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INFLUENCE OF WELDING SPEED AND GROOVE ANGLE ON STRENGTH OF V-GROOVE BUTT WELD JOINT USING SMAW

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Abstract - Welding is a fabrication process that join materials, usually metals are thermoplastic. by using high heat to melt the parts together and allowing them to cool, causing fusion. Welding is a distinct from lower temperature techniques such as brazing and soldering, which do not melt the base metal. Arc welding is a type of welding process using an electric are to create heat to melt and join metals. A power supply creates an electric are between a consumable or non-consumable electrode and base material using either direct arc or alternating currents. To study the weld properties on a butt joint by using are welding process. First, we took mild steel. By using the electrode E6013 we have filled V groove. The welded workpiece is settled at room temperature. LPT test is performed on the workpiece by using penetrants to check the internal defects which are formed on the welded material. We have observed slag. porosity defects during LPT test. Later hardness test is performed on the workpiece at 5 different positions like Heat Effected Zone, Weld zone, Base Metal. The maximum hardness observed on weld zone by using gas cutting. the workpiece is cut into required shape for tensile test. Tensile test is performed on UTM. by gradually increasing the load on workpiece, the workpiece breaks at a load of 55 KN which is known as breaking point.

***Key Words*:** Welding, SMAW, Butt joint, Lap joint, T joint, speed of weld, shielding gas.

1.INTRODUCTION
1.1 Welding

Welding is a manufacturing process that joins materials, usually metals, by using high heat to melt and cool the parts together to create a fusion. The welded pieces unite into one entity. Welding differs from low-temperature techniques such as brazing and soldering, which do not melt the base material instead they deposit other material as joining material.

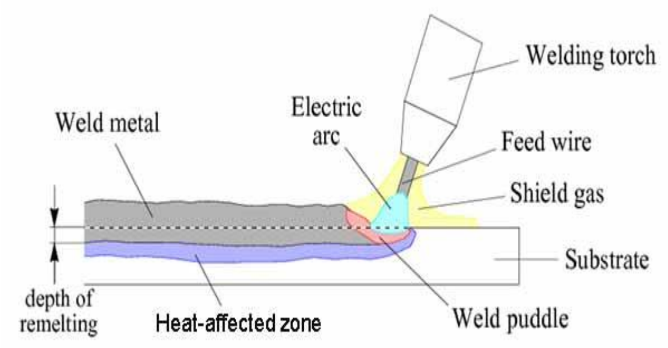
In addition to melting the base metal, filler metal is usually added to the joint to form a pool of molten material (weld puddle). As it cools, the weld configuration (butt, full penetration, fillet, etc.) is stronger than the base metal. Pressure can also be used in combination with heat or alone to create welds. Welding also requires some form of protective shielding to protect the filler metal or molten metal from contamination and oxidation. Welding can use a variety of energy sources including gas flames (chemical), arcs (electrical), lasers, electron beams, friction, and ultrasound. Welding is often an industrial process, but it can be performed in a variety of environments, including outdoors, underwater, and in space. Welding is a dangerous activity and requires precautions to avoid burns, electric shock, visual impairment, inhalation of toxic gases and fumes, and exposure to intense UV radiation.

1.2 Types of welding

Welding processes can be classified into different types based on electrode, filler material, shielding gas, source energy, etc. Few of the processes are listed below.

