International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 03, March-2019

A Study on single V-Butt Weld Joint with Constructional Modifications in Weld Edge

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Abstract: The objective of this paper is to introduce the novel idea of reinforcement of a single V-Butt welded joint by drilling holes at beveled faces of varying diameter and varying number. The number of holes have been varied from one to four and diameter have been varied from 3mm to 4.5mm at a pitch of 7.5mm, 6mm deep on the 12mm thick mild steel plates and then welding by gas metal arc welding at a suitable speed so that these holes are filled with weld metal. Tensile tests of weld specimens were performed on computer interfaced servo-hydraulics universal test machine. Enhancement in strength has been observed in all the cases. It has been found that the strength of weld joint can get enhanced up to 25% more by drilling a series of holes of varying diameter. It has been experimentally verified that the plates 12mm thick with drilled holes of diameter greater than 3.5mm did not reveal sufficient increase in tensile strength.

Keywords: Welding, V-Butt, weld joint, tensile strength.

1. Introduction

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, so that materials can be joined into one piece. The particular combination of these variables can range from high temperature with no pressure to high pressure with no increase in temperature. Thus welding can be accomplished under a wide variety of conditions, and a number of welding processes have been developed [1].Arc welding method is generally preferred because it is economically cheap. Shielded metal arc welding (SMAW) and Gas metal arc welding (GMAW) are common forms of arc welding [2]. High current electric arc is produced in Arc Welding .The temperature of heat produced by electric arc is of the order of 6000^0C to 7000^0C. In order to produce the arc, the potential difference between the two electrodes (Voltage) should be sufficient to allow them to move across the air gap. The electrodes used for providing heat input in Arc Welding are of two types, the consumable and the non-consumable electrodes. When the arc is obtained with a consumable electrode, the metal under the arc melts as also the tip of the electrode .The molten metal from the electrode and that obtained from the base metal gets intimately mixed under the arc and provides the necessary joint after solidification [3].When the Arc is initiated, the electrode is continuously consumed and hence the electrode should be moved towards the work piece to maintain the constant arc length. Consumable electrodes are made of various materials as steel cast iron, Copper, Brass, or aluminum .Gas Metal Arc Welding (GMAW) utilizes a consumable electrode. Gas Metal Arc Welding (GMAW) can be used to weld all types of metals, but it is more suitable for thin sheets .The consumable electrode is in the form of a wire reel which is fed at a constant rate, through the feed rollers .The length of this electrode varies from around 0.635 millimeters to about 4 millimeters [4, 5]. Generally DC Arc welding machines are used for Gas Metal Arc Welding (GMAW). In Gas Metal Arc Welding (GMAW) method, the filler metal is transferred from the electrode to the joint [6].

2. Literature Review

The extensive state of the art literature work in the same domain is carried in this section of the study.

Ilkerkasikci in his study on [7] “Effect of gap distance on mechanical properties and cross sectional characteristics of MIG-MAG butt welds” determined the effect of gap distance on the weld bead geometry and the mechanical properties of the weld metals. Low-alloyed and low carbon steel plates were welded under different conditions where each weld metal had different gap distance and weld bead grooves. The influences of welding parameters namely, welding speed, current and voltage on the weld bead were examined in terms of weld bead penetration and heat affected zone and weld metal zone hardness variations.

Kah Paul Chu in his study on [8] “Welding of sheet metal using modified short arc MIG/MAG welding process” presented the results of an investigation dealing with welding of sheet metals with diverse air gap using Fast root modified short arc welding method and short circuit MAG welding processes. Welding runs were made under different conditions and, during each run, the different process parameters were continuously monitored. It was found that maximum welding speed and less HAZ are reached under specific welding conditions with fast root method with the emphasis on arc stability. Welding results show that modified short arc exhibits a higher electrode melting coefficient and with virtually spatter free droplet transition. The cooling rate has a great deal to play on the metallurgy properties of the welded material and it is high with fast root method as compared to synergic pulse method and conventional MAG method due to the low heat input of about 25% lower than normal MAG and about 14 % lesser than synergic pulse method [8].

