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EFFECT OF FREQUENCY ON IMPACT STRENGTH OF DISSIMILAR WELDMENTS PRODUCED WITH VIBRATION

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ABSTRACT

This paper presents the effect of vibratory dissimilar TIG (Tungsten Inert Gas) welding process on impact strength of welded joins with respect to change of frequency of specimens to be welded. In this study, new vibratory setup has been developed with two metal engravers for inducing mechanical vibrations to the specimens to be welded. Finally, analyze the effect of vibration frequency on impact strength of welded joints.

Key words: Vibratory welding, Tungsten inert gas (TIG) welding, Frequency, Impact strength, Vibratory setup and metal engravers.

INTRODUCTION

To overcome the disadvantages in normal welding process, vibratory assisted welding has been introduced for improving mechanical properties of welded joints. In vibratory welding, a force is applied periodically to the specimens during welding process. Due to this periodic force, weld pool is stirred to refine the grain structure in order to enhance the weld joint properties.

Lu et al.[1] made an attempt to increase the quality of full welded valve by the application of vibratory weld conditioning (VWC). Welded joint properties have been studied by the influence of VWC. Cylinders with different thicknesses have been welded by submerged arc welding (SAW). The experimental values depicted that the mechanical vibration given during welding decreases the residual deformation and stress. The yield strength, as well as the tensile strength, does not change specifically in vibratory SAW (V-SAW) when compared with that in normal SAW (N-SAW). The bend property has been

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improved in V-SAW. Fracture test was carried out using single edge notch bend (SENB) specimens. The fracture surfaces of failed weld metal (WM) specimens are characterized by dimple-like structures. The depth and the density of these dimples are increased after the vibration applied in welding. River marking, the characteristic of cleavage fracture, is observed in the heat-affected zone (HAZ) specimens[2]. Stress concentrations usually occur at structural geometry discontinuities, e.g. weld toes, and crack like defects. These stress concentration sites may serve for crack initiation and cracks that are propagating may lead to failure.

Rao et al.[3] developed a new vibratory welding technique for giving mechanical vibrations into the weld pool during welding process. The designed vibratory setup produces the required vibrations at frequency with the amplitude and acceleration in terms of voltages. An increase in the flexural strength, impact strength, ultimate tensile strength and hardness of the weld pieces at the heat affected zone (HAZ) is observed. The increase in mechanical properties is attributed to, as the weld pool solidifies, grains are not only limited in size but also dendrites are broken before they grow large in size and forms refined microstructure. This mechanism is responsible for the improvement in flexural strength, ultimate tensile strength, impact strength and hardness of welded joints. From the experimental results it is clear that the mechanical properties are improved considerably with the increase in the acceleration and amplitude of the specimens. Mechanical properties are improved with rise in the input voltage and vibration period. Munsi et al.[4] investigated the influence of vibratory treatment on the fatigue life of welds by comparing with thermal stress relief.

Jijin et al.[5] compared VWC and normal submerged arc welding of multi pass girth-butt welded pipes. They found that VWC can reduce the residual hoop stresses at the outer surface and the radial distortion significantly. Liu et al.[6] addressed vibration responses of railway steel bridge considering welding residual stress based on a reasonable heat source model. Aurimas et al.[7] investigated the effects of vibration energy input on stress concentration in weld and Heat Affected Zone of S355J2 Steel and observed that by re-distributing the internal residual stress of welded structures, stress concentration can be reduced effectively. Rao et al.[8] used the vibratory setup to induce the mechanical vibrations to the weld pool during welding. Due to vibratory welding process, improvement of mechanical properties was observed. It was concluded that the refined microstructure mechanism was responsible for the improvement of impact strength. Rao et al.[9] designed a vibratory set up to induce mechanical vibrations into the weld pool during welding. As the weld pool solidifies, vibratory set up produces the mechanical vibrations. Due to this dendrites were broken up into smaller grains, which lead to the improvement of flexural strength of welded joints. Govindarao et al.[10] employed a dynamic solidification technology to induce the mechanical vibrations during welding of butt welded joints. It was concluded that butt welded joints prepared under vibratory conditions possessed high hardness without any loss of its ductility.

