PREDICTION OF RESIDUAL STRESSES IN WELDED JOINT UNDER MECHANICAL VIBRATION

Mr. M.C.Ingale[1] and Prof. S.I.Kolhe[2]

[1]ME Student J.T.Mahajan College of Engg Faizpur (NMU) Maharashtra.
mcingales@gmail.com
[2] Professor J.T.Mahajan College of Engg Faizpur(NMU) Maharashtra.
sikolhe@gmail.com

Abstract

Welded joints are used for construction of many structures. In this investigation vibratory stress was applied to mild steel specimens while they were being welded to observe its effect on the residual stress microstructure and hardness of the material. Residual stresses were found to decrease in response to vibration whether it was applied during welding or after welding Welding is a joining or repair process which induces high residual stress field which combines with stresses resulting from in-service loads strongly influencing in-service behavior of welded components. When compared with stresses due to service loads tensile residual stress reduces crack initiation life accelerates growth rate of pre-existing or service-induced defects and increases the susceptibility of structure to failure by fracture. Also welding residual stresses are formed in a structure as a result of differential contractions which occur as the weld metal solidifies and cools to ambient temperature. Previously some of the methods like heat treatment and peening kind techniques were used for reduction of residual stress. However those methods need special equipment and are time consuming. In this we are proposing a new method for reduction of residual stress using vibration during welding. For this Mechanical vibrations will be used as vibration load for Mild steel butt welded joints

Keywords Residual Stresses Arc Welding Vibration Vibratory weld conditioning.

1. INTRODUCTION

Welding process is one of the widely used joining and fabrication process used in industrial and structural applications. Welding residual stresses are formed in a structure as a result of differential contractions which occur as the weld metal solidifies and cools to ambient temperature. Welding processes inevitably induce a state of residual stress into materials and products. This poses a series of problems in terms of dimensional stability corrosion cracking reduced fatigue life and structural integrity. The conventional way to relieve the residual stresses is by post-weld heat treatment (PWHT) which is an effective process but it suffers from several disadvantages the cost of treatment in terms of equipment and energy is high the growth of oxide scale on the surface implies the need for subsequent . Finishing processes to remove the scale in many metals annealing relieves residual stresses at the cost of important mechanical properties and in some metals PWHT is unable to relieve the residual stresses. The use of vibration to modify welding residual stress has been reported but as yet the process has not received a detailed investigation. Residual stress remains as a single largest unknown factor in industrial damage situations. Residual stresses have a significant effect on corrosion fracture resistance creep and corrosion/fatigue performance and reduction of these stresses are normally desirable. Welding process induces high residual stress field which combines with stresses resulting from in-service loads strongly influencing in-service behavior of welded components. When compared to stresses due to service load tensile residual stress reduces crack initiation life accelerates growth rate of pre-existing or service-induced defects and increases the susceptibility of structure to failure by fracture. Residual stress in weld elements can be reduced by applying heat treatment and peening techniques. However these methods need special equipment and are time consuming. In the present project work a novel method for reducing the residual stresses using vibration during welding is proposed. For this mechanical vibrations will be used as vibration load. The plates to be welded will be held fixed and excited by an external source such as motor at lower frequencies which are closer to the natural frequency of the specimen plates. In the proposed work Residual stresses in the direction of bead is measured by using Multi channel strain indicator strain values are obtained. This method is used for assessment of welding residual stresses It is observed that when the excited frequency is closer to the natural frequency of the specimen plates the residual stresses are minimized compared to the specimen plates which are welded without any vibration.

2. PREORDINATION

1. Earlier times heat treatment and shot peening are practically used for reduction of residual stresses However those methods need special tools and time consuming.
2. In this paper a new method for reduction of residual stresses using vibrational load during welding.
3. Estimation of residual stresses nearer to weld bead in two directions (i.e. Longitudinal and Transverse direction and on the bead) as shown in figure 1.
4. Two thin plates are supported to supporting device and are butt welded by using Arc welding machine.
5. Residual stresses in the direction of bead is measured by using Multi channel strain indicator strain values are obtained.
6. These results are converted to stress values by hole drilling method later.

