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Research Article

The Effect of Changes in the Traversal and Rotational Velocities on the Microstructure of Aluminum based Composites Reinforced with %20 Sio_2 Particles in Friction Stir Welding

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Abstract

In this study, we evaluated the microstructure and mechanical properties of friction stir welded composite base aluminum with 20% sio2 particles. One of the most effective parameters on microstructure and mechanical properties in the welding zone of friction stir welding (FSW) is Rotational velocity and forward motion of the non-consumable tool which the major factors affecting the rate of input heat in the process. in this research, effect of changes in rotation speed and progress of welding tool on the microstructure and mechanical properties of aluminum base composite reinforced with 20% sio2 particles was prepared by stir casting has been studied. Finally, it was found that reducing the welding step in this procedure will cause defects in the weld. Experimental results were confirmed optimum rotation speed and forward velocity of the welding tool.

Keywords: Friction stir welding; Aluminum based composites; welding step

I. Introduction

In recent years, the growing needs for high quality materials in the automotive and aerospace industries, Development of lightweight alloys especially aluminum alloys and their composites have become inevitable. Aluminum matrix composites because of the light weight, high strength, high specific modulus, good wear resistance, low coefficient of thermal expansion as new engineering materials have been special considered. Mainly due to the high price of the finished composite products are limited to specific industries such as aerospace and military industries. Recently, aluminum matrix composites in automotive parts such as piston engines, cylinder and disc brakes have been used. Different techniques have been used to fabricate aluminum matrix composites which most of them to be powder metallurgy techniques or stirring casting (Eddy) method Noted. Here, due to the availability and cost effective of method of stirring casting, special attention has been considered (J.P.Lucas et al., 1991; A.R.Kennedy, 2002; A.R.Kennedy

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et al., 2001; K.M.Shorowordi et al., 2003). Among the factors determining the mechanical properties of aluminum matrix composites fabricated by stirring casting, the particle distribution in matrix and defects such as gas pores, shrinkage cavities and being of oxide films in microstructure that can have opposite effect on the mechanical properties. However, FSW aluminum alloys especially are used for alloys which could not welded by fusion methods. FSW tool consists of two important non-consumable pin and pin shoulder. Pin in contact with the surface during rotation of the tool resulted to generates heat, and due to rotational motion of the pin junction, materials undergoes serve deformation at high temperatures, Thus, along with the loss of seam binding, recrystallization occurred in the area and very fine and Coaxial grains are formed in the region.

In this method, the welding is done in the solid state. There are not solidification defects such as voids, porosity and hot cracking which abundant in fusion welding methods. Tool geometry, tool rotational speed (ω), the forward speed (v) and forging force are important parameters affecting the pattern of materials flow and distribution of temperatures (R.S. Mishra et al., 2005). At friction stir welding, both turbulent and intermediate region are formed at adjacent base metal. Alloys have been working in the middle of two heat-affected zones (HAZ) and the thermo mechanical affected zone (TMAZ) is classified. Cross section perpendiculars to the movement direction the tool are defined in two parts: advancing side and retreating side. The two parts are specified by the order of direction or dissimilar direction of rotation speed and feed rate. When these two have the same speed, called advancing side and as they are opposite, called retreating side. In this study, the effect of changing of tool rotational speed and progressive tool welding on the microstructure, properties , fracture toughness and impact resistance properties of aluminum composites reinforced with silica particles have been investigated.

II. Experimental Procedure

Base metal used in this study, aluminum matrix composite reinforcing silica particles, which were prepared by stir casting. To this purpose, the silica powder with an average grain size of 6 to 10 microns was preheated and after supplying molten metal and before molding, was added. Preheating has been done to remove moisture and impurities from the surface of silica particles and improve the surface wettability. And then molten metal is heated above the melt temperature (40 to 50 degrees above the melting point of aluminum) and kept at this temperature for 5 minutes, following the metal molds were cast with dimensions 10×100 cm. In order to vanish of deposition and proper distribution of particle-phase of silica thin ceramic rods were used for stirring the liquid before freezing. After solidification and polishing, to remove surface impurities and slag (with respect to the surface of the mold), samples with suitable size and thickness of 6 mm were prepared for welding process. To prepare shoulder of friction stir welding tool used HSS steel that the chemical composition included 0.09% carbon , 0.19 silicon , 1.51% manganese and elements such as chromium , molybdenum , titanium, niobium, vanadium and copper that have high wear resistance to the silica particles, according to diameter of the 6mm friction stir welding is used, the type and shape of the pin that has the least wear with particles as well as to create Max Turbulence within the welding zone, a tapered threaded was