➢ Gas Metal Arc Welding (GMAW)

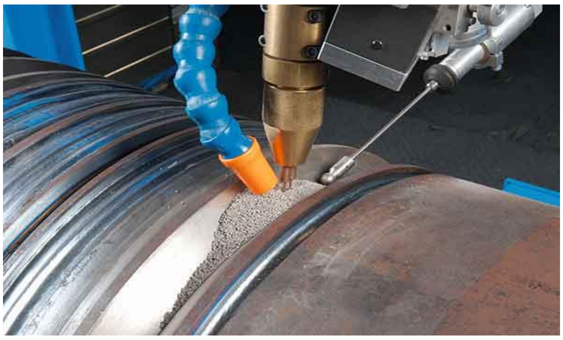
Gas Metal Arc Welding is also called as metal inert gas welding (MIG). It is a semi-automatic, quick process where filler wire is fed through the gun, and shielding gas is expelled around to protect from environmental impurities. The filler wire is fed on a spool to act as an electrode as well. The tip of the wire acts as an electrode and the base metal melts as filler metal to create the weld. This process is continuous and parameters should be preset according to welding requirements. A versatile process for welding an extensive list of metals that produces clean, smooth and visually pleasing welds.



GMAW schematic diagram

➢ Submerged Arc Welding (SAW)

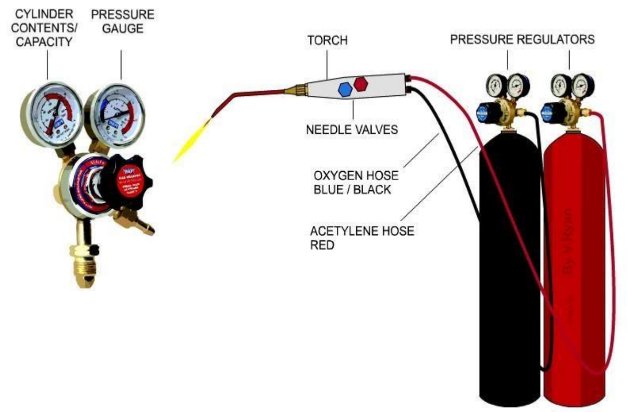
This type of welding involves the covering of metal pieces, welding wire, arc, and welding joint by a blanket of flux. It makes the process safe as there are no emissions of welding fumes, strong arc lights, and flying slags. The flux barrier protects the human and robot whosoever is performing the welding. It is a faster process for high-production industries. SAW produces strong welds with deep penetration, with minimal preparation quickly and efficiently. It protects the welder from UV light and infrared radiation because of the flux layer.



Submerged arc welding process

➢ Oxyacetylene Welding

One of the hottest methods of welding at 3500 degrees Celsius. The temperature of welding here reaches seven times as hot as the biggest, hottest pizza oven. It generates heat when a mixture of fuel gases and oxygen passes in a torch. The process involves three types of flames: neutral flame, carburizing flame, and oxidizing flame. The advantages of the welding process are many. It is portable because of pressurized gas filled in a handy steel cylinder. It is fairly easy to use, and versatile for different sizes of metals. It is a very safe and economical option where a novice can perform easily.



Oxyacetylene gas Welding arrangement

2.LITERATURE SURVEY

Sanjeev Gupta 2016 [1] Performed the experiment to optimizer the condition for performing the welding on Ultra-90 specimen in which he varies the current and voltage while keeping the gas flow rate constant and observed that welding joint not made properly below 50A and 200A since then burning of specimen stated.

Ravinder & S.K. Jarial [2] studied the parametric optimization of Arc welding on stainless steel [202] and mild steel by using Taguchi method and found the control factor which had varying effect on the tensile strength, are voltage having the highest effect and also found the optimum parameter for tensile strength current 80A. Arc voltage 30V.

Dr. Simhachalam et al. [3] carried on the effect of welding process parameters on the mechanical properties of stainless steel -316 [18Cr-8N] welded by TIG welding. The specimen size is 40x15x15mm for experimentation observed that the welding current has a significant effect though filler rod does have some effect similar to current but compared to current it is less significant. MINITAB software is used for the prediction of the hardness, impact strength and depth of penetrations.

Javed Kazi et al. [4] represent a review on various welding techniques in international journal of modern engineering research publications in 2015. Their prime focus is on fulfilment of objectives of industrial application of welding with producing better quality product at minimum cost and increases productivity. The attempt is made to understand various welding techniques and to find the best welding technique for steel. Special focuses have been put on TIG and MIG welding. For this study they analysed strength hardness, modulus of rigidity, ductility, breaking point, % clongation etc. at constant voltage on hardness testing machine and UTM.