Pornwasawongpanya [9] in his study on "Welding Residual Stresses in Two Competing Single V-Butt Joints" analysed that during fabrication of welded components residual stresses are generated as a result of non-uniform temperature distribution during the welding and particularly the cooling process. Such residual stresses have a major effect on the overall performance of a component in service, especially when hydrogen is involved and the component might become prone to Hydrogen Assisted Cold Cracking (HACC).

Kehai Li and YuMing in their study [10] "Interval Model Control of Consumable Double-Electrode Gas Metal Arc Welding Process" found that.modeling and control of an innovative welding process, namely, the Consumable Double-Electrode Gas Metal Arc Welding. This innovative process can dramatically increase welding productivity and reduce weld distortion. It has demonstrated the feasibility to double the travel speed for automatic welding but requires controls to realize its unique advantages. To reach this goal, the bypass voltage an base metal current were selected as process outputs to be controlled. The bypass current and main wire feed speed were selected as the inputs and the control system was reduced to two single-input–single-output (SISO) subsystems for convenient implementation and design. Physical analysis and derivation show that these subsystems can be approximated as first-order model systems but their parameters depend on manufacturing conditions. Hence, they were described using first-order interval models whose parameters are unknown but bounded by known intervals. Step response experiments were conducted with selected range of manufacturing conditions to identify a few models for each of the subsystems. These models were then used to derive two interval models. To increase the stability margin, the intervals identified were artificially enlarged.

Finally, a prediction-based interval model control algorithm was used to control the resultant interval models and closed-loop control experiments verified the effectiveness of the developed control system. Gas metal arc welding (GMAW) is the most widely used arc welding process. However, its current melting the wire is the same as the current heating the base metal. Increasing the melting speed for higher productivity proportionally increases the base metal heat input resulting in increased distortion. To resolve this problem, the authors proposed a simple way to modify the GMAW process such that the base metal current is independent from the melting current. The melting speed can thus be increased, while the base metal heat input and resultant distortion are still controlled at given desirable levels. This modified process, referred to as the double-electrode GMAW or DE-GMAW, has been proved to be capable of doubling the travel speed for automobile welding. However, it is more complex than GMAW and requires appropriate controls to achieve its claimed advantages. This paper is devoted to the modeling and control of this innovative process.

K. Kishore, P. V. Gopal Krishna, K. Veladri and Syed Qasim Ali. in their work of [11] "Analysis of defects in gas shielded arc welding", attempted to analyze the effect of process parameters in qualitative manner for welding of AISI1040 steel using processes of Shielded Metal Gas Welding (MIG and TIG). Taguchi method is used to formulate the experimental layout. Exhaustive survey suggest that 5-7 control factors viz., arc voltage, arc current, welding speed, nozzle to work distance and gas pressure predominantly influence weld quality, even plate thickness and backing plate too have their own effect.

To enhance the strength of butt weld joints by increasing the depth of penetration at various sections at butt joint by drilling holes at the beveled faces of joint which are filled during welding and this promotes extra reinforcement the joint, which leads in increase in tensile strength.

3. Experimental set-up and discussions

The set-up used during the experiments includes shielding gas regulator, welding machine and a wire feeder unit which carries and guides the welding gun and travels with the desired constant speeds along the plates to be welded on a 1m long rail system. Figure 1 (a), (b) and (c) shows shielding gas and its regulator, welding machine and wire feeder unit resp.

Fig. 1: (a) Gas Regulator and Pressure Gauges (b) Gas metal arc welding transformer(c) Wire feeder unit

Following steps were taken to prepare the sample:-

1. A 25 mm thick plate is cutted by gas cutter in the dimensions 25 x 100 x 40.
2. The samples were machined on shaper and then grinding was done
3. After machining, V-groove cutting is done on shaper along the 100mm side having bevel angle of 30° as shown in Fig. 2

Fig.2: Single V-butt samples without holes

Other samples are prepared in the same way as above but are provided with 3.5mm diameter five holes at the center of the groove at 15mm distant as shown in Figure 3.

