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Experimental Investigation and Material Characterization of A356 Based Composite (Tio2) By Friction Stir Processing

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ABSTRACT: Friction stir processing (FSP) was used to incorporate TiO_2 particles into the matrix of A356 alloy to form composite material. The mechanical properties of the composite material are strongly dependant Aluminium A356 on the microstructural parameters of the system matrix-reinforcement, a judicious selection of a certain number of variables has to be achieved to optimize the properties of the composite. Different tool rotation speed of 1500 r/min and 2000 r/min and constant travel speed of 30 mm/min were used in this study. The results indicated that the uniform distribution of TiO_2 particles in A356 matrix by FSP process can improve the mechanical properties of specimens.

KEY WORDS: friction stir processing; A356 alloy; TiO_2 powder

I. INTRODUCTION

Friction stir processing (FSP), which is a solid-state microstructural modification technique, has been recently noticed for making aluminum alloys with excellent specific strength (MMC). Aluminum and its alloys are used mostly in fabrication of aerospace and transportation machine because of their noble properties such as high strength to weight ratio and low density. The properties of aluminum and its alloys such as strength, elastic modulus, and resistance to wear can be improved with corporation of TiO_2 particle into aluminum matrix(MMC).

Producing of MMCs using FSP has some advantages over the other techniques. This solid processing can reduce hydrogen porosity occurred during aluminum alloys fabricated by liquid processing and fine grains can also be obtained in stir zone. Though FSP has been basically advanced as a grain refinement technique. It is a very attractive process for fabricating the composites. Used FSP for fabrication of the A356/ TiO_2 surface composites with a good distribution of TiO_2 particles in matrix, they also acquired a composite with acceptable bonding with the Aluminium matrix. A356/TiO_2 composite have been recently used in production of composites with elevated wear resistance, good Chemical stability, and corrosion resistance.

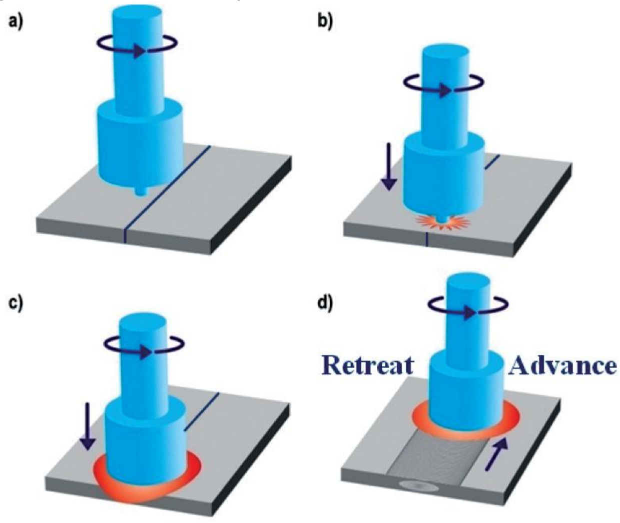

Fig.1. A schematic of FSP (a) showing the rotating, non-consumable tool , (b) frictional heating upon plunging into the work piece in,
(c) frictional and heating in and (d) traversing of the tool to weld/process the work piece in.

This study is investigating the possibility of incorporating TiO_2 particle into surface layer of aluminum alloy to

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form surface composite by means of FSP technique. The effect of rotational and traverse speed is investigated on the maximum temperature, grain size and stir zone area. Also the effect of tools penetration depth is surveyed on TiO_2 particle distribution. The FSP process shown in (fig .1)

II. EXPERIMENTAL PROCEDURE

The An Aluminium A356 alloy with 100mm length, 50mm width and 6mm thickness was used for making samples. In order to produce the surface composite layer, TiO_2 powder with 200nm particles size were filled in a groove carved in middle of the specimens with the width and depth of 3mm×2mm respectively(Fig. 2a). Before doing the FSP process, TiO_2 particles were compacted into the groove by a plastic plate and then to prevent the TiO_2 particles scattering out of the groove, the upper surface of the groove was closed with a FSP tool that have no pin(Fig. 2b). Then a tool by the pin attached to bottom was plunged into the plate for stirring the friction zone and producing the composite (Fig.2c).

