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SEM ANALYSIS OF AL6082 BY ADDING NICKEL & TITANIUM AFTER FRICTION STIR PROCESSING

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Abstract

Friction-stir processing (FSP) is an emerging surface-engineering technology that can locally eliminate casting defects and refine microstructures, thereby improving strength and ductility, increase resistance to corrosion and fatigue, enhance formability, and improve other properties. FSP can also produce fine-grained microstructures through the thickness to impart super plasticity. The technology involves plunging a rapidly rotating, non-consumable tool, comprising a profiled pin and larger diameter shoulder, into the surface and then traversing the tool across the surface. Large surface areas can be traversed rapidly by using the appropriate tool design accompanied by raftering. These processes are more likely to have an influence on the design, engineering and manufacturing of passenger vehicles in future. A lot of emphasis has been placed on the manufacture of fuel-efficient vehicles, increased use of lightweight materials as well as more efficient and cost-effective processing techniques. In the present study Scanning Electron microscope results of the prepared specimen is discussed.

1. INTRODUCTION

The ability to strengthen materials through repeated thermal treatments and deformation processes has long since been recorded. Even today new and innovative fabrication techniques are continuously being developed to take advantage of these concepts. Among these techniques, Friction Stir Processing (FSP) is gaining attention as a new bulk or even post processing method to perform highly selective modifications on materials without producing significant distortion to the materials original shape. Many of these complex fabrication techniques rely heavily on empirical data to refine and finalize process controls and parameters. Now, in a time where computing power is cheaper than the time required for testing and materials, studies and experiments are instead being used to hone and validate more cost effective numerical models. In a program funded by the Defense Advanced Research Projects Agency, the research being conducted at the Naval Postgraduate School in collaboration with other program participants aims to provide the microstructural analysis and related characterization studies to provide the foundation necessary to help commercialize FSP, and, in particular, for the technique to be used in the post processing.

1.1 Principal of Friction Stir Processing

FSP is considered a hot working process in which extreme strain, strain rate and thermal gradients are imposed over a small volume of material. These conditions are achieved through the use of a non-consumable tool that, simply stated, is rotated, pressed into and traversed through a material under specified process conditions. The process parameters and material conditions are defined with definitions borrowed from welding processes. In common with welding processes, FSP shares the concept of a “heat affected zone” (HAZ), however the term thermo mechanically affected zone (TMAZ) is often used because of the localized hot working that also occurs [Ref. 4]. In some locations peak temperatures (Tpeak) reach > 0.9 Tmelt although melting is not observed. Features not common with welding that are immediately apparent in FSP are the “stir zone” (SZ), also known as the “stir nugget”. Unlike welding, FSP does not have a fusion zone because it is believed that this process remains entirely in the solid-state. To friction stir process a sheet a specially designed cylindrical tool is used, the tool consists of a pin and a concentric larger diameter shoulder as shown in Fig 1 .While the tool is rotating the pin is plunged into the sheet and the shoulder comes in contact with the surface of the plate shown in fig 1.1.

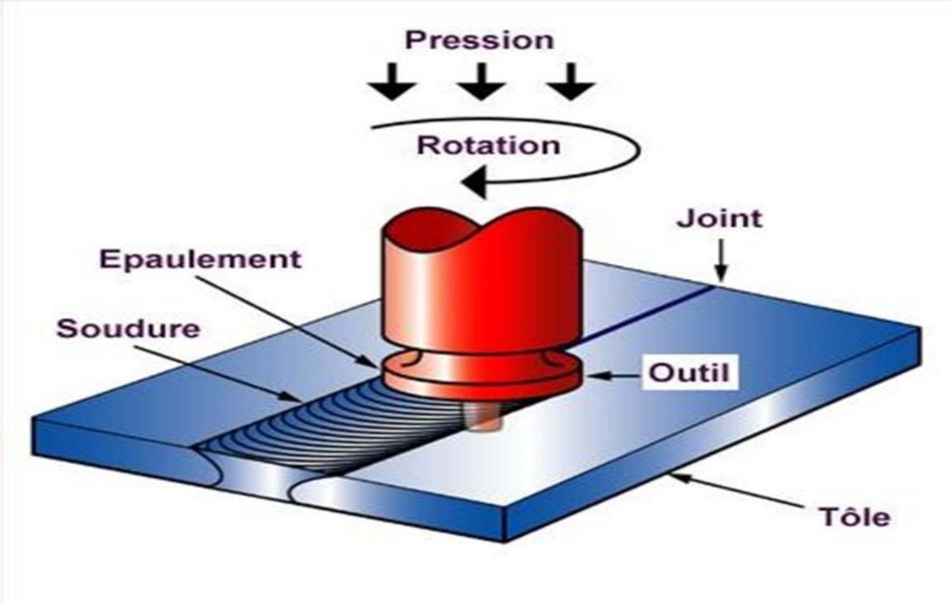

Figure1 - Schematic for friction stir processing (FSP)

