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Investigate the Influence of Mechanical Vibrations on the Hardness of Al5052 Weldments

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Abstract

Objectives: This paper presents the influence of vibratory Tungsten inert gas welding on the hardness of aluminum 5052-H32 alloy weldments are studied. **Methods/Statistical Analysis**: Hardness of Al5052-H32 is analyzed for different voltage inputs keeping other parameters like welding current, welding speed and gas flow rate constant. **Findings**: Hardness values are compared for the specimens prepared with vibrations and without vibrations. Hardness of Al5052-H32 specimens prepared at 160 V input voltage is more compared to the specimens prepared at 70 V, 230 V and without vibration. There is a decrease of hardness value is observed for specimens prepared at 230 V compared to the specimens prepared at without any vibrations.

Keywords: Aluminum 5052-H32, Grain Refinement, Hardness, Tungsten Inert Gas Welding, Vibratory Welding

1. Introduction

Welding is widely used for construction of many structures. Tungsten Inert Gas Welding is widely employed in welding of almost all the metals as it produces the finest quality of welded joints. Even though GMAW produces a good quality of welds the generated thermal cycles along the weld line induces the considerable amount of residual stresses. The main reason for the development of residual stresses is non-uniform temperatures maintained in different regions of the weldments. It causes the distortion of the weldments. These residual stresses adversely affect the mechanical properties of the welded joints which greatly influence the service capability of the welded joints.

Vibratory Welding (VW) is a non-thermal method for enhancing the mechanical properties of welded joints. In this, a periodic energy is given to the specimen during welding. This periodic energy influences the pool of weld, in such a way that grain structure will be refined. This refined grain structure enhances the weld joint mechanical properties. In vibratory welding, vibration energy is introduced to the component at different amplitudes and can be successfully applied to the specimens during welding. To best of knowledge, this technique has been employed to weld the mild steel specimens using the Manual Arc Welding process.

In this, the Vibratory TIG Welding technique has been implemented for welding of Aluminum 5052-H32 alloy. The property, hardness of welded joints is analyzed for the different input voltages of vibromotor keeping other parameters like welding speed, gas flow rate and welding current as constant.

Residual stresses near the weld bead reduce fatigue strength. A new technique[1] was proposed during welding to reduce the residual stresses. In this, two kinds of random vibrations are used one is white noise method contains all frequency components, and the other is filtered white noise in which the specimen is vibrated with fundamental natural frequency of the specimen. In[2] found that random vibration during welding reduces the tensile residual stresses. Another mode of vibration to

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reduce the residual stresses is harmonic load. By means of giving a vibration load of 20, 30 and 40 Hz to the rolled steel and high tensile strength steel, authors are able to reduce the residual stresses near the bead using harmonic vibrational load.

In[3] found that the microstructure, residual stresses and hardness is influenced by the vibratory stress. Vibratory treatment influences the crystal structure compared to the post weld vibratory treatment. Hardness is improved in high amplitude vibrated specimens. In[4] observed the formation of refined grain structure, relief of residual stresses in the welding of 304 stainless steel with eccentric circulating vibrator and magnetic telescopic vibrator at resonant frequency. Hardness values were increased in vibration welding due to grain refinement.

Dynamic hardening innovation technique was proposed[5–14] to prompt the mechanical vibrations amid welding of butt welded joints. It was presumed that butt welded joints arranged under vibratory conditions had high hardness with no loss of its ductility. Authors utilized the vibratory setup to affect the mechanical vibrations to the weld pool amid welding. Because of vibratory welding process, change of mechanical properties was observed. It was inferred that the refined microstructure component was in charge of the change of impact strength, tensile strength, flexural strength and hardness of butt welded joints of mild steel plates. Authors observed that post weld vibratory treatment will not influence the crystal structure, the increase in all properties are related to the crystal structure only. General Regression Neural Network Technique (GRNN) based tool was developed for estimating impact strength, flexural strength and hardness for given input parameters.

MIG welding was performed on AA6061. Influence of properties like fatigue life, impact energy and bead penetration by the welding current, arc voltage and bead penetration are studied[15]. With the increase in heat input the fatigue life was decreased but impact energy first increases then it decreases. Increase in voltage and welding current leads to the increment of depth of penetration. Heat effected zone was studied for choosing the appropriate and shielding gas and nozzle gas in plasma arc welding[16]. Simulate the aluminum temperature field and thermal profile in laser welding process. Observed that with the increase in spot size the penetration depth increases to maximum and then decreases[17]. Authors in[18] show that using pulsed current tungsten inert gas welding improves the micro hardness and tensile strength with the optimized peak current, base current pulse on time and pulse frequency.