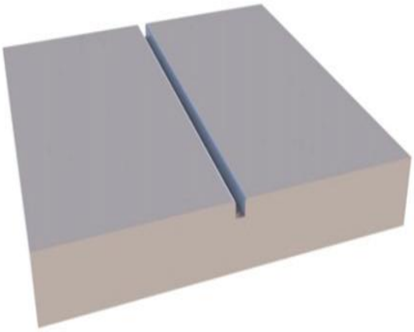


Fig.2a.Specimen(A356)

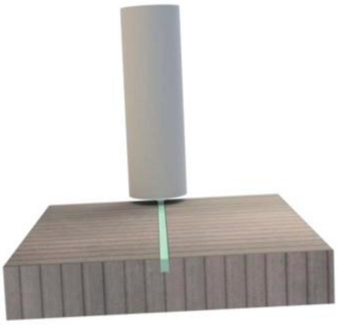


Fig.2b.Packing without pin

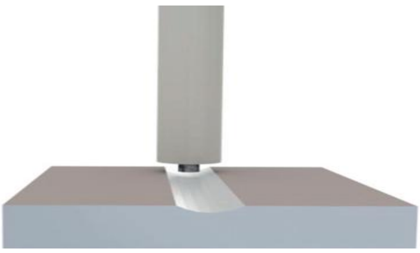


Fig.2c. Tool with pin

The FSP machine used here was a modified horizontal milling machine. And finally, specimens were FSPed by tools that had pin(Fig.2d)(Squaer type pin).Tilt angle of tools in direction of travel was set in 2degree.

These experiments were performed at different tool rotation speed and constant travel speed were used in this study. Rotation of tools during the process induced severe plastic deformation at high temperature that hastens metal deformation. Also rotation of tool mixes the TiO_2 particles inside the metal substrate and produces a surface composite layer. The distribution of the TiO_2 particles was studied by SEM and also the hardness was measured .

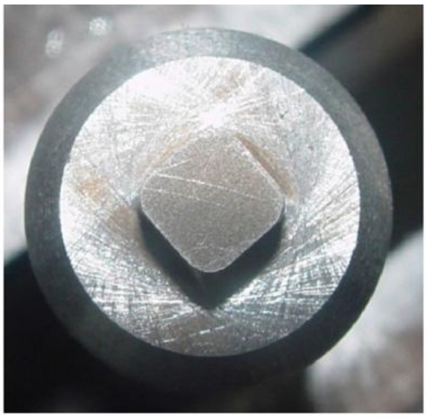


Fig.2d. Square Pin Profile Tool

III. RESULTS AND DISCUSSION

FSP results in intense plastic deformation around rotating tool and friction between tool and workpieces. Both these factors contribute to the temperature increase within and around the stirred zone. Since the temperature distribution within and around the stirred zone directly influences the microstructure of the welds, such as grain size, grain boundary character, coarsening and dissolution of precipitates, and resultant mechanical properties of the welds, it is important to obtain information about temperature distribution during FSP. However, temperature measurements within the stirred zone are very difficult due to the intense plastic deformation produced by the rotation and translation of tool. Therefore, the maximum temperatures within the stirred zone during FSP have been attained at 2000rpm. In this study the rotation speed and traverse speed was successful in uniformly distributing the TiO_2 particles into A356. As shown in Fig.3.3.