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selected. This pin has six spiral grooves on its surface with an average depth of 0.1 mm. Figure 1 shows the pin type and general characteristics.

After preparation work, the piecework was fastened by the clamp to minimize displacement and slip has during the process. Table 1 describes the welding parameters. Rotation speed of the shoulder is 1140 rpm and pin tool with speed 1.81 inch/ minute moves, the speed of rotation and moving forward will have optimum of the welding quality. Length of the pin is 6 mm and a depth of pin penetration in samples is 5.5 mm which to create the pool, before the initial confusion rotation, around 5 seconds without having forward and then began to move with speed mentioned Before performing welding operations, operations to preheat the samples over 100 °C have been helped to make the plastic region, and it is to prevent the heat shock induced heating of the sample surface in contact with the tools. Then the changes were made in the welding step (speed than the forward velocity of the pin) and re-welding was done. Reduce speed and increase the forward velocity of the pin causing defects in the weld, which microstructure was also examined by optical microscopy and Vickers and Brinell hardness and impact testing using Charpy method. We paid to investigate the causes of defects. For impact testing, the samples according to Charpy impact test were cut, for testing the four region are include : base metal (BM), welding zone (WZ), thermo mechanical affected zone (TMAZ) and heat-affected zone of welding (HAZ), samples of the notch (V-shaped) to a depth of 2mm in room temperatures are obtained, and impact tests were performed by Zwick Roell450j. To study the microstructure, the broke samples grounded and etched for metallographic purpose and the samples were etched in a solution by combining 190ml water / 5ml HNo3 / 3ml HD / 2ml Hf for 90 seconds. In fact, over etch has done to achieve better results.

III. Results and Analysis

After welding, metallographic sample preparation and etching steps, the resulting images produced by light microscopy was examined. Figure 2 shows Aluminum's Composite microstructure and distribution of sio_2 particles.
Given that both forms are provided at the same magnification, as well as grain size is determined after the welding operation. The difference between the grain size of the base metal and weld nugget due to friction welding was generated and the resulting increase in temperature is caused by the pin moving. However, by comparing the base metal used for welding (Figure 2b) and the base metal without welding, Uniform microstructure changes in the size and shape of the grains, it can be concluded that, Due to the use of solid state welding, the heat caused by friction welding and fusion welding temperature is not comparable and not enough to make an influence on the microstructure of the base metal, Therefore, in the base metal, the grain shape and size distribution did not change. But the difference in the grain size at the nugget zone and the base metal (figure 2), due to the welding heat input is justified. Heat generated by the friction and deformation caused by the forward moving in the seam binding, Conditions for continuous recrystallization of particles after passing pin is provided, So that new grains formed will have a

