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

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ABSTRACT

Welding is the metal joining process in which two or more metal having same material or different can be joined by heating to a plastic state .It is mostly used for joining metals in process industry, in fabrication, maintenance, repair of parts and structures. The metal plates and pipes used in process industry and they have welding strength as their important parameter. In this paper study of welding speed and geometry to find out tensile and impact strength in case of butt weld joint will be done. For V-groove geometry different models of plate with various included angles from 30^0, 40^0, 50^0 will be made from structural steel (A633 Grade E). Currently different welding speeds are used in precision welding applications such as nuclear reactor pressure vessels, boilers etc. where welding accuracy as well as quality with strength is an important parameter. So in this project experimentation will be done on different welding speed such as 0.3 cm/sec, 0.6 cm/sec and 0.9cm/sec to prepare a V-groove butt weld joint. Generally the V-groove geometry with included angle up to 60^0 is in use. After studying the Indian Welding Journal published by Indian Welding Society it is observed that distortion and residual stresses increase with increase in groove angle . Joints strength also increases with groove angle increase of the welded material which affects the economy of welding. The industries facing problems related to strength, the V-groove geometry can make use of the satisfactory results obtained from this investigation.

KEYWORDS: Welding Speed, TIG Welding, V- Groove Butt Weld Joint, Bevel Height

INTRODUCTION

Welding is a method of repairing metal structures by joining the pieces of metals or plastic through various fusion processes. Generally, heat is important to weld the materials. Welding equipments can utilize open flames, electric arc or laser light. In the 19th century, major breakthroughs in welding were made. The use of open flames (acetylene) was an important milestone in the history of welding since open flames allowed the manufacture of intricate metal tools and equipments. The term joining is generally used for welding, brazing, soldering, and adhesive bonding, which form a permanent joint between the parts. The term assembly usually refers to mechanical methods of fastening parts together. Some of these methods allow for easy disassembly, while others do not. We begin our coverage of the joining and assembly processes with welding. For the development of the new technique, operation, process or methodology it is very important to make detail study on the existing techniques, methodology and to understand the same for elimination of problem concerned with them. This study can be helpful for improving the weld strength of metal, also reduced in cost of welding. In this paper detailed discussion is carried out on the various mechanical properties by selecting proper Welding speed & angle in the tungsten inert gas welded joints.

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LITERATURE REVIEW

This section covers the literature review for all welding process and its study carried out by other researchers in the same field. This study can be helpful for improving the weld strength, also reduced in cost of welding. They are summarized below.

R. R. Balasubramanian et.al. (2015) studied and compared the mechanical properties of non-heat treatable aluminum alloy AA5083 and heat treatable Aluminum alloy AA7020 using TIG welding. 5556A filler were used to weld AA7020 alloy and 5183A filler for AA5083 alloy. Effects of pulsing mode over conventional mode of GTA process were also investigated for AA5083 alloy. In this work, gas tungsten arc welding process has been selected because it is low heat input process. Low heat input process has selected because AA7020 and AA5083 were low melting point material. [1]

G. Magudeeswaran et.al (2014) studied quenched and tempered (Q&T) steels are widely used in the construction of military vehicles due to its high strength to weight ratio and high hardness. These steels are prone to hydrogen induced cracking (HIC) in the heat affected zone (HAZ) after welding. The use of austenitic stainless steel (ASS) consumables to weld the above steel was the only available remedy because of higher solubility for hydrogen in austenitic phase. The use of stainless steel consumables for a non-stainless steel base metal is not economical. Hence, alternate consumables for welding Q&T steels and their vulnerability to HIC need to be explored. Recent studies proved that low hydrogen ferritic steel (LHF) consumables can be used to weld Q&T steels, which can give very low hydrogen levels in the weld deposits. [2]

G. Magudeeswaran et. al. (2014) studied the activated TIG (ATIG) welding process mainly focuses on increasing the depth of penetration and the reduction in the width of weld bead has not been paid much attention. The shape of a weld in terms of its width-to-depth ratio known as aspect ratio has a marked influence on its solidification cracking tendency. Hence in this study, the above parameters of a TIG welding for aspect ratio of ASTM/UNS S32205 DSS welds are optimized by using Taguchi orthogonal array (OA) experimental design and other statistical tools such as Analysis of Variance (ANOVA) and Pooled ANOVA techniques. The optimum process parameters are found to be 1 mm electrode gap, 130 mm/min travel speed, 140 A current and 12 V voltage. [3]

