechanical properties such as Tensile strength, Hardness and Bending stress.

5.2.1 Hardness Test
In hardness test we can use Rockwell Hardness Testing machine during this process we need to consider three zones on the work piece those zones are Base Metal Zone, Heat Affected Zone, Weld Pool. The work piece is placed on the hardness testing machine the load is applied on the work piece in varies zones that is HAZ, Weld pool, Base metal zone observe the readings from the hardness testing machine of two work pieces of angle 500 and 650.

The various observation shown below.

Fig 5.2.1 Rockwell Hardness Testing

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Table 5.1: hardness test reading for lap joint

S.No	Weld metal zone		HAZ
zone	Base		
metal			
1	110	104	95
2	112	103	91
3	106	98	88

Table 5.2: hardness test reading for butt joint

S.No	Weld		
metal zone		HAZ	
zone	Base		
metal			
1	149	117	98
2	145	114	95
3	146	118	88

From this it has been concluded that the hardness value of weld zone is higher than any other zone. From the hardness test results it has been concluded that the hardness of the butt weld is greater than the other which is not very advisable. And the lowest hardness values were found in lap weld which is also not recommended. So the optimum values were found in butt weld.

5.2.2 Tensile test

In tensile test the work piece is placed between two fixtures of Universal testing machine (UTM) and Gradual load (pull force) is applied on both sides. Thus the material reaches its yield strength and starts breaking. From this test we can evaluate the strength of two work pieces of butt weld joint and lap weld joint after calculation of elongation we can conclude that the work piece having butt joint as more tensile strength as compared to lap joint. So we prefer butt weld joint is work piece is best suitable for industrial application. For lap weld joint the load was increased gradually and the changes in dimensions are noted. Thus the maximum load applied was 59 kN where the fracture was observed.The load is applied till the failure is observed. Initially, the deformation was not observed till 50 kN. Thereafter, the steady deformation is observed. The deformation observed was of 10mm when the fracture has occurred. The results are as follows.

Fig 5.2.2 Tensile machine

Fig 5.2.3 Specimen after breaking

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Table 5.3 Tensile test values of butt weld joint.

Guage Length	Thickness	Load	Deflection	Elongation
185mm	6mm	59kN	10mm	195mm

Table 5.4 Tensile test values for lap weld joint

Guage Length	Thickness	Load	Deflection	Elongation
180mm	6mm	51kN	20mm	200mm

IV. CONCLUSION

We need to used Arc Welding process for bulk production because of its less complexity and shielded production and also we preferred v-groove butt joint to do the weld. From the above observation the work piece with butt joint is best suitable for industrial application due to its salient futures. The tensile strength for butt joint work piece is more that of lap joint work piece and also the hardness is also better in lap joint as compared to butt joint work piece these observation can be done by using universal testing machine and rockwell hardness testing.In hardness we found that hardness is more at weld pool as compared to heat affect zone and base metal zone.

FUTURE SCOPE

However many latest technologies are involves in various activities welding is process that is following the traditional process. Welding is the best method to join the metal pieces which is very strong. It is important to know its mechanical properties of weld joint. And also those properties effect due to various parameters such as groove angles, current, depth of weld, type of weld joint.
After knowing these properties it is easy to weld bulk components in future.

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