Naitik s Patel et al. [5] they carried out the features highlighting the TIG as a better prospect for welding then other processes especially for joining of two dissimilar metals with heating therial or applying the pressure or using the filler material for increasing productivity with less time and cost constrain. They made an attempt to understand the effect of TIG welding parameters sha welding current, gas flow rate, welding speed, that are influences on responsive output parameters such as hardness of welding, tensile strength of welding, by using optimization philosophy.

Leroy Gardner [6] comprising tensile test on flat and corner materials. Initial geometric imperfections were generally low in both the hot rolled and cold rolled steels sections, with large imperfections emerging towards the ends of the cold formed members. Current codified slenderness limit was evaluated on the basis of compressive and bending test on hot rolled and cold rolled section.

Jaile mill (2004) [7] self-drilling screw joint for cold rolled steel channel portal. The conclusion of earlier testing by the first author that widely used bolted and plate moments connection is not suitable. They knew joint of portal frames constructed from thin cold formed channel sections. The order traditionally used joint configuration of a mitred joint with two bolts is end is ending plates may need to be sized conservatively.

Shah Foram Ashok bhai [8] steel consumption is more in industrial shed structure using hot willed steel and cold rolled steel sheets as compared to industrial shed structure using cold formed steel sections. The weight is more in industrial shed which use of hot rolled sheets. The weight of industrial shed with cold formed sections is reduced with 32.03% than industrial shed structure with hot rolled sheets. An attempt is being carried out the comparison between hot rolled and cold milled steel.

D. Devakumar & D. B. Jabaraj [9] the gas tungsten arc welding (GTAW) of sheets 2mm thickness of hot rolled medium and high tensile structural steel (HRS) is carried out to investigation of mechanical properties and composition analysis through energy dispersive analysis of X ray DAX) to find out the hardness test, tensile test, bend test to determine the mechanical properties of the weldments. The increase in the weld zone micro hardness and formation of dendritic delta ferrine microstructure, when compared with HRS parent metal having elongation grained austenite with ferrite and the HRS parent metal having fine grains of ferrite, caused the joint efficiency of the HRS weldments to increase.

Ruangyot Wichienrak & Somchai puajindanetr [10] cold rolled steel industry in type of batch sealing furnace, the mechanical properties of steel sheet have variation by each position. The meters of annealing temperature and time were analysed to work out the source of mechanical properties variation. The mechanical properties which were examined i.e., Yield strength, tensile length, 4 elongation and hardness. Increasing the annealing temperature could remarkably case the yield strength, tensile strength and hardness, whereas the elongation model 5982.

Sachita S.Nawale [11] thin sheet steel products are extensively used in building industry. These thin steel sections are cold formed i.e., their manufacturing process involves forming steel sections a cold state (Le. without application of heat) from steel sheets of uniform thickness. The thickness of the cold rolled sheets is usually 1 to 3mm. The method of manufacturing is important as it differentiates these products from hot rolled steel sheets. Normally, the yield strength of steel sheets used in cold from sections is at least 280N/mm2, although there is a trend to use steels of high strengths, sometimes as low as 230N/mm2.

Chunquan Liu et al [12] study and investigation of mechanical properties of hot rolled and cold rolled steel. In experimental steel, processes by quenching and tempering (Q&T) heat treatment. exhibited excellent mechanical properties of hot rolled (strength of 1050-1130 MPa) and cold rolled steel (strength of 878-1373 MPa). The fracture modes of hot rolled sample. quenched from 650c, and cold rolled sample, quenched from 650e.