Mayur. S et. al. (2013) studied the structural and mechanical properties evaluation of AA-5083 alloy after single pass Tungsten Inert Gas(TIG) welding were investigated to reveal the weld strength, hardness of welded joints by using weld current as varying parameter. AA-5083 alloy plates were joined by TIG welding technique to examine optimal welding current. Welded specimens were investigated using optical microscopy, tensile and Vickers's micro-hardness tests. Optical microscopy was used to characterize transition sites of welded zone, HAZ and base metal. Tensile test was conducted to characterize weld strength by determining ultimate tensile strength and micro-hardness test was conducted to characterize the homogeneity of welding in terms of mechanical properties.. [4]

N. E. Ipek (2012) studied the gas metal arc welding (GMAW) process is extensively used in manufacturing for a variety of ferrous and nonferrous metals because it greatly increases the quality of welding. The objective of this study is to develop an approach that enables the determination of critical GMAW variables and optimization of process variables by using integrated de- sign of experiment (DoE) and goal programming (GP) methods conjunctively. [5]

H.R.Ghazvinloo (2010) studied the arc voltage, welding current & welding speed on fatigue life, impact energy & bead penetration of AA 6061 joint produced by robotic MIG welding, result clearly found that when heat input increases ,fatigue life of weld metal decreases so impact energy increases. linear increase in depth penetration with increasing welding current & arc voltage also observed. [6]

T. Senthil Kumar (2007) Medium strength aluminium alloy (Al–Mg–Si alloy) has gathered wide acceptance in the fabrication of light weight structures requiring a high strength-to-weight ratio, such as transportable bridge girders, military vehicles, road tankers and railway transport systems. In the case of single pass TIG welding of thinner section of this alloy, the pulsed current has been found beneficial due to its advantages over the conventional continuous current process. The use of pulsed current parameters has been found to improve the mechanical properties of the welds compared to those of continuous current welds of this alloy due to grain refinement occurring in the fusion zone. Hence, in this investigation an attempt has been made to study the influence of pulsed current TIG welding parameters on tensile properties of AA 6061 aluminium alloy weldments. [7]

Parikshit Dutta (2007) studied conventional regression analysis was carried out on some experimental data of a tungsten inert gas (TIG) welding process (obtained from published literature), to find its input–output relationships. One thousand training data for neural networks were created at random, by varying the input variables within their respective ranges and the responses were calculated for each combination of input variables by using the response equations obtained through the above conventional regression analysis. It is interesting to note that for the said test cases, the NN-based approaches could yield predictions that are more adaptive in nature compared to those of the more conventional regression analysis approach. It could be due to the fact that NN-based approaches are able to bring adaptability, which is missing in the conventional regression analysis. Moreover, GA-NN was found to perform better than the BPNN, in most of the test cases. [8]

T. H. Hyde et. al. (2003) studied finite element creep and damage analysis were performed for a series of new, service-aged, fully repaired and partially repaired circumferential welds in CrMoV main steam pipes under an internal pressure and a uniform axial stress, using simplified ax symmetric models. Thickness of pipe was 63.5mm, angle $15^0$and welding width is 46 mm. Authors conclude that, because of complex nature of the problem exact analytical solutions can not be obtained for the stresses and strain within welds under creep conditions. Weld width on the failure life is relatively small. [9]

M. Ericsson (2003) studied the fatigue strength of friction stir (FS) welds is influence by the welding speed, and also to compare the fatigue results with results for conventional arc-welding methods: MIG-pulse and TIG. The Al–Mg–Si alloy 6082 was FS welded in the T6 and T4 temper conditions, and MIG-pulse and TIG welded in T6. The T4welded material was subjected to a post-weld ageing treatment. According to the results, welding speed in the tested range, representing low and high commercial welding speed, has no major influence on the mechanical and fatigue properties of the FS welds. [10]