Fig. 3: Single V-butt samples with holes

After machining welding was done by GMAW.

Fig.4: Samples after welding

After samples are ready for test, these are tested on UTM (universal testing machine), but the welding of the samples did not fail and the griper of UTM could not hold the work piece firmly due to large thickness, and new samples were prepared to suit the dimensions of UTM gripper available in the lab.

3.1 Sample preparation

Mild steel plates with the dimensions of 12 x 35 x 100 are prepared with the bevel heights of 0 millimeters, bevel angle of 30°. Then, they were tack welded to get a gap distance of 3mm and 1.5 millimeters. Following steps are followed for the sample preparation.

3.2Sample preparation, without holes

1. Plates are marked 3-4 mm more of the desired (12 x 35 x 100) dimension as shown in the Fig.5.

Fig. 5:Measurement and marking of the sample

S. No	parameter	value
1	Type	CSM 63
2	Maximum length of ram stroke	630mm
3	Maximum horizontal travel of table	65mm
4	Maximum vertical travel of table	370mm

5	Maximum distance table to ram	430mm
6	Minimum distance table to ram	60mm
7	Maximum travel of tool slide	150mm
8	Length and width of table top	600×350mm
9	Depth of table side	380mm
10	Floor space	2200×1270mm
11	Number of speeds to ram	4
12	Number of ram cycle/minute	10 to 80
13	Speed of driven pulley(RPM)	400
14	Driving motor power	2.2 KW
15	Approximate net weight	1

Table 1: Technical specifications of shaper

2. Plates are cutted by the gas cutter and shaper into sample pieces as shown in Fig 6.

Fig.6: Cutting of the sample

3. After cutting, the samples are grinded on the cutting surfaces to remove the uneven surfaces as shown in Fig.7.

Fig.7: Grinder on sample pieces for smooth surface

4. The next step is to cut the sample on one surface to form V-groove at a bevel angle of 30° on shaper as shown in Fig.8 [14].

Fig. 8: Edge cutting at an angle of 30° with sample surface

5. The sample are aligned for the welding as shown in Fig. 9.

Fig. 9: Single V-grooved samples ready for welding

3.3 Sample preparation with drilled holes

1. Same steps are followed from step 1 to 4 as in sample preparation without holes.

2. A 3.5 mm diameter and 6 mm deep three holes at a distance of 7.5mm from each other are drilled on the groove surface perpendicular to the cut as shown in Fig.10.

Fig.10: Holes drilled on the groove perpendicular to the cut

3. The drilled samples are ready for welding as shown in Fig.11

Fig.11: Single V-grooved samples with holes for welding.

Mild steel plates with the dimensions of 12x35x100 mm are prepared with the bevel height of 0 millimeters, bevel angle of 30°,but in these plates, three holes are drilled in each plate in the v-groove perpendicular to the cut having diameter 3.5 millimeter and tack welded to get a gap distance of 1.5 and 3 millimeters. After proper preparation, plates are placed on the workbench. In each placement, distance between the nozzle and workpiece and the electrode extension were 20 millimeters. The orientation of the welding electrode with respect to the weld joint was 90°. After checking the flow rate ofshielding gas, which was set to 10 lt/min, welding was started. Both plates were welded at single pass.