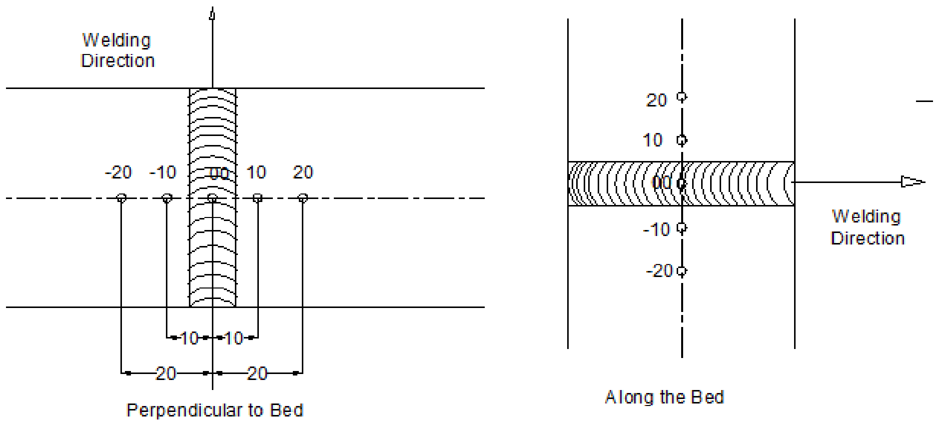


Figure1. Weld Directions on Bed for Estimation of residual stress

3. EXPERIMENTAL PROCEDURE

3.1 Test Specimen

Figure2. shows a typical specimen used in the current study of mild steel material.

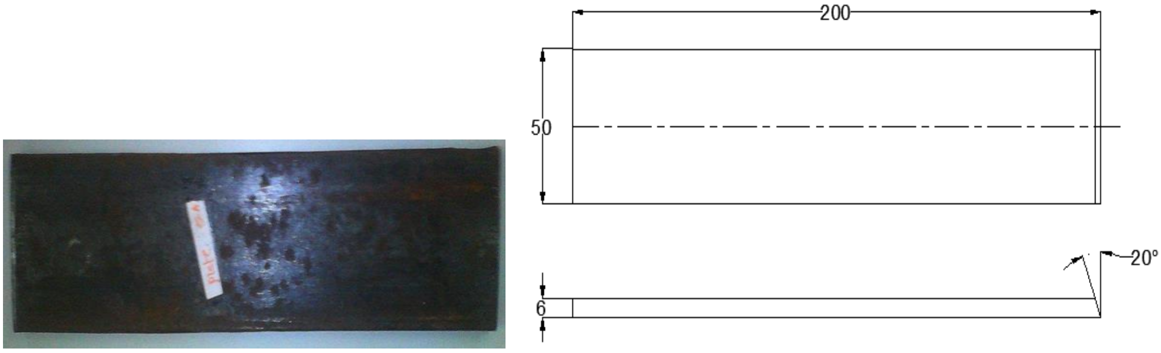


Figure. 2 Specimen piece

3.2 Experimental Setup

Figure 3(a) shows the experimental setup of the vibrator machine and welding process used for laying down the vibratory welding bead Reduction of residual stress on both sides of the specimen using vibrational load is examined experimentally.

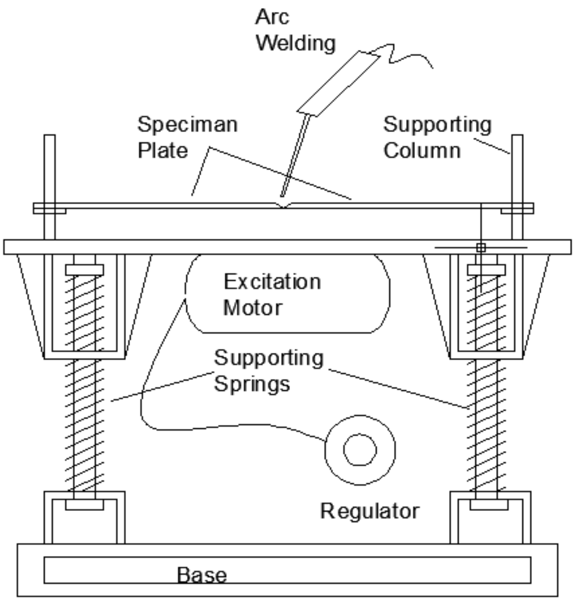


Figure 3(a) Supporting device for welding.