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smaller size compared to its prior state. Welding samples with 1140 rpm rotational speed and tool forward speed 1.81 inch/min, was successful.
At Figure 3A welded connection, the progress and direction of rotation of the tool is shown. Also at the observation of the macroscopic and microscopic binding, no defects in the weld or the complexity of the work piece were observed. Reduce the speed to 1000 rpm tool, because micro pores on the outer surface of the weld and Indicating complete mixing of the material in this area and the lack of a suitable plastic region that the mechanical properties, especially tensile properties of the samples decrease.
Also, observing the microstructure of the weld vertical cutting is shown in Figure 3, tool's turbulence decreases with increasing of transfer rate and the possibility of defects in the weld increases. Under these conditions, the deformed material is colder and therefore harder forging by tools are marked and the resulting in cavities near the heat-affected zone at advancing side which shown In Figure 3b. In fact, insufficient material flow in this region will lead to cavities.
Addition to microstructure studies, hardness and impact tests were performed on the samples, Figure 4 shows the impact energy variation in different regions of the weld.
According to Graph and compare the toughness of the weld regions, increasing the impact strength of weld zone than base metal is visible which Due to rising temperatures, recrystallization and become more fine-grained in the area. It also creates a strong phase mixing and uniform distribution of particles, resulting in better mixing, after cooling. Therefore, with preserve flexibility in this region has higher hardness and strength.
Considering microscopy observations, Become finer microstructure resulting from recrystallization and Uniform and homogeneous distribution of reinforcing particles in the region, was due to perturbation and the forward moving of the rotating tool which In total the region has increased hardness and strength. It seems hardness of the weld zones is higher than surrounding areas; As a result, the strength of the weld region due to the welding is higher. As mentioned above, the flexibility is also acceptable at the welding zone and is higher than other parts, that seems rise strength and toughness in the weld area, on the optimized of the mechanical properties of this connection is emphasized.

IV. Conclusions

Butt welding of the composites base aluminum reinforced 20 % volume sio_2 is done successfully using friction stir welding technique. Optimized rotational speed and tool speed was 1140 rpm and 1.81 inch/min respectively.
Increase or decrease the speed of rotation and forward velocity tools, causing Defects in the stirring region which the defects at the interface between the weld and the HAZ, in the progressive side as the region holes were observed.
Impact testing via Pendulum machine was revealed that Impact energy of the weld zone is substantially higher than the base metal. This related to modifying the microstructure caused by the friction-stir processing.

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Tables

Table 1
Friction stir welding parameters composite AL7075/20%Sio_2

Preheated temperature	Tilt degree	Advancing speed	Rotational velocity	Pin type	Shoulder diameter	Welding tool	thickness	Welding type
100°c	One degree	1.81 inch/min	1140rpm	tapered threaded	20mm	Hss steel	6mm	FSW

Figures

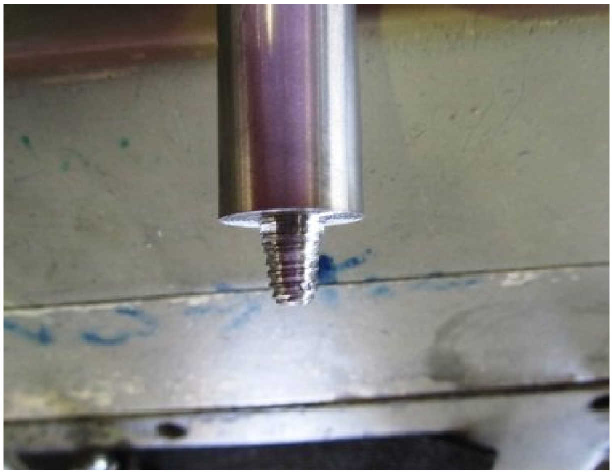

Figure. 1. HSS steel tool used for friction stir welding. Shoulder Diameter 20mm, diameter at the bottom of the taper pin: 5.3mm, diameter at the top of the tapered pin: 6.3mm and tool height is 20 mm.

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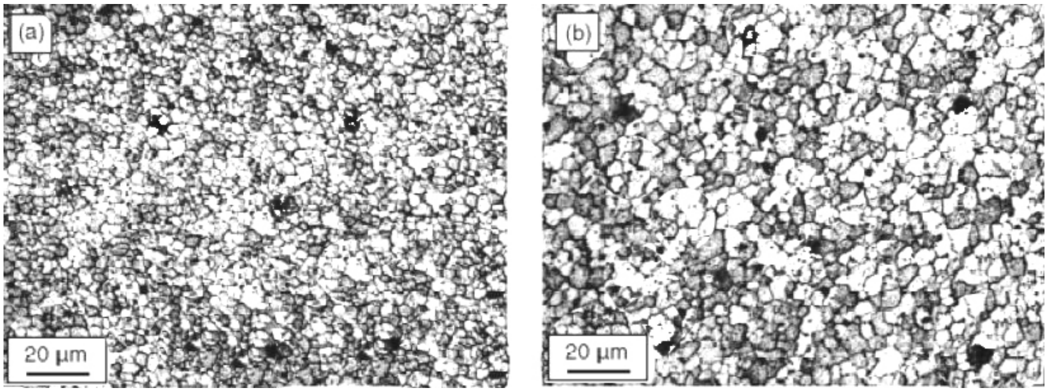