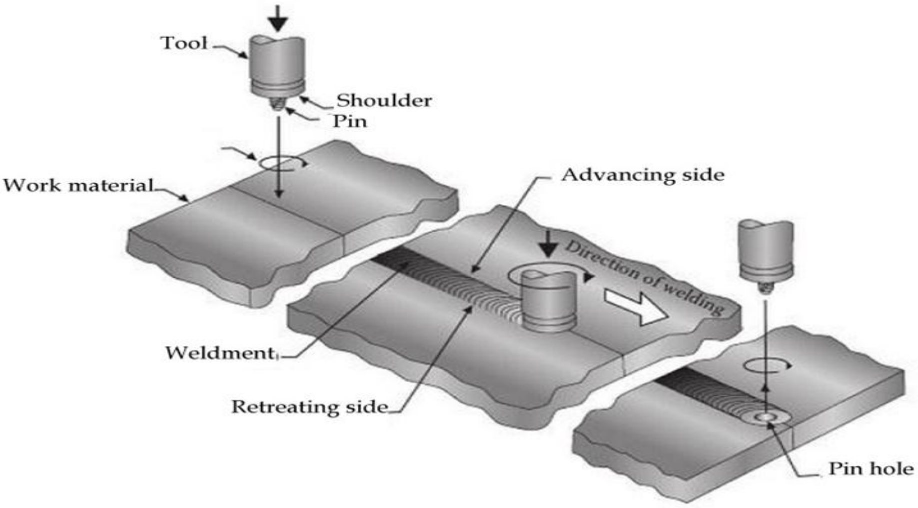

Figure1.1 - Schematics of the stages of friction stir processing (FSP)

2. LITERATURE REVIEWED

Bendzsak et al (2000) used the finite volume method to calculate the flow around the tool. The flow indicated by the model was divided into two regions. Near the shoulder, it was largely rotational while further down, it was to extrude around both sides of the tool. Spirals were observed between these two regions and it was postulated that these could be the cause of weld defects

Guerra et al (2001) studied the material flow of FSW 6061A1 by means of a faying surface tracer and a pin frozen in place at the end of welding. Based on the microstructural examinations, they concluded that the material was moved around the pin in FSW by two processes. First, materials on the advancing side front of a weld entered into a zone that rotates and advances simultaneously with the pin. The material in this zone was very highly deformed and sloughed off behind the pin in arc shaped features. This zone exhibited high Vicker's micro hardness of 95. Second, material on the retreating front side of the pin extruded between the rotational zone and the parent metal and in the wake of the weld fills in between material sloughed off from the rotational zone. This zone exhibited low Vicker's micro hardness of 35. Further, they pointed out that material near the top of the weld (approximately the upper one-third) moved under the influence of the shoulder rather than the threads on the pin.

Ma et al (2003) studied the microstructural modification of cat aluminium alloys via friction stir processing and reported that FSP cannot be simply considered as an extrusion process, particularly with the threaded pins used in this study. An extrusion process cannot significantly break up coarse acicular Si particles and aluminium dendrites and uniformly disperse the broken Si particles into aluminium matrix. The threaded pins result in a superimposed vertical and horizontal material flow from geometrical considerations. The threads tend to move the material downward along the pin wall and once this material reaches the bottom, the geometrical constraints require that the material move up away from the pin wall. The lateral travel of the pin requires that the material move from front to back. How these three material flow patterns, based on the geometrical and volume constraints, interact with each other is complex.

Zhao et al (2005) reported that when insufficient material comes back to the advancing side, void defection will generate on the advancing side. The material flow is influenced very significantly by tool design. Therefore, any generalization should be considered with caution. Also, most of the studies do not report tool design and all process conditions. Therefore, differences among various studies cannot be easily discerned (Mishra and Ma 2005)

Johannes and Mishra (2007) studied the effect of multiple passes of friction stir processing for the creation of superplastic 7075 aluminium. They observed that the effectiveness of friction stir processing in creating superplastic material can be extended to multiple passes to create larger areas of material with superplastic properties. They further reported that the elongations achieved in multiple passes of 7075 Al are superplastic, although the single pass material exhibits slightly greater elongations

Surekha et al (2008) reported that the average hardness values in the nugget of the multi-pass friction stir processed samples are lower than the base metal. It was found that the area in the softened zone (nugget zone) and the hardness in the nugget region increased with increase in the number of passes. The increase in area of softened zone is attributed to the increase in heat input and the increase in hardness with multi-passing may be attributed to the decrease in particles size of insoluble dispersions. FSP creates a softened region around the weld centre in a number of precipitations hardened aluminium alloys. It was suggested that such a softening is caused by coarsening and dissolution of strengthening precipitates during the FSW.