2. Experimentation

The samples of Al5052-H32 with dimensions of 300 mm X 120 mm X 5 mm of double V-joint are prepared for the welding. Then the cleaned samples are clamped on the work Table 1. The working condition is set to 130 A welding current and vibro motor input voltage as 70 V. The welding of the specimen is done on its first side when it is under the continuous vibration. Then it is cooled in the atmospheric air for some time. At the same voltage the second pass is run on the other side of the work piece. The weld specimens are also prepared at 160 V, 230 V of vibromotor input voltages and for without vibrations.

Table 1. Values of frequency, acceleration and amplitude values for different voltage input to the vibromotor

S.No	Voltage of vibromotor (Volts)	Frequency (Hz)	Acceleration (mm/sec^2)	Amplitude (mm)
1	70	815	18.39	0.351
2	160	1035	32.7	0.492
3	230	1202	49.29	0.564

3. Results and Discussion

After completion of welding, the welded specimens are tested for the hardness along the bead using Rockwell Hardness Tester according to ASTM standards for hardness measurement ASTM E18. Different points along the weld bead are marked at specified distances. Hardness is measured at the points along the weld bead. Figure 1 shows the measurement of hardness on Rockwell hardness Tester. Figure 2 and 3 shows the graphs of Rockwell hardness values of different voltages along the bead on first side and second side respectively. Values of hardness of Al5052-H32 on the first side of the specimen is shown in Table 2, Values of hardness of Al5052-H32 alloy specimens measured on second side is shown in Table 3 at different voltages along the weld bead.

Figure 1. Hardness measurement along the bead.

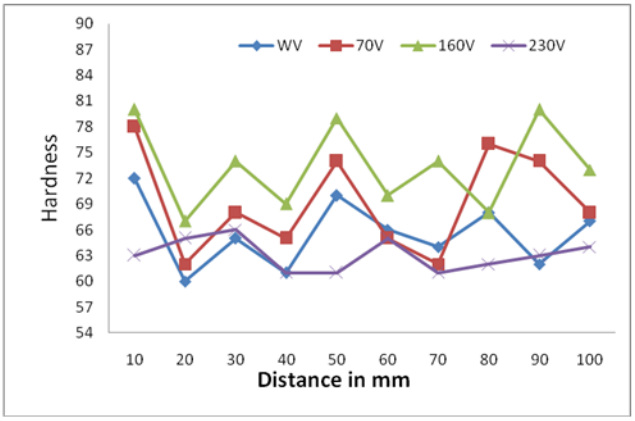

Figure 2. Hardness on first side.

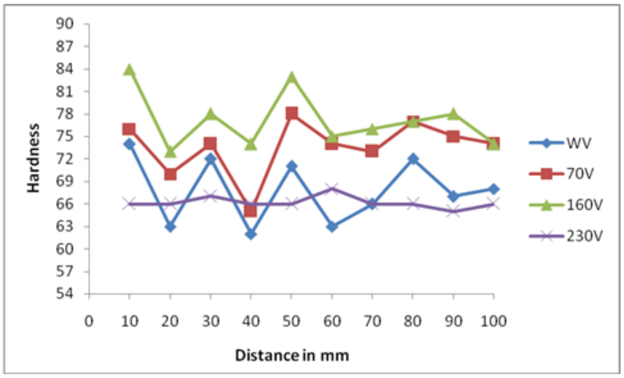

Figure 3. Hardness on second side.

Table 2. Values of hardness measured on first side along the weld bead at different voltages

	Hardness			
Distance	WV	70V	160V	230V
10	72	78	80	63
20	60	62	67	65
30	65	68	74	66
40	61	65	69	61
50	70	74	79	61
60	66	65	70	65
70	64	62	74	61
80	68	76	68	62
90	62	74	80	63
100	67	68	73	64

Table 3. Values of hardness measured on second side along the weld bead at different voltages

	Hardness			
Distance	WV	70V	160V	230V
10	74	76	84	66
20	63	70	73	66
30	72	74	78	67
40	62	65	74	66
50	71	78	83	66
60	63	74	75	68

4. Conclusions

From the Rockwell hardness testing results, hardness of the Aluminum 5052-H32 is more for the vibratory TIG welding at 160 V input voltage when compared to without vibration, 70 V and 230 V. At 230 V, porosity is suddenly increased due to the over excitation of specimens. This over excitation leads to sudden increase of arc gap which in turn reduces the hardness at the weld bead region. Hardness of Al 5052-H32 is more at 160 V is due to the fine grain structure at the vibratory weld bead region. Finally, this paper concludes that the hardness of welded joints produced at 70 volts and 160 volts of vibration is increased at the rate of 5.03% and 12.36% respectively, when compared to welded joints produced without vibration. But, when compared with vibration at 230 V there is a decrease of hardness about 4.13% compared with without vibration. This is because of the over excitation in terms of higher amplitudes of specimens.

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