Improvement of Tensile Strength of 1018 Mild Steel Welded Joints Produced Under the Influence of Electrode Vibration

Bade Venkata Suresh, P Srinivasa Rao, P Govinda Rao

Abstract*: *In recent years, welding has gained its supremacy in the field of production. It is vastly used in almost all the production applications. There are many defects in welding process. Of which, residual stresses have become a serious matter of concern. Post weld heat treatment methods were adopted to overcome the defects. One of the methods adopted was to introduce mechanical excitations into the welding. Earlier, the weld pool is excited by vibrating the workpieces. But this method cannot be used at all the places as the equipment cannot be moved to all the places and the weld pieces can be welded. As the process became complex in some cases further improvement was made and a new type of methodology is induced by vibrating the electrode with the help of electric motor. Due to the excitations, weld pool refinement and grain refinement takes place. The specimens were welded with varying frequencies and voltages and tested to identify the change in mechanical properties with respect to vibration frequencies. The specimens were prepared according to ASTM standards and tested for tensile strength. After studying the results, it is observed that there is a betterment in the mechanical properties due to the weld pool refinement. The refinement of weld bead is a result of formation of very small nuclei in large numbers and making the grain structure very fine. It is observed that there is an improvement in Ultimate Tensile Strength up to 14.16%. The peak values in properties is observed at a frequency of 4450Hz.

Keywords*: *Welding technology, Vibrations, Weld pool Refinement

I. INTRODUCTION

Welding is a technique in which two or more metal or non-metals can be joined together with or without application of heat, with or without application of pressure, with or without application of filler material. We can say that welding a joint can be performed with lesser weight than the bolted or riveted joint. Welding parameters in welding decides quality of the weld and the life span of that weld joint. The parameters like welding current, electrode size, arc length, welding current, welding voltage and weld travel speed have lot of effect on weld bead quality. As we know that each process will have its pros and cons, besides being widely used and effective joints, welding has a large heat effected zone. Due to the concentration of large amount of heat over a small area, there will be generation of residual stresses in the joints. As residual stresses being a major problem during welding, much research work is on the clock. Heat treatment and mechanical processing are the most commonly used stress relieving techniques. But these are both costly and time consuming and also involves a lot of hard work.

ASMY Musin et.al.[1] investigated the vibratory effects on microstructure of welded joints and istrubution of residual stresses. There it is observed that heat treatment after welding and measured residual stress. And identified stress levels reuced upto 75MPa because of vibration. S Aoki et.al.[2] finds a novel method to reduce weldments residual stresses. As Musin did post weld treatment for reducing stress he uses harmonic vibration load. In his experiment he performed welding using san automatic co2 gas shielded arc welding machine. After completion of vibration welding at different he observed for one side welding, residual stress in the direction of weld bead. J. Kalpana et.al.[3] created a novel process for providing excitations to pool at the time of welding. In this we can produce required vibrations at a frequency and acceleration in terms of voltage. So, they done welding to dissimilar materials by vibratory Gas welding to check for improvement of tensile strength. A.S.M.Y. Munsi, et.al.[4] made a comparison between stress relief due to post heat treatment and introduction of vibrations during welding. They observed that vibrations in the welding has a great impact on the mechanical properties of the weld. When fatigue life of the specimens was studied, it decreased by 43% in thermally relieved specimens and it decreased by 17% to 30% in case of vibration assisted welding. Alaa Raad Hussein et.al.[5] conducted their experiments by using a vibratory table to their stress relieving process and welded the specimens using different frequencies of vibration of the work table. P. Govinda Rao,et.al.[6] done work on giving excitations to specimens at different frequencies and time period and observed the improvement in mechanical properties . Tso-Liang Teng et.al.[7] observed the improvement in mechanical properties and reduction in residual stresses at welded zone through mechanical excitations. A.J. Waddell et.al.[8] used vibratory stress relief (VSR) technique by cyclic loading treatments. Kuo et.al.[9]. studied to know the effect of excitations to diminish residual stress during joining process. Węglowska et.al.[10] observed to know the effect

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of vibrations on weld quality. The assessment of quality is done by observing microstructure and tensile test. G PRao et.al., [11] studied on welded specimens of 304L stainless steel on material testing system. To simulate the vibratory stress relief (VSR) processing, the tensile-compress cyclic loading was applied. The experimental results showed that the dynamic strain has feature of cyclic creep. Zhu et.al.[12] studied on vibratory conditioning technology that was used in the electro-slag welding of blast furnace steel and mechanical properties of welded joint were measured. The results have proved that vibratory conditioning technology can effectively improve the comprehensive properties of welded joints. Especially, at the 0.6 (acceleration of gravity) vibratory state, the qualification rates of side bend performance are up to 100%. Mostafapour et.al.[13] introduced a process to enhance the properties of weldments with the application of vibration to weld molten pool. The plate is made of stainless steel 304 with 2 mm in thickness. Prakash et.al.[14] describes the solidification behaviour and changes occur in mechanical properties under vibratory welding condition. Balasubramanian et.al.[15] made an attempt to fusion zone refinement and diminish the hot cracking during welding of alloys of aluminium through mechanical excitations. The AA7075 aluminium alloy taken as test specimen. Vibratory process is done at 100Hz to 2050Hz frequency ranze and identified the improved results with vibrations.