S.C. Juang et.al (2002) In this paper, the selection of process parameters for obtaining an optimal weld pool geometry in the tungsten inert gas (TIG) welding of stainless steel is presented. Basically, the geometry of the weld pool has several quality characteristics, for example, the front height, front width, back height and back width of the weld pool. To consider these quality characteristics together in the selection of process parameters, the modified Taguchi method is adopted to analyze the effect of each welding process parameter on the weld pool geometry, and then to determine the process parameters with the optimal weld pool geometry. Experimental results are provided to illustrate the proposed approach. [11]

In the present situation, a number of papers published so far have been surveyed, reviewed and analyzed. A substantial amount of work has been conducted on different welding parameters such as power inputs, gas flow etc for their strength in the past. Also a substantial amount of work has been conducted on the variations of groove geometries and groove for strength and distortion. From the literature survey it is clear that there is vast scope to optimize the welding speed parameter for strength of V-groove butt weld joint. Because welding speed is an important parameter in metal joining processes. So the study of effect of welding speed on strength of butt weld joint is very important in fabrication field. The purpose of this work is to carry out the study on effect of welding speed and groove angle on tensile strength, impact strength in plate welding to increase the strength of weld.

3.MATERIALS AND METHODS

In materials and methods detail discussion is carried out, about material used, specimen preparation and welding geometry used.

3.1 Materials

The base materials used for the experimental work is structural steel (ASTM A633 Grade E). This material is commonly used in industry for different application such as refineries, industrial shades, metro station, aircraft hangers, commercial buildings etc. This material has good machinabilty and weld ability. Focus of this project work is to identify the strength of singleV-Groove butt welded joint by increasing the included angle from 30^0 to 50^0. As included angle increases the contact area will also increases, therefore strength also increases. . The dimensions of base metal plates are 8x300x300 mm. The composition and mechanical properties of work material ASTM A633 Grade E are given in following Table 3.1, Table 3.2, respectively.

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Fig-3.1 Base material (ASTM A633 Grade E)

Table -3.1 Chemical Composition of Work Material ASTM A633 Grade E

Elements	C	Mn	P	S	Si	Cr	Cu	Mo	Ni
Weight, max, %	0.23	0.66	0.09	0.016	0.24	1.29	0.40	0.24	2.9

Table -3.2 Mechanical Properties of Work Material ASTM A633 Grade E

Tensile Strength, min, (MPa)	550-690
Elongation, min (%)	18

3.2Preparation of specimen

In literature survey we were investigated in V-groove butt weld joint the volume of filler material required is less so the cost of welding is also less. Also V groove is easy to prepare. So in this experimentation we are going to connect two plates by using V-groove geometry. The selected standard V-groove geometry is as per American Welding Society Handbook.

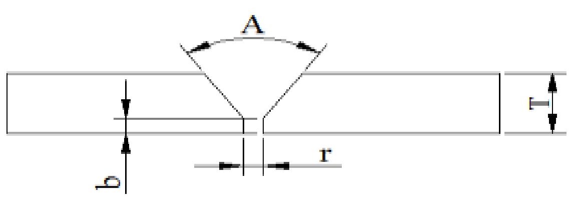

Figure-3.3 Geometry Dimensions as Per Standard of ASTM

Table-3.4 Welding Samples

Sr. No.	**Sample Name**	**Groove Angl (Degree)**	**Bevel Heigl B (mm)**	**Root Opening (mm)**	**Welding Speed cm/sec**
1	D1	30^0	1	2	0.3
2	D2	40^0	1.5	2	0.3
3	D3	50^0	2	2	0.3
4	D4	30^0	1	2	0.6
5	D5	40^0	1.5	2	0.6
6	D6	50^0	2	2	0.6
7	D7	30^0	1	2	0.9
8	D8	40^0	1.5	2	0.9
9	D9	50^0	2	2	0.9

