

Effect of Vibration on Macro and Micro Properties of SMAW Weldment

M.Saravanan¹ D.Praveen Kumar², K.Naveen³

Assistant Professor & Head, Department of Mechanical Engineering, Cauvery College of Engineering & Technology,
Trichy, Tamil Nadu, India,¹

Assistant Professor, Department of Mechanical Engineering, Cauvery College of Engineering & Technology, Trichy,
Tamil Nadu, India,²

Assistant Professor, Department of Mechanical Engineering, Cauvery College of Engineering & Technology, Trichy,
Tamil Nadu, India,³

ABSTRACT: Welding process induce a state of residual stress into materials and jobs . This poses a series problems in terms of dimensional stability , corrosion cracking , reduced fatigue life and structural integrity. Thermal cycle produced near weld line generates residual stress and inhomogeneous plastic deformation in weldment. Understanding the grain nucleation and grain growth is very necessary as they are highly influenced under welding condition. After completion of nucleation the solidification process will continue with nucleus growth.

A number of methods utilizing external forces have been applied to induce fluid flow during solidification of weldment. These include electromagnetic stirring , mechanical vibration etc. Vibratory conditioning commonly called as vibratory stress relief uses mechanical energy in the form of low and high frequency vibrations to relieve residual stresses in weldments. VSR , in essence , a vibrating device to induce vibration at the natural resonant frequencies of the structure treated. The induced frequency is varied until it coincides with one of the natural frequencies of the structure when resonance occurs. With vibratory weld conditioning, the enhancement of weld metal microstructure can be achieved. The mechanical properties, level of residual stresses and deformation can also be affected. Structural changes of the welds prepared under vibratory conditions affects the mechanical properties of the welds. The vibration during welding benefits energy absorbed in impact toughness test of weld metal and improves fracture behavior.

I. INTRODUCTION

Austenite chromium - nickel stainless steel are most widely used stainless steel. While resistance to corrosion is chief attribute of these steels ., they may be selected for their low magnetic permeability , good temperature strength and excellent toughness at low temperatures. Types 304 represent the so called – “18 – 8” stainless steel. The microstructure of steel is largely modified and positively influenced by heat treatment resulting in recrystallization and homogenization of segregation and elimination of harmful precipitates. In case of welding such possibilities are rather limited since welded components can in rare instances be affected by heat. Therefore the structure of welded metal is considerably less homogeneous than the parent metal. Fluidity is one of the most important factors in welding processes . Fluidity is the ability of a melt to flow and fill very narrow spaces as in the case of welding where the clearance between the work pieces is normally between two millimeters to three millimeters. It was found that by applying external forces , fluid flow during solidification can be improved which results in refinement of grain size which eventually enhances the mechanical properties. In AISI 304 stainless steel , the existence of one γ - austenite is normal . However the weld always contains residual δ - ferrite results from micro segregation during solidification. The δ - γ transformation normally occurs quickly during welding producing dendrite growth and segregation . Therefore observing the residual δ - ferrite is useful for understanding the difference between solidifying process in vibration welding.

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II. EXPERIMENTAL PROCEDURES

FIGURE 1 EXPERIMENTAL SETUP



AISI 304 specimen used for this research comprises of 6mm thickness plate , 8mm thickness plate and 10 mm thickness plate. The size of the AISI 304 specimen used were 300 x 150 and the each thickness consists of three specimen. The welding method used in this study is shielded metal arc welding and the electrode used was SS 304 . The welding current was 60A and the voltage used were 85V , the traveling speed was 126mm/ min .The diameter of the electrode used was 3.14mm. The frequency was maintained at 100Hz during vibration welding . The specimen was first subjected to edge preparation . The edges were beveled to an angle 30° in a shaping machine. Single V groove is maintained in all the specimen. There were totally fourteen specimen pieces and two plates are paired together to give seven pairs. The steel pieces with smooth and uniform bevels were cleaned of oxides, rust grease and paints by sand grinding. The cleaned

FIGURE 2 cross sectional view of plain weld



FIGURE 3 cross sectional view of vibratory weld



pieces were swabbed in water and dried in hot air. Further the paired steel pieces with smooth and uniform bevels were tack welded together with a root gap of 2mm. The tack welded pairs were marked as specimen 6P 01 , 6V 01, 6 V02, 8V 01 , 10 P 01, 10 V01 10 V 02 where in P represents the specimen welded without vibration and V represents the specimen welded under vibratory condition. To start with all the specimen were root welded in vertical position without