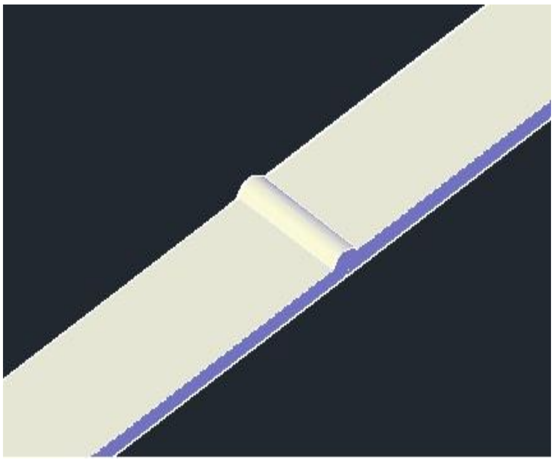


Figure 3(b) Schematic Dia. of Welding test plate

Figure3(b) shows the Schematic Dia. of Welding test specimen used in this experiment. Material of specimen is Mild steel(Is2062) Two thin plates are supported on to supporting devices by bolts as shown in figure 3(a) Specimens are vibrated by a vibromotor during welding specimens are butt welded using an arc welding machine. In order to examine the effect on excitation frequency on reduction residual stress amplitudes of excitation frequencies are chosen as 30, 35, 40 and 45Hz. The frequencies are measured by the FFT analyzer.

Size and shape of specimen made of mild steel for general structure (mm) in fig 2. With an aim of improving the mechanical properties of weld joints through inducing of favourable changes in the residual stress an auxiliary vibratory set up capable of inducing mechanical vibrations into the weld pool during manual metal arc welding is designed and developed. Different frequencies and with different amplitude are applied along the weld length just trailing behind the welding arc so that weld pool could be mechanically stirred in order to induce favourable reduction of residual stress effects. This setup produces the required frequency with the amplitude by varing the voltage of vibromotor.

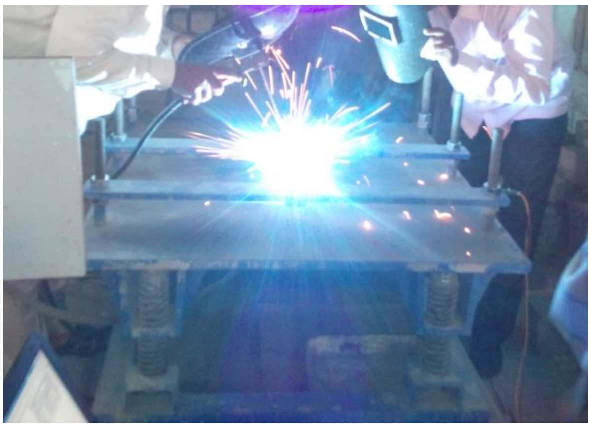


Figure 4(a). During welding

Figure 4(b). After welding

After completion of welding the specimens are taken to the multi channel strain indicator for measuring strains. In this method therefore strain gauges in the form of a three element are placed in the area under consideration. A through-thickness hole is drilled in the centre of the strain gauge. In this way the residual stresses in the area surrounding the drilled hole are relaxed and the relieved radial strains can be measured with a suitable multi channel strain gauge as shown in figure 5(a) and figure 5(b).

Fig.5(a). The strain gauges are bonded to the specimen

Fig.5 (b). Strains are measured by Multi Channel Strain Indicator

3.2.1. The hole drilling strain gage method

There are many situations where X-ray diffraction is not useful for measuring residual stresses. These include non-crystalline materials large grained materials nanomaterials textured or heavily deformed metals. In these cases other mechanical methods such as the hole-drilling method is used. The hole-drilling method (ASTM Standard E837) relies on stress relaxation when a hole is drilled into the canter of a strain gage such as that shown in figure 5(a). When the material is removed by drilling the extent of the strain relief is monitored by the gages and the direction and magnitude of the principal stresses can be calculated. A drill (shown above) is used to first locate the drill at center and then to remove material to a controlled depth. At each depth increment the strain relief on each of the gages is measured and converted into stress. As subsequent material removals occur the stress distribution as a function of depth can be estimated. The hole drilling method is used in those situations where the residual stress is relatively uniform over the drilling depth. Thus it is not intended for situations where the residual stress is superficial. The accuracy of the hole drilling method is directly related to the ability of locating the hole accurately in the center. In practice the location accuracy is better than this so the overall accuracy in residual stress measurements is quite good. The hole drilling strain gage procedure is