Bread Wolter & Gred Dobmann [13] In forming of steel by hot rolled and cold rolled steels a broad range of semi-finished and final products can be produced with a specific, customtailored technological properties. Micro-magnetic techniques, like 3MA have been reached a sophisticated level of industrial standard and are ready to be integrated into the production process of steel manufacturers. Mechanical properties, like tensile, yield strength and hardness as well as residual or structural stress level can be predicted with high accuracy.

Chandel et al [14]. presented theoretical predictions of the effect of current, electrode polarity. electrode diameter and electrode extension on the melting rate, bead height, bead width and weld penetration in Submerged Arc Welding. They indicated that the melting rate in SAW can be increased by using (1) higher current (ii) straight polarity (iii) a smaller diameter electrode and (iv) longer electrode extension. The percentage difference in melting rate, bead height, bead width and bead penetration has been found to be affected by the current level and polarity used. They have concluded that when a smaller diameter electrode is used, the increase in the current level does not make a significant effect on the percentage change in the weld bead geometrical parameters.

Chandel and Seow [15], presented the mathematical prediction of the effect of current, polarity wed, electrode diameter and its extension on the melting rate, bead height, bead width and weld SAW They concluded that for a given current (heat input) the melting rate can be aced by using electrode negative polarity, longer electrode extension, and smaller diameter alsodes. There are two other ways to increase the deposition rate without increasing the heat ip these are: (1) using a twin-arc mode and (ii) adding metal powders.

Gansraj and Margan [16], developed analytical models to establish a relationship between process parameters and weld bead volume in SAW of pipes. They also carried out the optimization of weld bead volume using the optimization module available in the MATLAB software

Mostafa and Khajavi [17], described the prediction of weld penetration as influenced by Flux Cured Arc Welding process parameters like welding current, are voltage, nozzletoplate distance. derode-to-work angle and welding speed. The optimization result shows penetration will be I'm when welding current, are voltage, nozzle-to-plate distance and electrode-to-work angle is at their maximum possible value and welding speed is at its minimum value.

Erdal Karadeniz [18] et al., have investigated the effects of various welding parameters on weld in Erdemir 6842 steel of 2.5 mm welded by Robotic Gas Metal Arc Welding Process. The welding current, are voltage and welding speed have been chosen as variable process parameters. The depths of penetration have been measured for each specimen after the welding operations and the of these welding process parameters on penetration have been determined. The welding currents in step of 95A, 105A and 115 A, Arc voltages in steps of 22V, 24V and 26 V and welding speeds in steps of 7,10 and 14 mm/s have been used for all experiments. has been found that increase in current; substantially increases the depth of penetration while crease in voltage, very slightly increases the penetration. The highest penetration has been served at 10mm/s welding speed.

Cats and Parmar [19], developed mathematical models by using fractional factorial technique pict the weld bead geometry and shape relationship for Submerged Arc Welding of micro nel in the medium thickness range of 10-16 mm. The response factors namely head, weld width, reinforcement, dilution, weld penetration shape factor (WPSF), weld moment form factor (WREF) as affected by wire rate, open circuit voltage, nozzle to- distance, welding speed and work material thickness have been investigated and analyzed

Ravindran and Parmar [20], developed mathematical models by using fractional factorial apes to predict weld bead geometry and shape relations for CO2 voltage, welding current, adding speed, nozzle-to-plate distance and gun angle.

Kamanan, Edwin Dhas and Gowthaman [21], worked on the application of Taguchi Technique ad Regression Analysis to determine the optimal process parameters for SAW. They have carried an experiment on a semi-automatic submerged arc welding machine and the signals to noise s have been computed to determine the optimum parameters.

Patnaik, Biswas and Mahapatra [22], established a relationship between the controlling factors and performance outputs by means of Non-linear Regression Analysis and developed a valid hematical model and Genetic Algorithm (. In SAW a large number of process parameters influence the outputs such as deposition rate, dilution and hardness, which affect the weld quality detired for hard facing.