3.4 Sample preparation with only one hole

1. Steps 1 to 4 are repeated as in previous preparations.

2. A 6mm diameter and 6 mm deep hole is drilled at center of the sample as shown in Fig.12

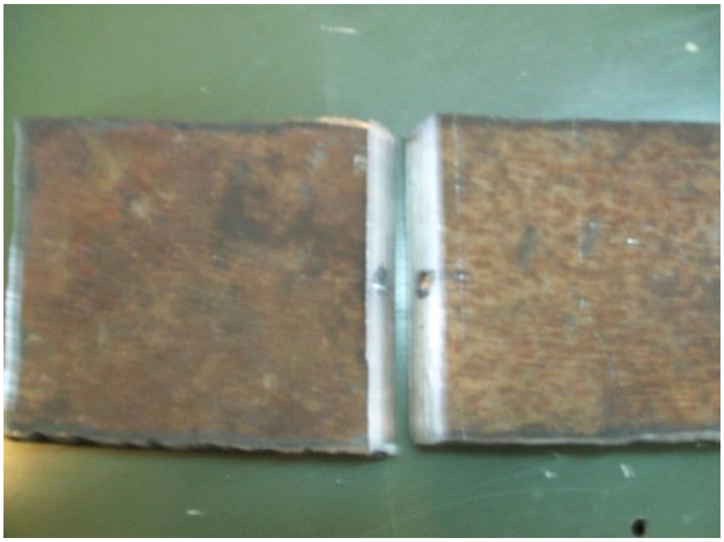

Fig.12:Sample with one hole at center

3.5 Welding process on the prepared samples

The parameters have been kept constant for all the samples. As already discussed I have prepared two types of samples, single V-grooved samples without holes and single V-grooved samples with holes. Then some samples are welded keeping root gap 3mm and some are welded at a root gap of 1.5 mm as shown in Fig 13.

The process parameters for the experimental investigation MIG welding are given below:-

S. No	Parameter	Value
1.	Voltage	20 volts
2.	Current	115 amperes
3.	Wire feed rate	60mm/sec
4.	Wire diameter	1.2 mm
5.	Arc length	20 mm
6.	Holder speed	1mm/sec

Table.2 Welding Process parameters

The welded samples for testing as shown in Fig.13 below.

Fig.13: Samples after welding

3.6 Tensile tests on universal testing machine (UTM)

Fig. 14: Universal testing machine (UTM)

S. No	Detail	Value	S. No	Detail	value
1	Type	4106	12	Round specimen dia.	(15-60)mm
2	Serial no.	30712012	13	Flat specimen thickness	(2-40)mm
3	Rated load	1000KN	14	Stroke speed range	(6-100)mm/min
4	Accuracy grade	1/0.5	15	Maximum cross-head travel speed	320mm
5	No. of columns	6	16	Displacement accuracy	±1%/±0.5%
6	Force range	1%-10%	17	Overhead load protection	5%
7	Load indicating capacity	±1%-±0.5	18	Dimensions of main frame	(1020×670×2600)mm
8	Piston stroke	250mm	19	Dimensions of hydraulic power unit	(1150×600×900) mm
9	Displacement between columns	510mm	20	Power KW	4(380V)+2(220V)
10	Maximum tensile space	850mm	21	Weight of main frame	3500kg
11	Maximum compressive space	700mm	22	Weight of hydraulic power unit	400kg

Table 3: Specifications of universal testing machine [18]

3.6 Testing procedure

Following are the steps for tensile test on UTM:-

1. Enter the software.
2. Select the test project in specimen para.
3. Select or input file name of save mode.
4. Measure the dimensions of the specimen.
5. Input specimen dimension and other parameters.
6. Fix one end of the specimen to the grip.
7. Clear load to zero.
8. Adjust the position of crosshead through operation panel, and fix another end of specimen.
9. Clear the displacement
10. Start to test. The test interface appears automatically.
11. Watching the process of the test.
12. After test the results calculated will be displayed in the test result area.
13. Print the test report and close the software

After completing the welding process of the samples, the samples are then tested on UTM in civil structural lab. Following are the some samples after the failure on universal testing machine.