1. Install a special three to six strain gage at the point where stresses are to be measured.
2. Wire the strain gages to a static strain indicator.
3. Attach and accurately position a drilling device over the target at center.
4. Balance the gage circuits.
5. Drill hole in increments being careful not to generate heat that would induce residual stresses.
6. Record strains after the strain indicator has stabilized.
7. Calculate stresses using strain data. Manual calculation of residual stresses from the measured relaxed strains can be quite burdensome, but there is available a specialized computer program H-DRILL that helps to measure the residual stress.

From the above experimental procedure through the multi channel strain indicator the following are the observations of residual stresses values are shown in tables and graphs.

First Side Perpendicular to bed (MPa)					
Distance	Without	30Hz	35Hz	40Hz	45Hz
+20	92	42	61	17	76
+10	120	72	89	31	87
0	250	151	225	43	212
-10	120	72	89	31	87
-20	92	42	61	17	76

Table1.Residual stress values at different frequencies at first side perpendicular to the bead

.

First Side along the bed (MPa)					
Distance in mm	Without	30Hz	35Hz	4 Hz	45Hz
+20	43	39	57	22	95
+10	52	43	62	35	122
0	89	96	67	49	175
-10	52	43	62	35	122
-20	43	39	57	22	95

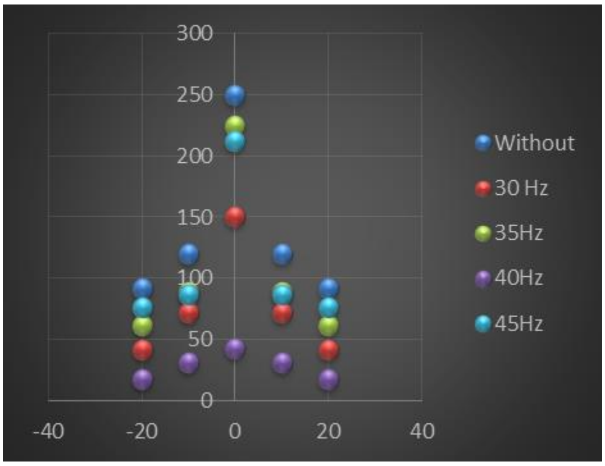
Table 2.Residual stress values at different requencies at first side along the bead.

Second Side Perpendicular to bed (MPa)					
Distance in mm	Without	30 Hz	35 Hz	40 Hz	45 Hz
+20	130	89	115	65	145
+10	208	105	199	95	205
0	283	262	190	142	309
-10	208	105	199	95	205
-20	130	89	115	65	145

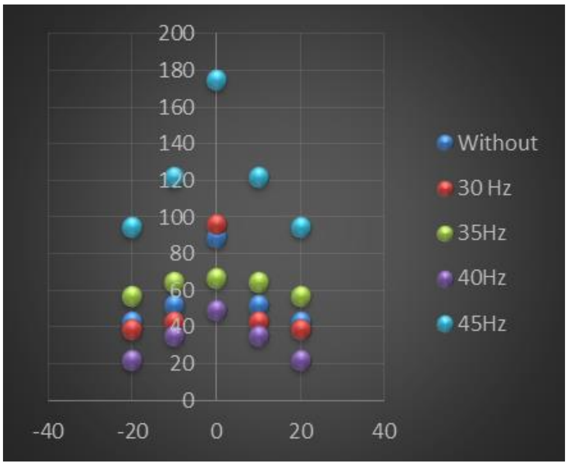
Table 3.Residual stress values at different frequencies at second side perpendicular to the bead.