Patter et al [23] in 1968 have discussed the joining of dissimilar metalo has progressed significantly during the past two decades because of the increasing use of dissimilar-metal nations in the aerospace, nuclear, chemical, and electronics industries. The selection and application of dissimilar metals in structural applications are dictated by the service requirements the structure, as well as the economics of material cost and the ease of fabrication.

Schaeffle et al, in 1949 [24] studied the increase the scope and accuracy of Ferrite Number (FN) prediction in stainless steel weld metal and related dissimilar metal joints, a modification of the Welding Research Council 1988 high. Also, the axes of the WRC-1992 diagram can be extended (as in the Schaeffler diagram) so predict dilution effects in dissimilar metal joints.

Odegard et al. [25] has studied in the year of 2014 about the metallurgical characteristics, taghness and corrosion resistance of dissimilar welds between duplex stainless-steel Alloy 2205 and carbon steel A36 have been evaluated. Both duplex stainless steel ER2209 and Nibased Alloy 625 filler metals were used to join this combination using a multipass, gas tungsten arc welding (GTAW) process.

Kacar et al. in 2004 [26] reported on the microstructure property relationship in dissimilar welds between martensitic and austenitic stainless steel. Both austenitic and duplex stainless-steel electrodes were used to join this combination, using multipass manual metal arc welding process.

W. Provost (1982) [27] explored the impacts of a pressure alleviation warm behavior on the strength of weight container quality steels. The aftereffects of this work depict the impact in weight vessels quality steels. Uncommon consideration is paid to the base plate thickness for which a post weld warm treatment ought to be prescribed.

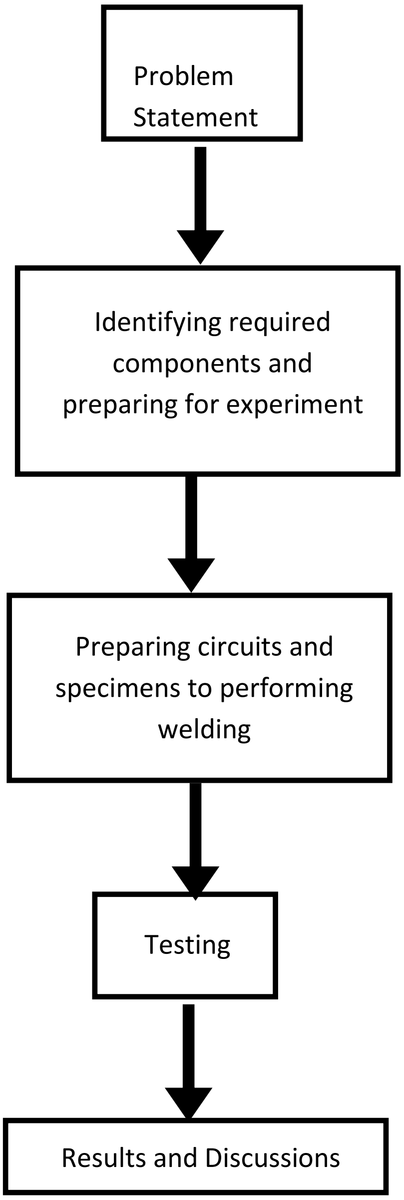
T.A Lechtenber and J.R. Foulds (1984) [28] explored the impact of pre-warm on the microstructure, hardness and strength of HT-9 weldments. A diminished preheat, affecting a quicker weld metal cooling rate, results in an expanded upper rack vitality and lower pliable

weak progress temperature with no charge in weld metal. SEM examinations show a diminished dendrite separating and bring down inter dendritic isolation with a quicker cooling rate.

J.N Clark (1986) [29] researched about the weld fix of low compound downer safe steel castings without preheat and post-weld warm treatment Extra information on downer pliability of the weld metal were given and talked about reference to the more extended term honesty of fixes.

