International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

A Study on Analysis and Process Optimisation of Weld Joint in Pipes for Different Weld Positions

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Abstract: ***The important goal in the modern industries is to manufacture the products with lower cost and with high quality in short span of time. There are two main practical problems that engineers face in a manufacturing process. The first is to determine the values of process parameters that will yield the desired product quality (meet technical specifications) and the second is to maximize manufacturing system performance using the available resource. Welding operation is widely used in automotive, aircrafts and many other industries. Welding is an efficient method of making permanent joints between two or more metal parts. Liquids and gases are transported in pipelines and any chemically stable substance can be sent through a pipeline. Pipelines exist for the transport of crude and refined petroleum fuels such as oil, natural gas and bio fuels and other fluids including sewage, slurry and water. In pipe joining process strength of a pipe joint place a very important role. Because the internal and external forces and pressure will be very high in oil or gas pipe line transportation system. Piping element is defined as material required installing the piping system. Elements of piping include design specifications, materials, components, supports, fabrication, inspection and testing. Most of the operation in a process industry occurs at temperatures and pressure, which are different from normal atmospheric condition. These operations are often hazardous and do put the surroundings at risk. The job of the mechanical engineer is to confirm these risky operations within vessels and pipes, act as boundaries between these risky but necessary operations and the outer world While protecting the outer world from risk, these structure suffer stress and stress themselves. Any flaw or shortcoming in any of these aspects would mean that these structures would be unable to do their protector's roll perfectly, and mishaps would occur. Mechanical designer have to make sure that the structure would guarantee reasonable safety for a reasonable period of time and not fail in spite of continuous or intermediate harsh condition faces by their design structure. Stress analysis is a subject, which is more talked about and less understood. The objective of pipe stress analysis is to ensure safety against failure of the piping System by verifying structural integrity against the loading condition both external and internal, expected to occur during the lifetime of the system in the plant.***

Keywords: Welding, Process Optimization, Weld Positions

1. Introduction

Welding is a fabrication or sculptural process that joints materials permanently, usually metals or thermoplastics by causing fusion, which is distinct from lower temperature metal joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is often added to the joint to form a pool of molten material that cools to form a joint that can be as strong, or even stronger, than the base material. Pressure may also be used in conjunction with heat, or by itself, to produce a weld. By testing of specimens the tensile strength, deformation, stress values are noted for all different positions of welding in both ERW and seamless pipes. The higher tensile strength for corresponding position of welding is concluded as result of our project.

Electric Arc Welding:
Arc welding processes uses an electric power supply to create and maintain an electric arc between an electrode and the base material to melt metal at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non consumable electrodes. The welding region is protected by some type of inert or semi inert gas, known as shielding gas.

The manual metal arc process occurs when two wires which from part of an electric circuit are brought together and then pulled slowly apart, an electric spark is produced across the ends. This spark, or arc as it called, has a temperature of up to 3, 600 degree Celsius. As the arc confined to a very small area it can melt metal almost instantly. If one of these wires is connected to the job and other to wire rod or electrode, as it usually called, the heat of the arc melts both the metal of the job and the point of the electrode. The molten metal from the electrode mixes with that from the job and forms the weld. It is important to realize that tiny globules of the molten metal from the electrode are forced through the arc (they do not fall by gravity). If this were not so it would be impossible to use this process for overhead welding.

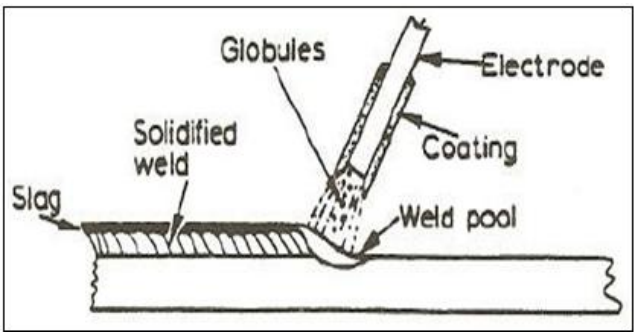


Figure 1: Schematic of Welding Process

To create the arc for welding, a voltage between 60 and 100 volts is required to create the arc, but once it has been established, 20 - 40 volts is required to maintain it.
The following stages occur when creating an arc:
1) With the welding plant switched on and before welding

commences, no current passes through the leads and ammeter reads zero. A voltage has been applied to the circuit however the voltmeter will read the open circuit or no load voltage.

2) When the electrode is brought into contact with the job a large current called short circuit current passes through the leads and the ammeter will deflect a large amount. While this is happening, however voltage drops almost to nothing. The tip of the electrode become hot because of resistance created between it and the job.
3) If the electrode is slightly withdrawn an arc is formed between the electrode and the job. As the arc is formed the voltage rises to between 20 and 40volts and the current falls to value to which it has been set. The arc is then in the normal welding condition. The heat generated by the arc melts both the work piece and the electrode and metal is deposited in weld pool.

During the depositing of the weld metal, variations in both the voltage and current of the arc can occur and the welding plant must be capable of coping with these changes.