Based on the past literature most of researchers have concentrated on improvement of mechanical properties of vibratory welded joints for similar metals. So that authors made an attempt to weld dissimilar plates by vibratory TIG welding process for observing impact strength of weldments with respect to change of frequency of specimens to be welded.

EXPERIMENTAL

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the welded joints. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. A constant-current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas and metal vapors known as a plasma. GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques. A related process, plasma arc welding, uses a slightly different welding torch to create a more focused welding arc and as a result is often automated.

Materials used

Mild steel and Stainless steel plates with 5 mm thick have been used for vibratory TIG welding process. Mild Steel (Grade 1018 M S) is composed of (in weight percentage) 0.18% Carbon (C), 0.6-0.9% manganese (Mn), maximum 0.04% Phosphorus (P), maximum 0.05% Sulphur (S) and the base metal iron (Fe). Stainless steel (Grade 304 S S) is composed of chromium (Cr) ranging from 18-20%, Nickel(Ni) ranging from 8-10.5 % and carbon 0.08%. Filler material (Grade ER 309L) is composed of carbon 0.032%, manganese 1.26%, Silicon 0.65%, phosphorous 0.028% and Sulphur 0.012%.

Vibratory welding setup

Fig. 1 shows new vibratory welding setup, on which TIG vibratory dissimilar welding has been carried out for different frequencies of 600, 800 and 1000 Hz.

Fig. 1: Front view of vibratory welding setup

This setup consists of two metal engravers as shown in Fig. 1, transfers vibrations to specimens during welding. Metal engravers are worked on the principle of electro-dynamic force, which coverts electrical signals in to mechanical vibrations. Frequency of specimens can be adjusted by the rotation of knob provided on the metal engraver, which is shown in Fig. 2.

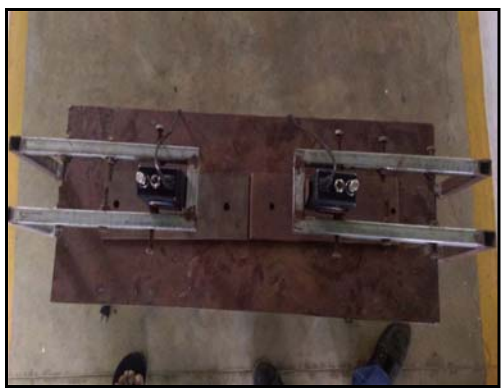

Fig. 2: Top view of vibratory welding setup with specimens ready for welding

Frequency of specimens can be adjusted from 600 to 1000 Hz, but if the frequency is exceeds 1000 Hz, welding cannot be possible because of over excitation of specimens. Below table shows amplitude and acceleration with respect to frequency of specimens. These vibration parameters have been measured by vibration tester. Table 1 shows acceleration and amplitude of specimens to be welded with respect to frequency. Frequency, amplitude and acceleration of specimens have been tested by vibration tester. Fig. 3 shows dimensions of mild steel and stainless steel plates for butt welding.

Table 1: Frequency, acceleration and amplitude of specimen

S. No.	Frequency (Hz)	Acceleration (mm/sec^2)	Amplitude (mm)
1	600	15.41	0.235
2	800	27.34	0.324
3	1000	40.29	0.425

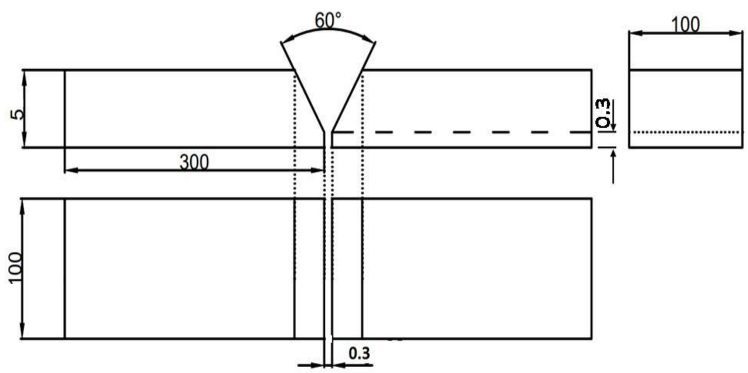

Fig. 3: Dimensions of stainless steel and mild steel plates for welding

Fig. 4 shows TIG welding has been carried out with mechanical vibrations.