D.G. Crawford and T.N. Dough (1991) [30] puncher examined about microstructure and strength of low carbon steel weld metal. An investigation of the trial information was completed, in view of the preface that minor stages were the essential locales for fragile break inception, and that effective proliferation or generally of such splits was an element.

3.METHODOLOGY



➢ Problem statement

Welding is a skilled demanding process as it requires precise movement of tool with optimum speed to achieve good weld. If the welding is not done properly the joint may fail and it can be catastrophic. In order to have a good finish on the weld speed of weld is an important parameter to be considered. With our study, we focus on finding on what is the relation between speed of welding and strength of joint and how it affects the finish of the weld. And also, we try to find optimized speed of weld that can be maintained to get better finish along with good strength of the weld.

Objectives

- To study the working of Shielded metal Arc Welding and to investigate parameters that effect the welding process.
- Study in detail what are the effects of weld speed on strength of weld.
- Optimization of weld speed to achieve good weld strength along with good finish.

4.EXPERIMENTATION

Material Selection

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 toits excellent weld ability.

Table 1. Chemical Composition of Base Material

Element	%
carbon	0.20
manganese	1.60
Sulphur	0.045
phosphorous	0.045
silicon	0.045

Selection 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 60° single v groove angle were selected. Then the specimen was beveled to the requiredangles with a hand grinding machine. In this procedure the mild steel plates were held fixed inthe bench vice. Then the grinding wheel was allowed to bevel the edges of the plates to therequired angles. The spatters formed on the surfaces of the steel plates are also removed to make a smooth surface.

Arc Welding

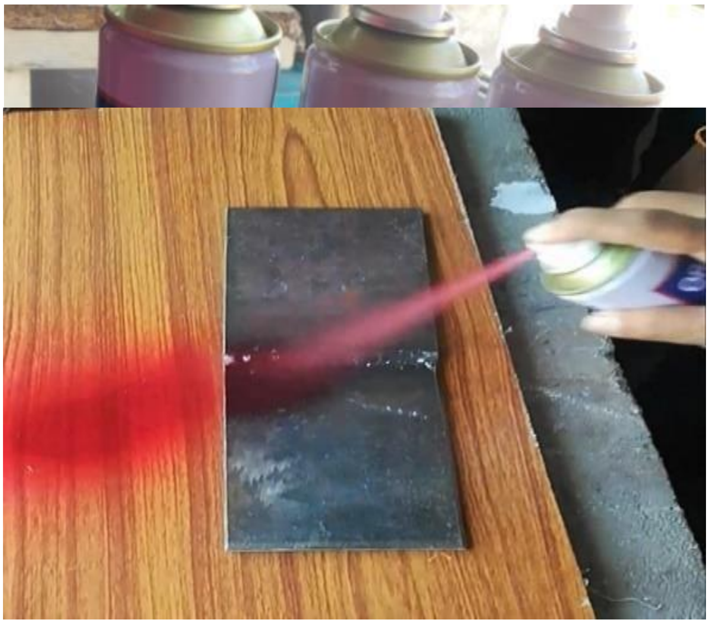
The welding process is done using Shielded Metal Arc Welding process. The DC rectifier having welding current rating of 450Amps with 60% rated duty cycle was used as a power source for the welding process. The butt and lap weld are made.

Arc welding

NON- DESTRUCTIVE TESTING

- **LPT TEST**

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



Equipment of LPT

MAGNETIC PARTICLE TESTING

Magnetic particle inspection is a non-destructive inspection method that provides detection of linear flaws located at or near the surface of ferromagnetic materials. It is viewed primarily as a surface examination method.

Test Equipment

Magnetic Particle Testing

HARDNESS TEST

- **LEEB HARDNESS TEST:**

In hardness test we can use Leeb Hardness Testing machine during this process we needto consider three zones on the work piece those zones are Base Metal Zone, Heat Affected Zone, Weld Pool.