Second Side Along the bed (MPa)					
Distance in mm	Without	30Hz	35 Hz	40Hz	45 Hz
+20	415	255	264	156	298
+10	430	262	275	163	378
0	485	288	295	180	402
-10	430	262	275	163	378
-20	415	255	264	156	298

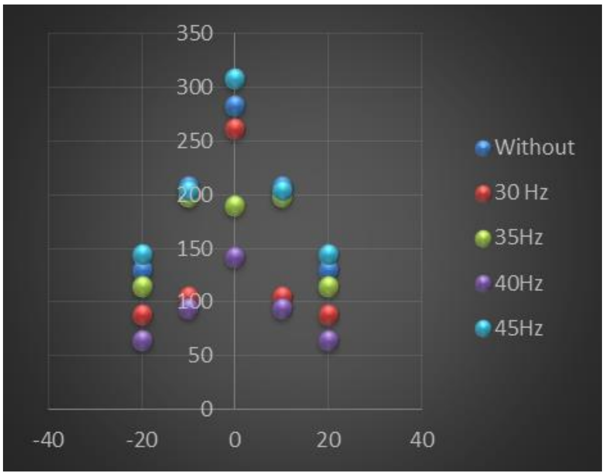
Table 4.Residual stress values at different frequencies at second side along to the bead.



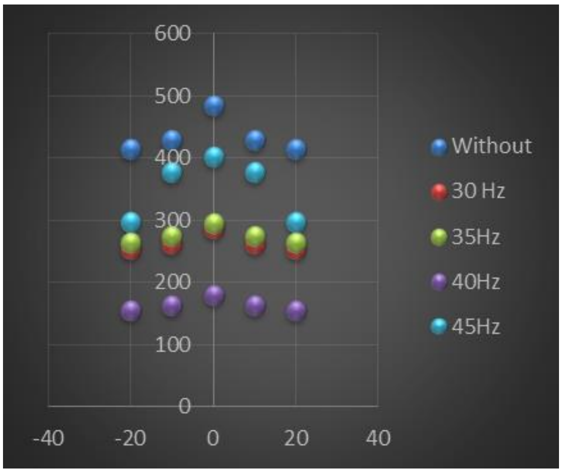
Graph 1.Residual stress values at different frequencies at first side perpendicular to the bead



Graph 2.Residual stress values at different requencies at first side along the bead.



Graph 3.Residual stress values at different frequencies at second side perpendicular to the bead.



Graph 4.Residual stress values at different frequencies at second side along to the bead.

4. CONCLUSION

A new method for reduction of residual stresses vibrational load during welding is proposed. The proposed method is examined experimently for some conditions. Two thin plates are supported on the supporting device and butt welded. For the frequencies between 30Hz to 45Hz experimentation was performed and it is found that residual stresses are greatly reduced at frequency of 40Hz. It is observed that weld bead quality of the specimen welded nearer to natural frequency was good compared to other specimen plates. Hence it can be concluded that the residual stress can be greatly reduced by maintaining frequency of forced vibration nearer to the natural frequency of the specimen and increasing the welding speed.

5. REFERENCES

1. A S M Y Munsi. 2011, The effect of vibratory stress on the welding microstructure and residual stress distribution. *Journal of Materials Design and Applications Proceedings of the IMechE* Part L 215 (2). pp. 99-111. ISSN 1464-4207

2. Tewari S. P. and Shanker A.1993, Effect of longitudinal vibration on the mechanical properties of mild steel weldments. *roc. Instn Mech. Engrs Part B Journal of Engineering Manufactur* **207**(B3) 173–177.

3. G.Ramkrishna.2013, Finite Element Analysis of Residual Stresses in Welded Joints Prepared Under Influence of echanical Vibrations, *International Journal on echanical Engineering and Robotics (IJMER)* , Volume-1 Issue-1, ISSN (Print) 2321-5747

4. Ch. Anil Kumar, 2013 A finite Element analysis of residual Stresses of welded joint through mechanical vibration *International Journal of Mechanical and Production Engineering (IJMPE)*, Vol-2 Iss-1. ISSN No. 2315-4489.

5. Shigru Aoki ,2005. Reduction method for residual stresses weld joints using Harmonic vibrational load, *Nuclear Engineering* " design 237

6. Liyajialg and Wang Juan, 2004. Finite element analysis of Residual stress in the welded zone of a high strength steel, *Indian Academy of sciences*. Vol 27 pp.127-132

A Brief Author Biography

***1st Mr. M.C.Ingale* -** ME Student ,J.T.Mahajan College of Engg. Faizpur (NMU), Maharashtra.
Email- ID - mcingales@gmail.com

2nd Prof. S.I.Kolhe - Professor , J.T.Mahajan College of Engg. Faizpur(NMU), Maharashtra.
Email- ID - sikolhe@gmail.com