II. EXPERIMENTAL SETUP

A. Electrode vibratory welding equipment setup:

To place the work pieces, a welding table is used as of in normal welding process. The vibrating set up includes a DC motor, a speed controller and an adapter as major component. The adapter converts the 220V AC supply to 20V DC supply and the converted voltage is received by the controller. The controller has a capacity to control the voltage to the DC motor from 12V to 20V. When DC current is passed to the motor, it rotates and as it is connected mechanically to the electrode, the electrode vibrates.

The motor is capable of inducing external vibrations of different frequencies to the welding electrode. The frequency of vibrations can be controlled by changing the voltage in the controller. During welding using vibration of electrode, the vibrations are not directly passed to the weld pool. Due to vibrations, the weld droplets get refined during deposition itself and the molten metal is uniformly distributed over the entire area of the weld pool. Due to this, there will be improvement in the mechanical properties of the weld joint and also the heat affected zone. The setup is shown in figure1.

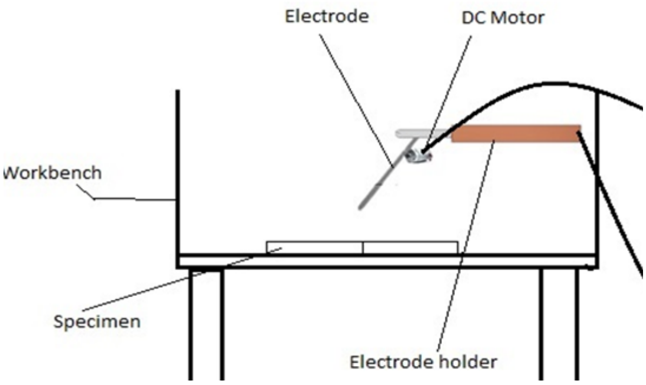

Figure: 1 Line diagram of Setup

B. Weldments preparation:

Here Arc Welding process is done to prepare weldments. But the difference is vibrations are given through the electrode and the specimen is prepared on the flat platform. In this work mild steel is selected as the work piece material. Specimens are placed on platform and power supplied to vibration setup. Test Specimen preparation line diagaram is shown in figure2.

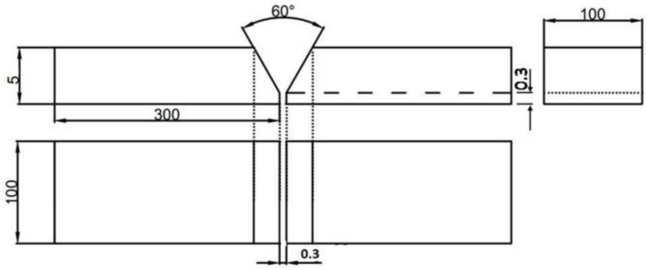

Figure2. Line diagram of work pieces before welding

III. VIBRATORY WELDING PARAMETERS

By using the vibro-meter, many frequencies and the dependent variables on the frequency are identified. A range of frequencies are identified between the operating range and the values are tabulated below table1.

Table 1 Frequencies and Dependent parameters

S.No.	Frequency (Hz)	Displacement (m)	Velocity $x10^{-5}$ (m/s)	Acceleration (m/s^2)
1	1071	0.005431	5.0760	2.691892
2	1625	0.006124	5.7951	3.182112
3	2292	0.007187	6.1758	4.025392
4	2469	0.009145	6.9795	4.12369
5	2828	0.010356	8.3754	4.29895
6	3452	0.010864	10.1943	4.376166
7	4450	0.0112364	13.5783	4.487418
8	5450	0.0118619	18.6210	4.680458

The combination of parameters chosen between voltage, current and frequencies are tabulated in

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the table below 2. These are the parameters which were chosen to work with.

Table 2: Combination of Parameters:

S.No.	DC Motor Voltage(V)	Frequency(Hz)
1.	12.80	1071
2.	12.94	1625
3.	13.08	2292
4.	13.69	2469
5.	13.97	2828
6.	15.24	3452
7.	16.19	4450
8.	17.24	5450

IV. RESULTS

A. Tensile Test

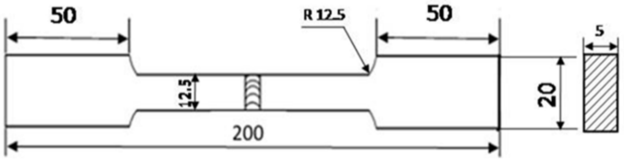

Figure. 3 Line diagram of a tensile test specimen

Tensile test is performed in UTM machine for a set of various specimens which are processed under mechanical vibration. Figure.3 and figure 4 shows the dimensions of specimens and prepared specimen respectively. The test specimen dimensions are taken from standards of ASTM D638.