Leeb Hardness Testing

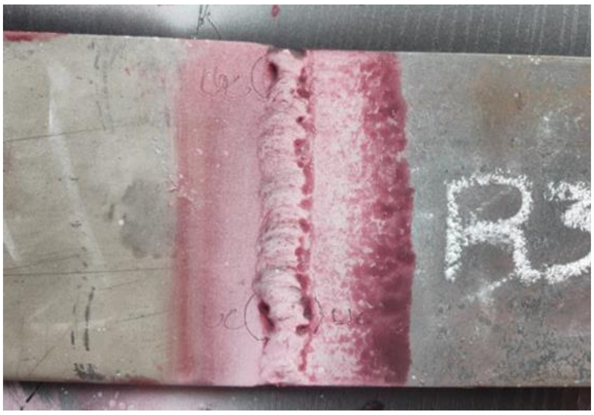
TENSILE TEST

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.

Tensile Machine

5.RESULTS

- Penetration Test

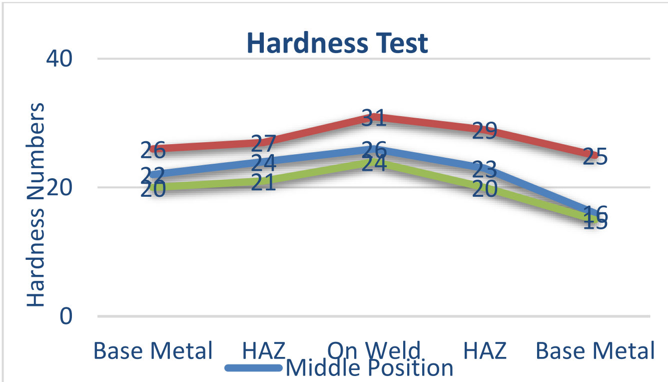


internal defects

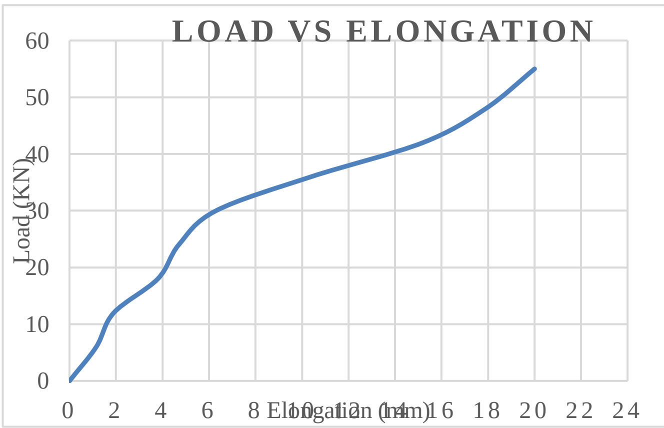
- **MAGNETIC PARTICLE TESTING**

Magnetic Particle Testing

- **HARDNESS TEST**



- **Tensile Test:**



CONCLUSION

After testing the weld joints by using dye penetration test the following are the defects like porosities, cracks and lack of penetration are observed. The weld effects are raised due to improper welding, residual stresses, distortion, inclusions, fluctuations, in voltage and current, selection of suitable electrode for material which is used for welding. The weld defect reduces the strength of weld joint. After NDT, hardness test & tensile test & magnetic are performed. We have observed that properties of hardness in cap is less than the root specimen and also hardness of welded zone is greater than heated effected zone and base metal. In tensile test we observed that the maximum elongation and breaking point. In magnetic test we observed that can defect surface and subsurface flaws in magnetic materials. Finally, we conclude that strength of weld joint is greater than parent material.

FUTURE SCOPE

In future, we perform various non-destructive tests on the weld to know the internal defects such as ultrasonic NDT, radiography NDT etc. We also analyses the microstructure with a help of optical microscope which is interfaced computer. The effect of current and material on the weldment microstructure is investigated.

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