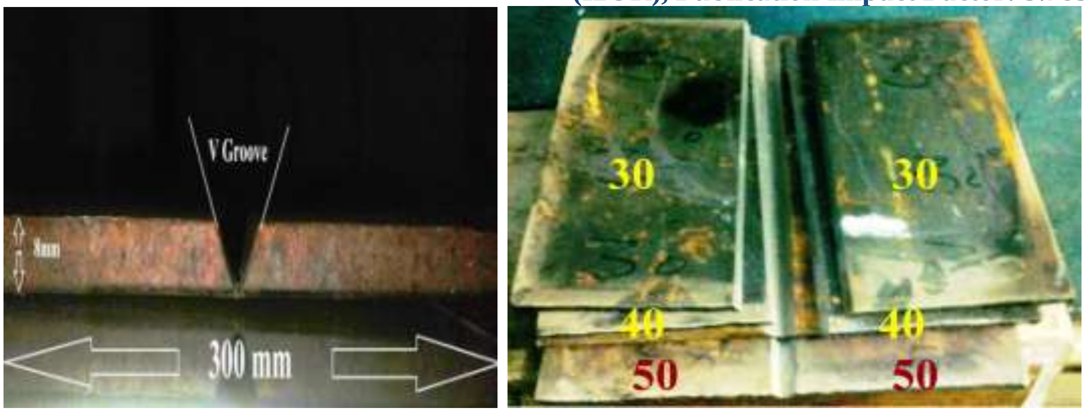

Fig -3.4: Edge preparation for welding

3.3Welding method

Robotic TIG Welding

The OTC AII-V6 is suitable for virtually all MIG, CO2, and TIG welding applications, and air plasma cutting applications. The OTC AII-V6 may be used for common materials such as mild steel, stainless steel, aluminum, titanium, as well as other exotic metals. During TIG welding, an arc is maintained between a tungsten electrode and the work piece in an inert atmosphere (Ar, He, or Ar-He mixture). Depending on the weld preparation and the work-piece thickness, it is possible to work with or without filler. The filler can be introduced manually or half mechanically without current or only half mechanically under current.

Figure -3.5 Robot OTC AII-V6 for TIG Welding

EXPERIMENTAL TESTING

The tensile strength, impact strength are evaluated by using following test.

4.1Tensile Test

Tensile test is used to find the values of yield strength and ultimate tensile strength to carry out this test we have to prepare standard specimens as per (As per ASTM).

4.2 Specimen Preparation

1.Tensile test Requirements for The Steel

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Longitudinal tension test specimens taken from the steel shall conform to the requirements as to tensile properties. At the manufacture's option, the tension test specimen is largely taken transversely.

2.Production of Test Specimens and Methods of Testing

- **i.** The test specimens and the tests required by these specifications shall conform to those described in test methods and definitions.
- **ii.** The longitudinal tension tests specimens of the steel shall be taken from the end of the plate**,** or by agreement between the purchaser and the manufacturer, or may be taken from the pipe or plate, at a point which will be approximately 90^0 of arc from the weld in the finished plate.
- **iii.** If the tension test specimen is taken transversely, the specimen shall be taken.
- **iv.** The specimens for the reduced section tension test of production welds shall be taken perpendicularly across the weld at the end of the pipe or plate. The test specimens shall be straightened and tested at room temperature.
- **v.** Reduced section tension test specimens shall be prepared.

3.Tensile Test Specimen

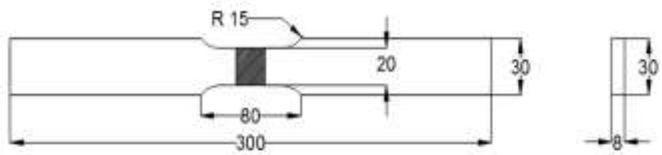
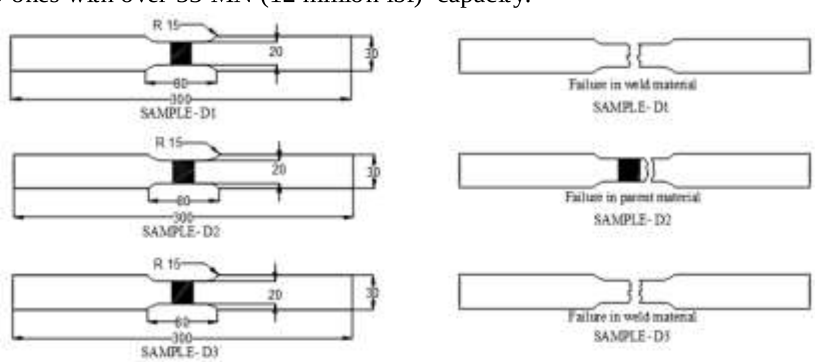


Figure- 4.1 Tensile Test Specimen

4. Process Setup for Tensile Test

The specimen is placed in the (UTM) 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 apply an increasing load on the specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen. Machines range from very small table top systems to ones with over 53 MN (12 million lbf) capacity.