Fig. 4: TIG welding during vibrations

RESULTS AND DISCUSSION

After vibratory TIG butt-welding process, impact strength has been measured for welded joints produced with three different frequencies of specimens. Impact strength of welded joints is increased with respect to increase in frequency of specimens. Fig. 5 shows dimensions of Charpy impact test specimen according to ASME standards. Table 2 shows impact strength values with respect to frequency of specimens. Fig. 6 shows specimen ready for impact test. Fig. 7 shows specimens after impact testing, further specimens made at without vibration, 600 Hz are fractured completely, but at 800 Hz and 1000 Hz specimens are bent without fracture. This is due to increase in impact strength and ductility with respect to increase in frequency. Fig. 8 depicts weld joint impact strength values with respect to frequency of specimens.

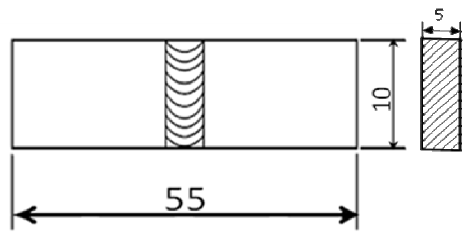

Fig. 5: Dimensions of impact test specimen

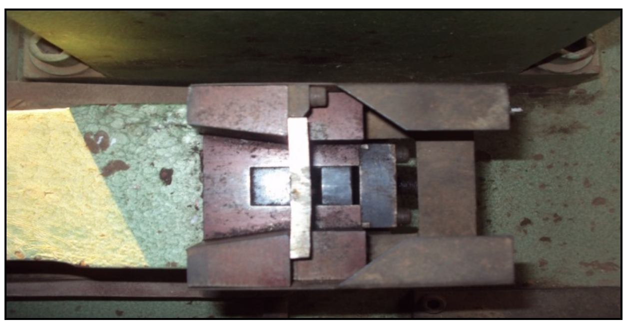

Fig. 6: Specimen ready for impact test

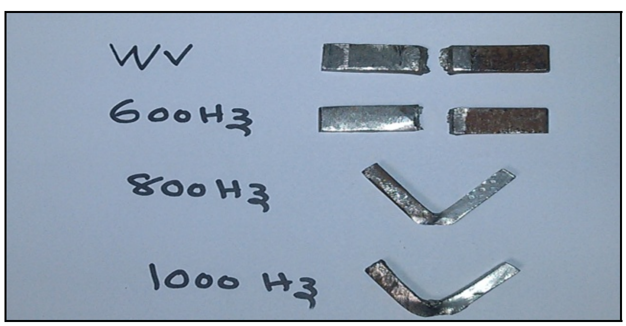

Fig. 7: Specimens after impact testing

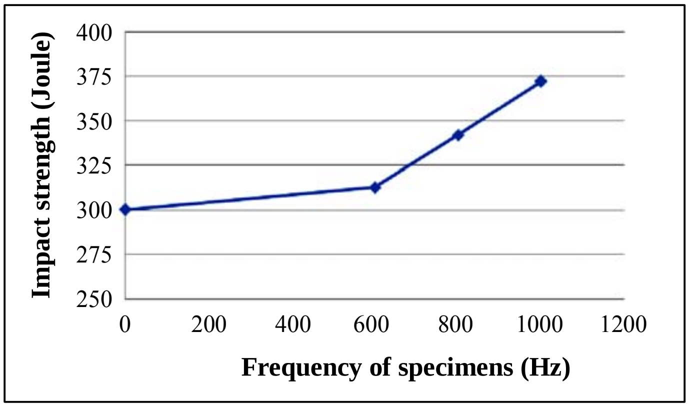

Fig. 8: Impact strength with respect to frequency of specimens

CONCLUSION

In the present study, welding of specimens has been done along with different frequency of vibrations during welding. Impact strength of welded joints is increased with respect to increase in frequency of specimens to be welded. Based on the past literature, this is due to the fragmentation of long dendrites in to small dendrites and better filler metal distribution, which leads to fine grain structure, is attained at the weld bead region.

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