(a)

(b)

Fig 16:(a) Sample without holes after test (b) Sample with holes after test

Sectioning of specimens

Sectioning of all test specimens was done to reveal internal defects and percentage filling of drilled holes by weld metal.It was revealed that 90% - 95% of the drilled hole cavities were filled with weld metal. However due to variable welding speed some holes were partially filled as shown in Fig.17 and Fig.18. but tensile results were satisfactory for these samples also.

Fig. 17: Sample with holes after testFig. 18 Section of tested sample with partial weld fill

3.7 Results and discussions

The study carried out this work revealed the following results as shown in the Table 4 below.
(1) Holes were drilled at beveled faces of varying diameter and varying number.
(2) The number of holes have been varied from one to four and diameter have been varied from 3mm to 4.5mm at a pitch of 7.5mm, 6mm deep on the 12mm thick mild steel plates.
(3) Results show enhancement in tensile strength in all the cases.
(4) Strength of weld joint can get enhanced up to 25% more by drilling a series of holes of varying diameter.
(5) 12mm thick mild steel plate with drilled holes of diameter 3mm to 3.5mm revealed sufficient increase in tensile strength as compared to the larger holes as shown in the Table 4 below.

S. No.	MS plate of 12 mm thick welded	Tensile strength MPA	Diameter of hole mm	No. of holes
1.	**X1**	**305**	**WH**	**WH**
2.	**X2**	**406**	**WH**	**WH**
3.	**X3**	**325**	**WH**	**WH**
4.	**X4**	**339**	**WH**	**WH**
5.	**A1**	**429**	**3**	**3**
6.	**A2**	**445**	**3**	**3**
7.	**B1**	**430**	**3**	**4**
8	**B2**	**436**	**3**	**4**
9	**C1**	**424**	**3.5**	**3**
10	**C2**	**402**	**3.5**	**3**
11	**C3**	**474**	**3,5**	**3**
12	**D**	**457**	**3.5**	**4**
13.	**E**	**400**	**4.5**	**2**
14	**F**	**406**	**4.5**	**3**

Table 4: Table related to values of Tensile strength

Conclusion

It is evident from experimental results that filling of weld metal in drilled holes leads to extra reinforcement which leads to approx.25% increase in tensile strength but proper care should be taken with regard to welding speed so that there is no partial filling of holes.

References

1) E. pauldegarmo, J.T. Black and Ronald A. kohser, Materials and processes in manufacturing eighth edition.
2) B. Raj, V. Shankar, and AK.Bhaduri, “Welding technology for Engineers”,*Alpha science*, 2008.
3) Kalpakjian, S. Schmid, and R. Steven, “Manufacturing Engineering and Technology”, *Pearson*, 2001.
4) HB. Cary and SC. Helzer, “Modern Welding Technology”, *Pearson/Prentice Hall*, 2005.
5) PJ. Norberto, L. Altino, and B. Gunnar, “Welding robots- technology, system issue and applications”, *Springer*.
6) R.S. Parmar, “Welding engineering and technology”, *Khanna publishers*, 1997.

7) Kasikci, "Effect of gab distance on mechanical properties and cross sectional characteristics of MIG-MAG butt welds", *PhD dissertation submitted to Middle east technical University*, July 2003.
8) KP. Chu at el., "Welding of sheet metal using modified short arc MIG/MAG welding", *PGdissertation submitted to Lappeenranta University of Technology*,Feb 2007.
9) P.Wongpanya at el., "Welding residual stresses in two competing single v-butt joints",*in proceedings of the 2nd Thailand metallurgy conference (2TMETC)*, pp:75-81.
10) K. li and Yuming, "Internal model control of consumable double electrode gas metal arc welding processes", *IEEE transactions on automation science and engineering*,Vol: 7, Issue:4, Oct 2010 .
11) K. Kishore, PV. Gopal Krishna, K. Viladri and SQ Ali, "Analysis of defects in gas shielded arc welding",*ARPN Journal of Engineering and Applied Sciences*, Vol: 5, Issue: 1, pp: 37-41, January 2010.