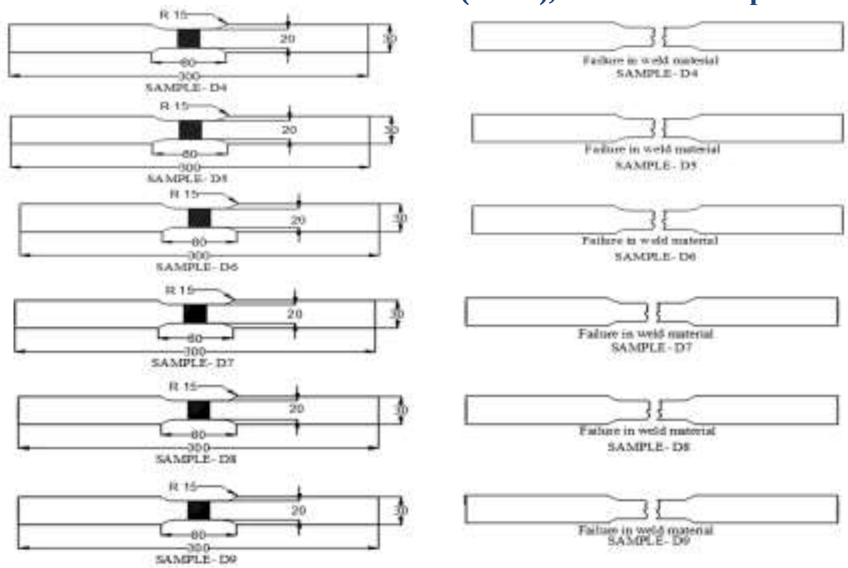


Figure -4.2 Tensile Test Specimens Before and After Test

Table -4.1 Tensile Test Results For All Specimens

Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Welding Speed cm/sec	UTS MPa	Failure location
1	D1	30^0	1	0.3	263.26	In weld
2	D2	40^0	1.5	0.3	569.62	In parent metal
3	D3	50^0	2	0.3	282.94	In weld
4	D4	30^0	1	0.6	240.94	In weld
5	D5	40^0	1.5	0.6	482.90	In weld
6	D6	50^0	2	0.6	340.25	In weld
7	D7	30^0	1	0.9	318.80	In weld
8	D8	40^0	1.5	0.9	560.61	In weld
9	D9	50^0	2	0.9	414.65	In weld

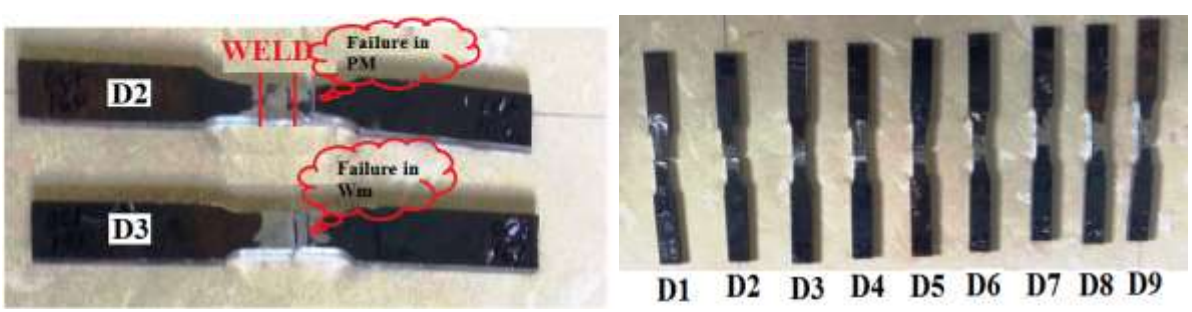


Figure -4.3 Tensile Test Specimens Before and After Test

4.2 Impact Testing

Notched bar impact test of metals gives the failure under high velocity loading conditions leading to sudden fracture where a sharp stress raiser (notch) is present. The energy absorbed at fracture is generally related to the area under the stress-strain curve which is termed as toughness. Brittle materials have a small area under the stress-strain curve (due to its limited toughness) and as a result, little energy is absorbed during impact failure.