Welding Positions:
Welding positions refer to the different orientations in which a welder performs a weld on a workpiece. These positions are classified based on the position of the weld joint and the direction of the welding process. The American Welding Society (AWS) and the International Organization for Standardization (ISO) have established standard welding positions used in various industries.

As per ISO and ASME welding positions, Butt weld in pipes are

1) 1G - pipe rotates with axis horizontal, welding down hand.
2) 2G - pipe fixed with axis vertical, welding horizontal - vertical.
3) 5G - pipe fixed with axis horizontal, welding upwards.
4) 6G - pipe fixed with axis under 45 degree angles welding upwards

Experimentation: Selection of Pipe Material:
In manufacturing or fabrication process material and its composition plays a very important role. Every material cannot satisfy all condition and structural properties so we should be careful in selecting material. Mechanical properties and thermal properties of selected material is very important in fabrication process.

Low Carbon Steel (Mild Steel): Typically contain 0.04% to 0.30% carbon content. This is one of the largest groups of Carbon Steel. It covers a great diversity of shapes; from Flat Sheet to Structural Beam. Depending on the desired properties needed, other elements are added or increased. For example: Drawing Quality (DQ) – The carbon level is kept low and Aluminium is added, and for Structural Steel the carbon level is higher and the manganese content is increased.

Selecting A Type of Pipe:

1) Seamless - An extruded seamless tube having certain standardized sizes of outside diameter and wall thickness, because a seamless pipe has not been welded, it does not have the seam.

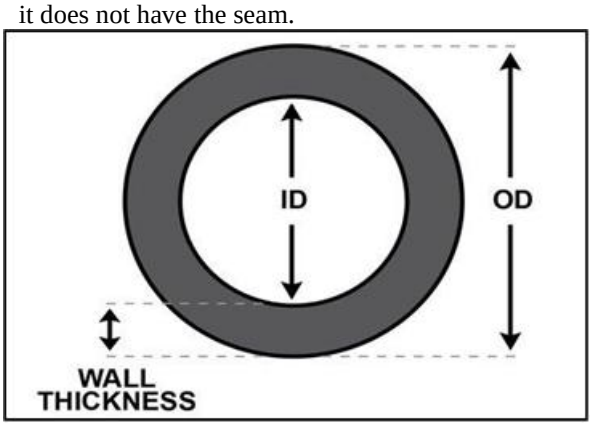


Figure 2: Seamless Tube

2) ERW (Electric resistance welded pipe) - A plate rolled to become a pipe and welded using electric resistance welding process usually for high diameter (cheapest process available).

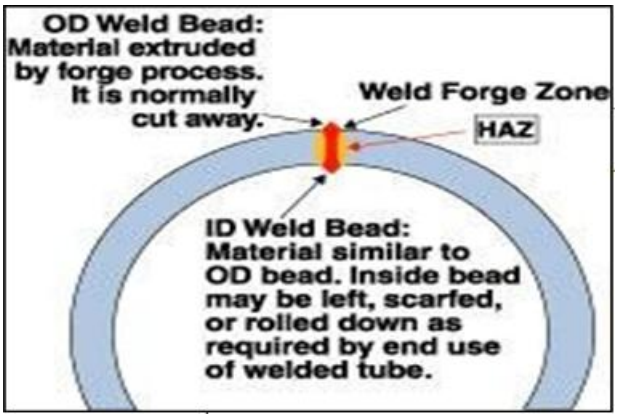


Figure 3: Electric resistance welded pipe

Dimension of Pipe Used:
As per ASME the total length of pipe for testing is 380mm, outer diameter of 42mm and the thickness is 3mm, and the standard dimensioned pipe is again cut into middle and joined from welding

Grooving:
In manufacturing process or mechanical a groove is a long and narrow indentation built into a material, generally for the purpose of allowing another material or part to move within the groove and be guided by it. Grooving is done by grooving machine and also by lathe.

Figure 4: Grooving of Pipes

Figure 5: Grooved Pipes

Welding of Pipe by EAW for ASME Weld Position:
Electric arc welding is a process of which uses an electrode that has flux around it to protect the weld puddle or arc. The electrode holder holds the electrode as it slowly melts away. Slag protects the weld puddle from atmospheric contamination.

Two types of standard welding

Fillet weld - A fillet is a closed weld, which means the base metal, is not cut through to accommodate weld metal. In most cases, extra steps are needed before welding, just good fit - up and clean surfaces for welding. Fillets are commonly performed on two plates where one is perpendicular to the other.

Groove weld - A groove welding is a type of welding, where narrow cut or indentation is given to one portion of work piece to give space for weld flow in between the joint of two pipes.

Figure 6: 1G position Welding

Figure 7: 2G position Welding

Figure 8: 5G position welding

Figure 9: 6G position welding

Analysis with UTM:
The welded specimen or pipes is ready to test for its tensile strength in universal testing machine. The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips.