Figure. 2. Microstructure of the base metal and weld metal: the right of the base metal and weld metal left.

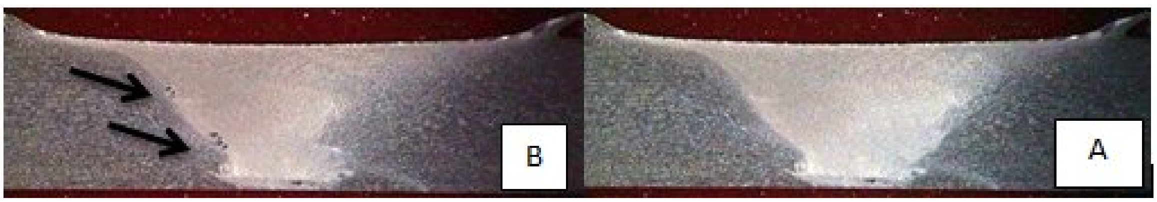

Figure. 3. The effect of forward velocity: (a) 1.81inch per minute (b) 2.5 inches per minute.

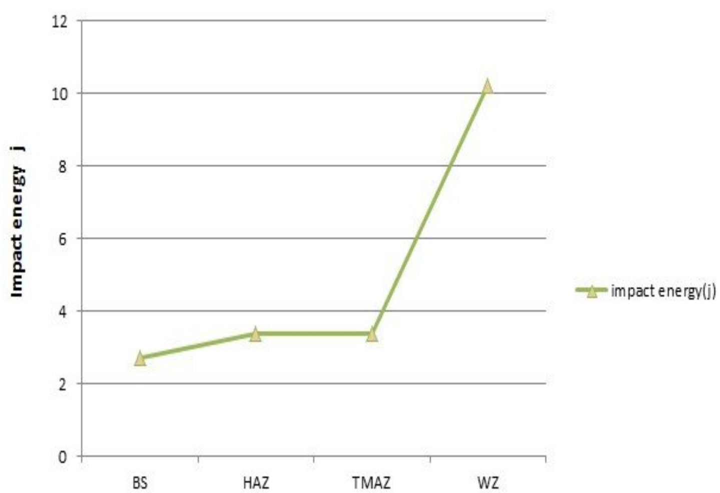

Figure. 4. Graph AL-Sio_2 composite impact test results at room temperature.

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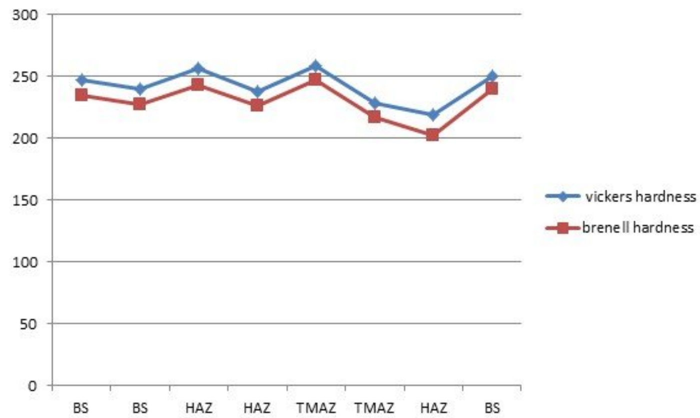

Figure. 5. Vickers and Brinell hardness variation with 5kg weights at the BS, HAZ.TMAZ regions according to standard ASTM E-92.

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