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any vibration. At the end of root weld the weldment was subjected to dye penetrant test and any surface defects were removed by grinding. Next one specimen in 6mm and 10mm plate were welded completely in vertical position without any vibration. This for the reference purpose. The macro and micro properties of the specimen in which the welding is carried out under vibratory condition is compared with the values so obtained for specimen welded without any vibratory condition. Next one specimen in each of the thickness is welded under the vibratory condition under the frequency of 100 Hz and at the maintaining the amperage of 65A. Subsequently another remaining specimen in 6mm and 8mm were welded under vibratory condition with the same frequency but altering the ampere to 80A . The change in amperage will result in change in the welding speed. It was observed that the 6mm thick plate required one root pass and another finish pass. On the other hand 8mm and 10mm plates required in addition to one root pass another two passes for finishing. At the end of each of pass weldments were subjected to dye penetrant test and defect were removed.

FIGURE 4 Dye penetrant testing



Composition of electrode:

The electrode is SS 308L and the chemical composition of the electrode is

Composition	Cr	Ni	Mn	Si	P	C	S
Percentage	19.5-22	10-12	1-2.5	1	0.045	0.03	0.03

Technical specification:

AWS A 5.4E 308L/ 16 electrode:

Low carbon rutile coated austenitic stainless steel electrode with approximately 8% ferrite.

Base metal details:

The base metal used is AISI 304 and the chemical composition is as follows:

Composition	C	Mn	Si	P	S	Cr	Ni	N
Percentage	0.08	2..0	0.75	0.045	0.03	18	8.0	0.10

III. RESULT AND DISCUSSIONS

(i)Micro structure:

FIGURE 5 weld bead under plain welding



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The micro and macro properties of the weld carried out with vibration and without vibration . The morphology of the weld bead without vibration and with vibration is studied. The cross section of the vibration less welding showed a flat surface with its axis unsymmetrical . On the other hand the cross section of the welding carried out under vibratory condition has a cup like structure with its axis symmetrical. Similarly the microstructure of the weld bead for vibration shows a fine structure whereas the microstructure of the plain welding shows a coarse grain structure. The dendrite arm of the weld bead with vibration is shorter whereas the dendrite arm of the plain welding is longer, thick and bigger in size. The size of the dendrite arm in vibration welding is $4\mu\text{m}$ - $5\mu\text{m}$ on the other hand for the vibration less welding it is $10\mu\text{m}$ to $12\mu\text{m}$. The reason for this phenomenon is under vibration welding the increase in the amount of nuclei has restricted the dendrite growth which resulted in a fine grain . In case of plain welding super cooling of liquid metal significantly decreased under vibration.

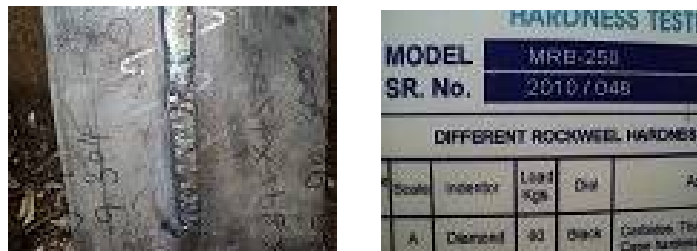


FIGURE 6 weld bead under vibration welding

Macro properties:

With respect to macroscopic properties of the vibration welding ,the tensile strength and impact strength showed a marked improvement over the plain welding. The tensile strength of the vibration welding is approximately 26% more and the impact strength is approximately 18% more .Similarly the hardness of the vibration welding is slightly more than the plain welding but the hardness is uniform over its length on the other hand plain welding shows variation in the hardness across its length. The penetration level under vibration welding is very impressive and the fusion of weld specimen is also very impressive under vibration welding.

IV. CONCLUSION

- (i)Dendrite arm of the δ - ferrite is very short and fine under vibration welding because the constitutional supercooling was decreased by vibration.
- (ii)There is a substantial improvement in the tensile properties , impact properties and hardness distribution in the vibration welding .
- (iii)Due to auxiliary mechanical vibrations long dendrites break and forms a new nucleation sites.

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