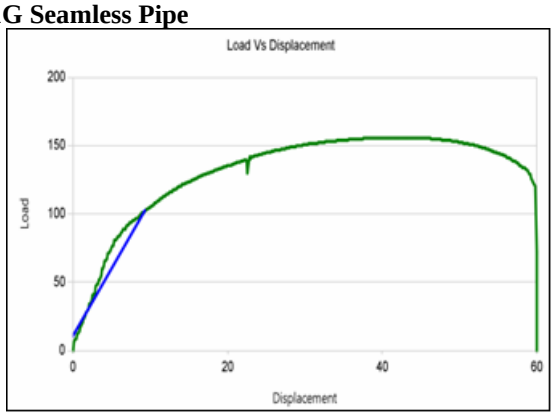
Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen. The ultimate strength can be calculated from output values or graphs which are taken from testing results.

Figure 10: Pipe placed between jaws of UTM

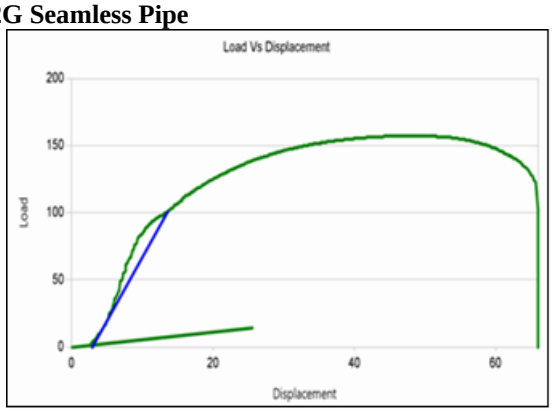
2. Results and Discussion

The results of the weld strength of different joints are depicted in Fig:

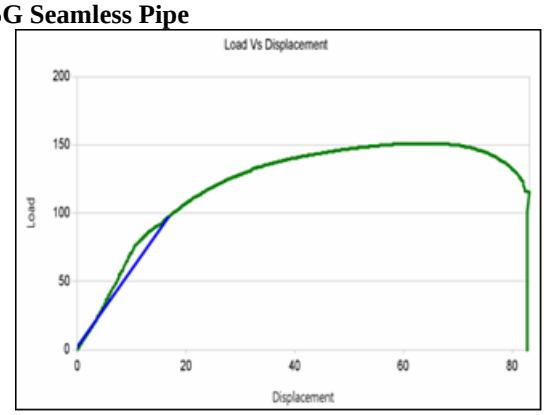
a) 1G Seamless Pipe



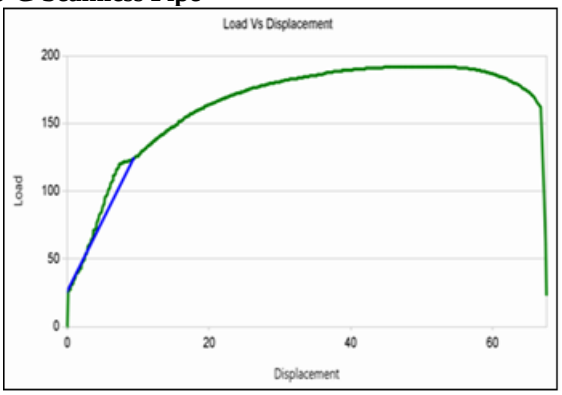
b) 2G Seamless Pipe



c) 5G Seamless Pipe



d) 6-G Seamless Pipe



Plot of load v/s different weld position

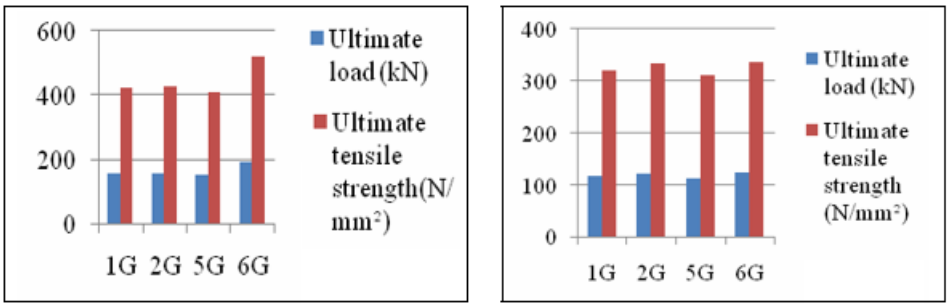


Figure 11: Comparison of Strength; Seam v/s ERW Pipe weld joints

3. Conclusion

1) Since the welded pipes are used for pressure vessels, longitudinal stresses are predominant compared to all other parameters which causes fracture of the pipes. So attention is focused on determination of tensile strength
2) In the present work tensile test is conducted for two types of pipes ERW and Seamless for various position of welding as per ASME standards.
3) The ultimate tensile strength of 6G welded joint for Seamless pipe found 522.48 N/mm² and ultimate tensile strength of 6G welded joint for ERW pipe found 337.75 N/mm².
4) Referring to the above results, it can be concluded that for higher stress the seamless pipes welded at 6G position are more suitable.

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