Figure:4 Tensile specimen welded at 2828Hz frequency

The test specimens are perfectly arranged in the testing machine and performing the processes until it reaches the fracture. At the time of tensile force application, the gauge section elongation is noted against force applied. The readings of elongation is used for the calculation of engineering strain (ε), by the given equation.

$$\epsilon = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}$$

Where ΔL is the change in length of the specimen, L_0 is specimen original length, and L is specimen length at the end. The measurement of force is used for stress calculation σ, by the given equation.

$$\sigma = \frac{F_n}{A}$$

Where F is applied force and A is area of cross-section of section.

B. Test data

Tensile test is conducted on Universal Testing Machine (UTM) to measure the ultimate tensile strength of the vibratory welded specimens the broken specimen is shown in figure 5.

Figure 5: Tensile specimen after testing.

Total 8 experiments are conducted and the experimental data is tabulated in the table. The results showed a good improvement in the Ultimate tensile strength and Yield strength upon the use of vibrations to the electrode during welding operation. The results from the tensile test are given in the table 3 as shown below.

Table 3 : Test Results for Tensile Test

Exp. No	Frequency (Hz)	Ultimate Tensile Strength (N/mm²)	Tensile test at yield Point (N/mm²)
1	0	435.98	368.24
2	1071	454.84	392.75
3	1625	455.77	380.15
4	2292	480.19	391.62
5	2469	483.81	408.97
6	2828	490.09	411.82
7	3452	496.93	401.71
8	4450	497.71	402.95
9	5450	474.12	384.72

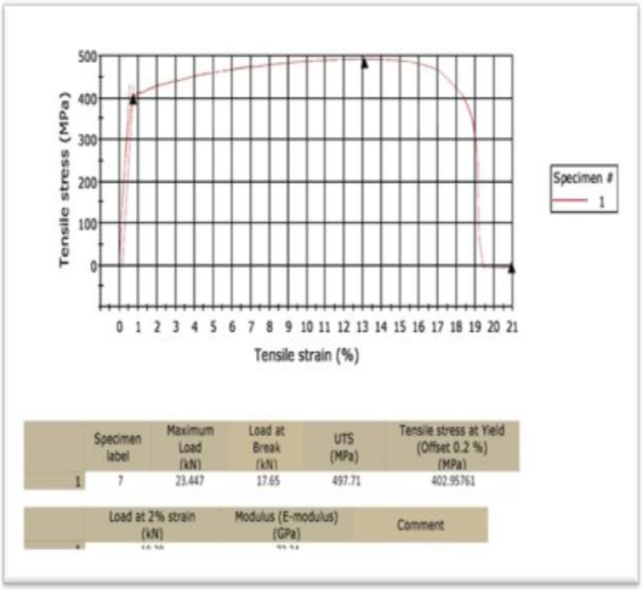

Figure: 6 Tensile test Graph at 4450 Hz Frequency

From the figure 6, it is observed that there is an enhancement in both Ultimate tensile strength and Yield strength of the specimens welded with vibration of electrode, when compared with weldments without vibration. The results showed an increse upto a frequency of 4450Hz and declined from there after.

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And a comparision graph is shown in figure7.

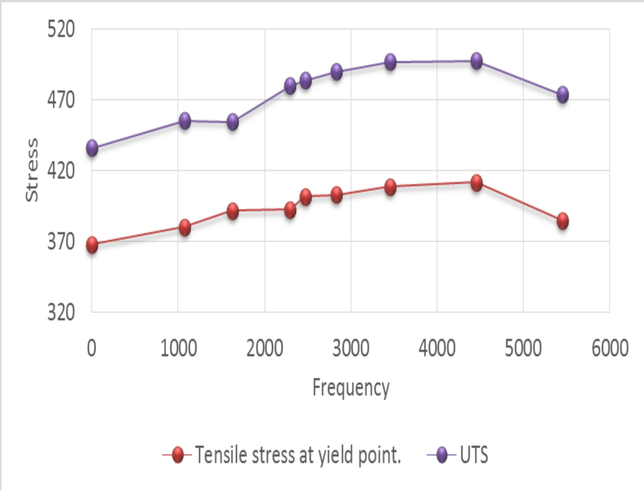

Figure 7: Variation of Tensile stress at yield point and Ultimate Tensile Stress (UTS) with respect to frequency.

V. CONCLUSION

The experiments revealed that there is a considerable effect of excitation frequency on the Ultimate Tensile Strength (UTS) of the welded specimens during mechanical vibrations and without vibrations. The tensile strength kept on increasing up to a frequency of 4450Hz and reached an optimum value and beyond this limit, the UTS value is observed to decline suddenly. The specimens welded without excitations are found to have low values of Ultimate tensile strength when compared to those welded with the assistance of electrode vibrations. The increase in Ultimate Tensile Strength is 14.16% (maximum) at 4450Hz in comparison to that of without vibrations.

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