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4.2.1 Specimen Preparation

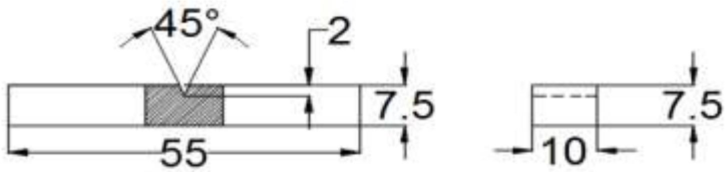
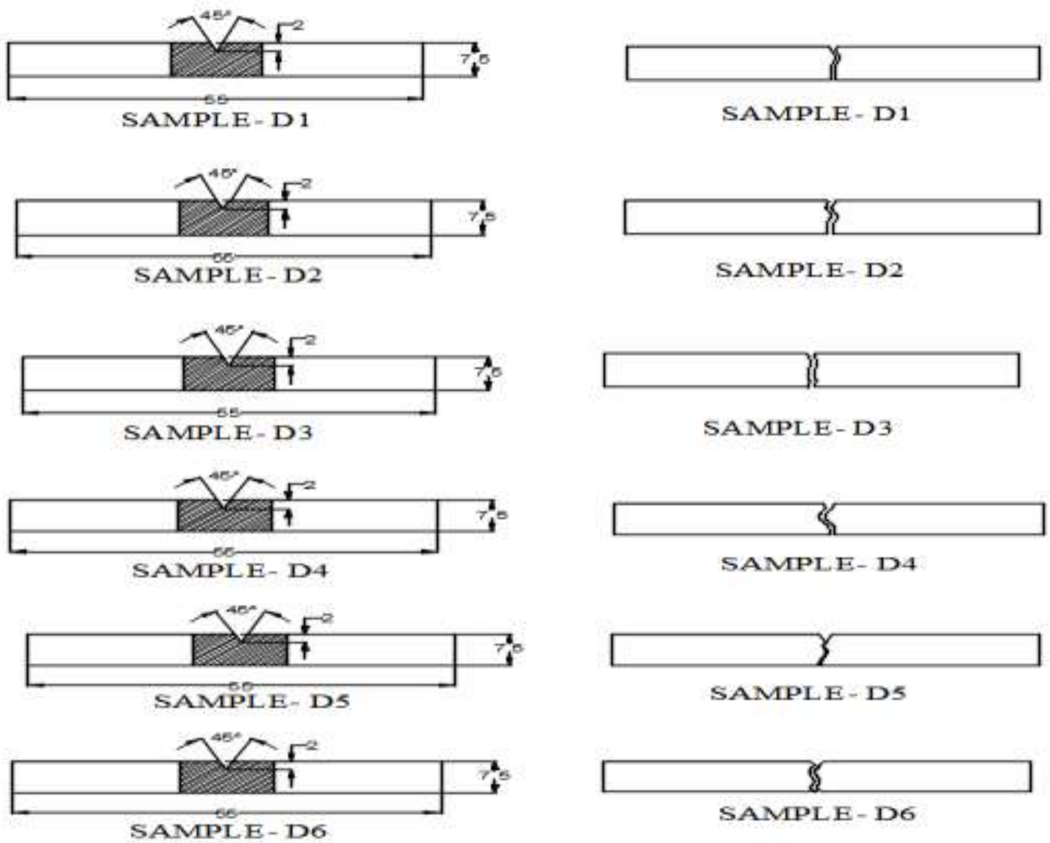


Figure-4.3Charpy Impact Test Specimen

4.8.2 Process Setup for Impact Test

Brittleness is characterized by fracturing with low energy under impact. The fracture energy is proportional to the area under the tensile stress-strain curve and is called the toughness. Tough steel is generally ductile and requires 100 ft-lbs of energy to cause failure. Brittle steel does not deform very much during failure and requires less than 15 ft-lbs energy to cause failure.Characterizing the toughness of a material is done in several ways. The most common method is the notched-bar impact test for which two types of specimens prevail, Charpy and Izod. By subjecting a specimen to an impact load, it will fail if the load exceeds the breaking strength of the material. By using a swinging pendulum to impart the load, the energy required to fracture the specimen can be calculated by observing the height the pendulum swings after fracture