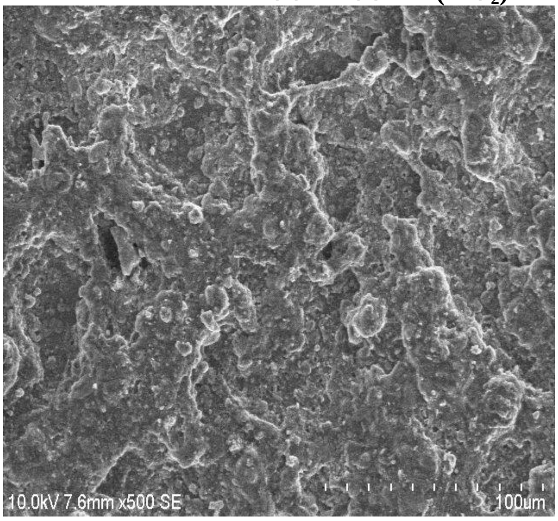


Fig 3.1 SEM micrograph of A356

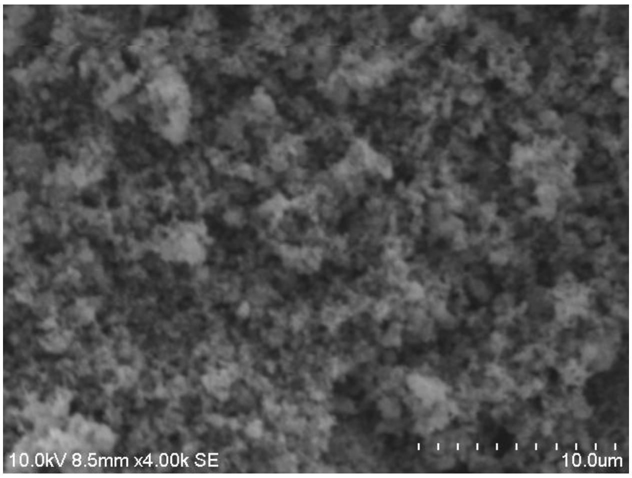
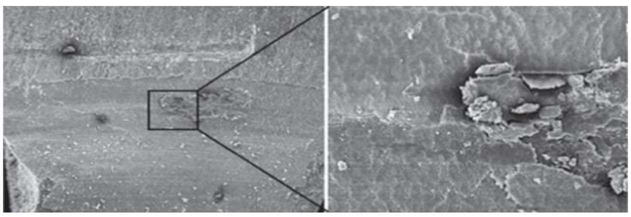
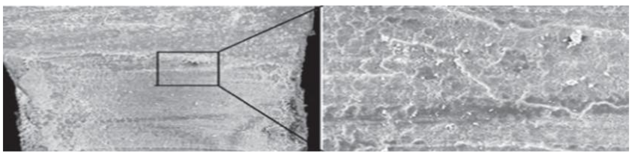


Fig 3.2 SEM micrograph of TiO_2



a)



b)

Fig.3.3 SEM micrograph of A356-TiO_2 composite
a) 1500 rpm
b) 2000 rpm

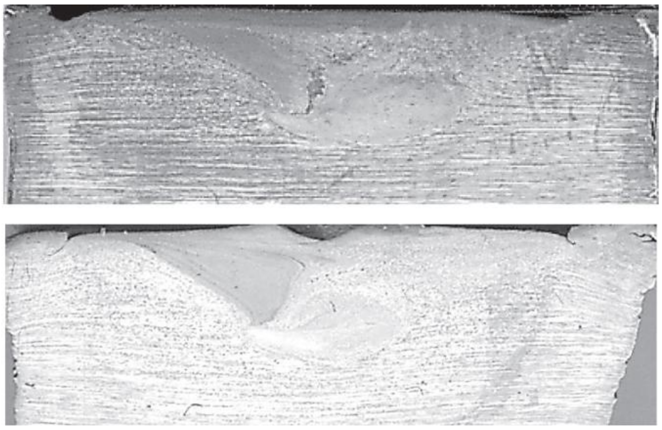


Fig. 3.4 SEM micrograph of A356-TiO_2 composite A) 1500rpm
B) 2000rpm

The cross section area of surface composite layer produced by FSP under two different rotation speed of 1500 rpm, 2000 rpm and the constant traverse speed of 30 mm/min as shown in Fig 3.4.

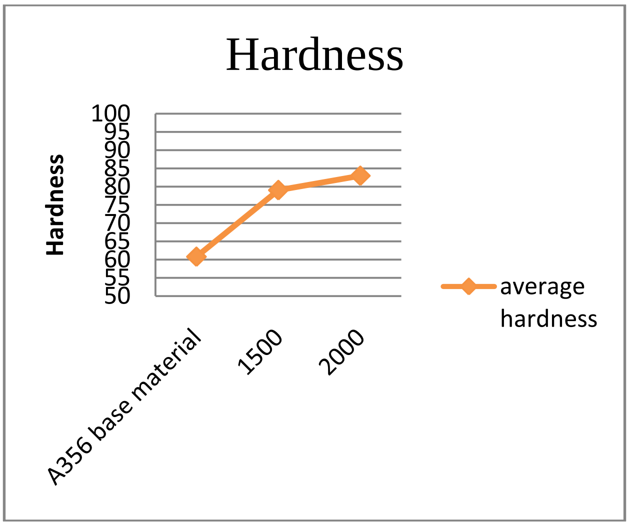


Fig 3.2 Hardness vs Speed

3.1 Hardness Test Result

The hardness of the A356/TiO_2 composites was evaluated using Rockwell hardness testing with 150 kg load and 0.5 mm diameter steel ball indenter. The average hardness of the A356-TiO_2 composites is shown in figure 3.1. The rotation speed was increased, the hardness of the composites also increased.

The average hardness values of base material (A356) ,1500rpm, and 2000rpm sample were measured. The FSP causes intense plastic deformation resulting in sufficient microstructural refinement of the processed zone increasing the hardness value. A sufficient hardness value is realised by traversing the FSP tool two times at a tool rotating rate exceeding 2000rpm.

IV. CONCLUSION

The increasing of rotational speed leads to increasing of maximum temperature .

The increasing of rotational to traverse speed ratio causes to higher stir zone area.

Due to high rotation speed, less traverse speed and less depth of cut the high heat was produced then the tool was move freely during FSP process so that the hardness was improved.

Finally the microstructural study of A356/TiO_2 surface composite layers fabricated by indicated that TiO_2 particles were well distributed in the aluminium matrix, and good bonding with the aluminium matrix was generated.

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