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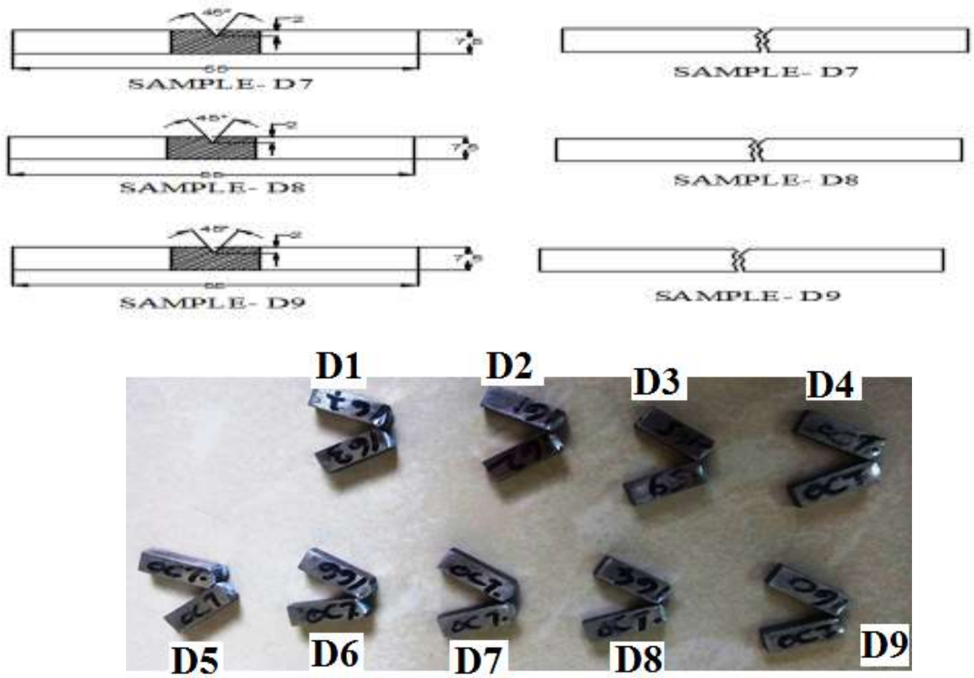


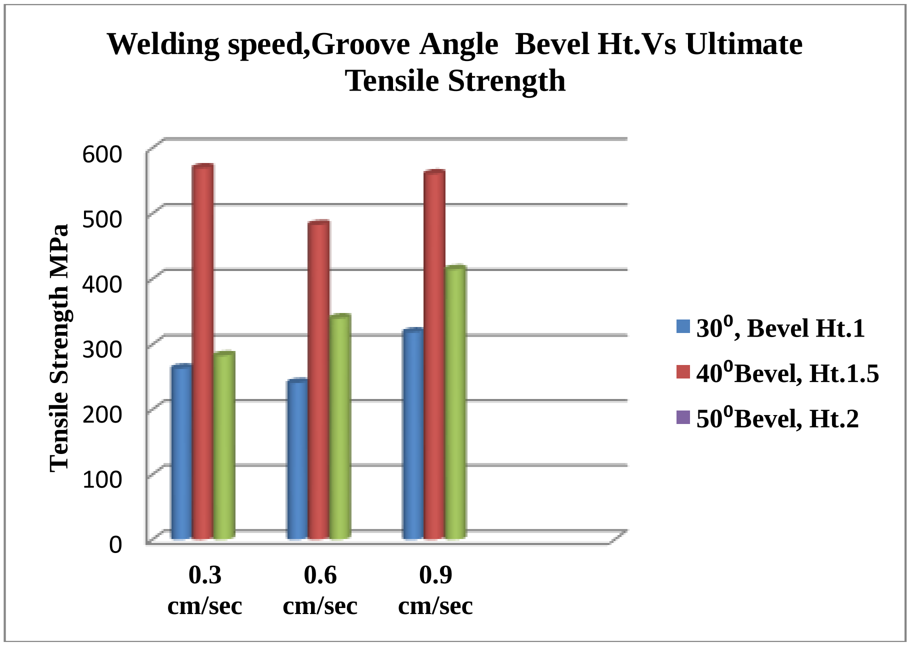
Figure -4.4 Impact Test Specimens Before and After Test

Table4.2Impact Test Results for All Specimens

Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Welding Speed cm/sec	Impact Strength J
1	D1	30^0	1	0.3	36
2	D2	40^0	1.5	0.3	36
3	D3	50^0	2	0.3	66
4	D4	30^0	1	0.6	64
5	D5	40^0	1.5	0.6	34
6	D6	50^0	2	0.6	62
7	D7	30^0	1	0.9	34
8	D8	40^0	1.5	0.9	64
9	D9	50^0	2	0.9	60

RESULTS AND DISCUSSION

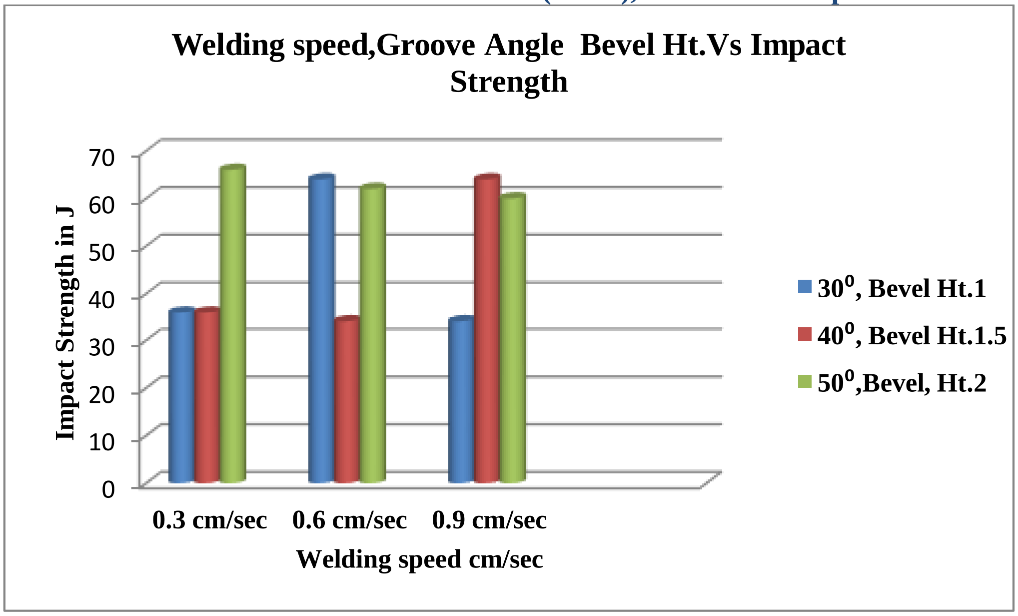
5.1 Tensile strength



Graph 5.1 Comparative Results of Different Parameters

From above graph we observed that as the groove angle increases the strength of joint increases but at 40^0 we are getting maximum strength. As we are increasing the groove angle we increase the volume of filler material deposited so it will affect on economy of the welding. So 40^0 groove angle is better option also we vary the welding speed at 0.3cm/sec we are getting maximum strength with 1.5mm bevel height.

5.2 Impact stength



Graph 5.2 Comparative Results for Impact Strength

From the above graph it is observed that as the groove angle increases the volume of filler material is increases so the impact strength also increases. We are getting maximum impact strength at 50^0 groove angle. It is observed that with the increase in welding speed the impact also increase. So at 0.9 cm/sec we are getting maximum impact strength.

CONCLUSION

From the results of the present investigation and discussion presented in the paper, the following conclusions are drawn.

1) The maximum tensile strength obtained was 569.76 MPa at 0.3 cm/sec welding speed for single V groove butt weld joint.
2) As welding speed increases the impact strength also increases at 0.9 cm/sec the impact strength is maximum.
3) The strength of butt weld joint increases with increase with groove angle at 40^0 groove angle it is maximum. Also the strength is maximum at 1.5 mm bevel and 0.3 cm/sec welding speed.
4) The impact strength increases with welding speed and groove angle. It is maximum at 0.9 cm/sec, 50^0groove angle and 2mm bevel height.
5) From this investigation we can suggest 0.3 cm/sec welding speed, 40^0 groove angle and 1.5 mm bevel height for maximum strength of butt weld joint. So this result was helpful for industry to save the cost and increase the productivity.

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