Kumar and Kailas (2008) studied the role of friction stir welding tool on material flow and weld formation. They reported that there are two different types of material flows, namely shoulder and pin driven material flows. Pin transfers the material layer by layer, while the shoulder transfers the material by bulk. Shoulder driven material flows from the retreating side and forges against the advancing side of the base material. The pin driven material flows layer by layer around the pin, and the layers are stacked in the weld line. The material flow below certain depth in the thickness is not affected by the increased interaction of the tool shoulder.

Rao et al (2009) investigated the effect of multiple-pass FSP on cast hypereutectic Al- 30Si alloy. Single pass and two pass (with 100% overlap over the first pass layer) FSP experiments were performed. They reported that the SEM micrographs distinctly reveal the significant favourable effect of FSP on the size, shape and distribution of Si particles with increasing number of FSP passes. After one pass of FSP, the average Silicon particle size.

3. EFFECTS OF ADDING NICKEL AND TITAINUM ELEMENTS TO ALUMINIUM

1. NICKEL base (Ni-base) alloy is one that has nickel as it primary constituent. These alloys have found usage in a variety of industries, such as aerospace, petroleum, chemical, and power generation industries. The alloys have been used in a variety of demanding environments from cryogenic to very high temperatures, fresh water and salt water to acidic solution containing vessels, steam and pressure vessels to electronic and biomedical components. It is evident that a wide variety of Ni-base alloys with different properties can be engineered for nearly any application**.** The solid solubility of nickel in aluminium does not exceed 0.04%. Over this amount, it is present as an insoluble intermetallic, usually in combination with iron. Nickel increase the strength of high purity aluminium but reduce ductility. Nickel is added to aluminium to improve hardness and strength at elevated temperature and to reduce the coefficient of expansion

2. TITANIUM melts at 1670 ±C and has a density of 4.51 g cm^{-3}. It should therefore be ideal for use in components which operate at elevated temperatures, especially where large strength to weight ratios is required. Titanium can catch fire and cause severe damage in circumstances where it rubs against other metals at elevated temperature. This is what limits its application in the harsh environment of aero engines; to regions where the temperature does not exceed 400 ±C. Titanium is added to aluminium primarily as a grain refiner. Titanium is a common addition to weld filer wire as it refines the weld structure and helps to prevent weld cracks.

4. Research Methodology

a. Cut three the specimen of AL6082 in size of 150*50*12 mm

b. Make a slot in the centre of the plate of size 1mm, 1.25 mm, 1.5 mm in width and 6mm deep along the length.

c. Pour the Ni + Ti powder in the slot as alloying element.

d. Perform the FSP on the specimen at 1100 RPM of tool speed & 25 mm feed rate.

5. Results & Discussion

Scanning electron microscope (SEM) of JEOL JSM 6510 LV at 20 KV was done at thapar university Patiala. All the FSP stir zone samples were mechanically ground & polished with 0.1 µm aluminum paste & cleaned with the acetone & triple distilled water. The SEM micrographs of the prepared specimen are shown in figure2. The distribution of the prepared specimen is shown in figure 2(a), 2(b), 2(c) with different width of the slot cut in the specimen. The distribution of Ti + Ni particles is fairly homogenous in the specimen. It is observed from the SEM test results that the Ti + Ni particles are more homogenous in specimen -1 as compared to the specimen -2 & specimen -3 which is due the large % age of pouring element in the specimen -2 & specimen-3. The average grain size of 4 – 5 µm is calculated in the specimen.

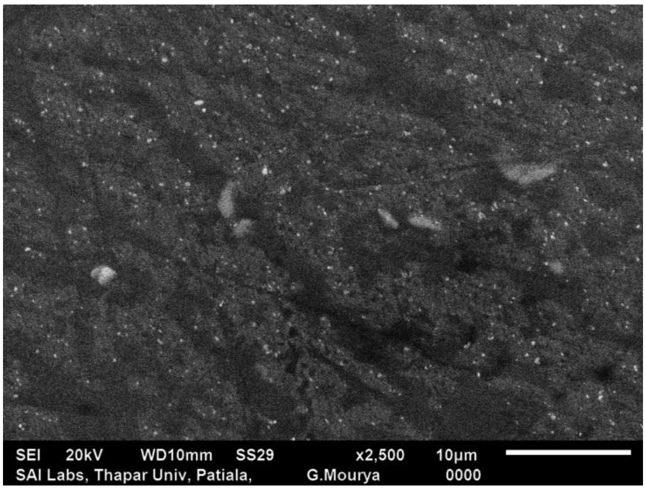

Figure 2 (a) SEM image of specimen-1 having 1mm slot size

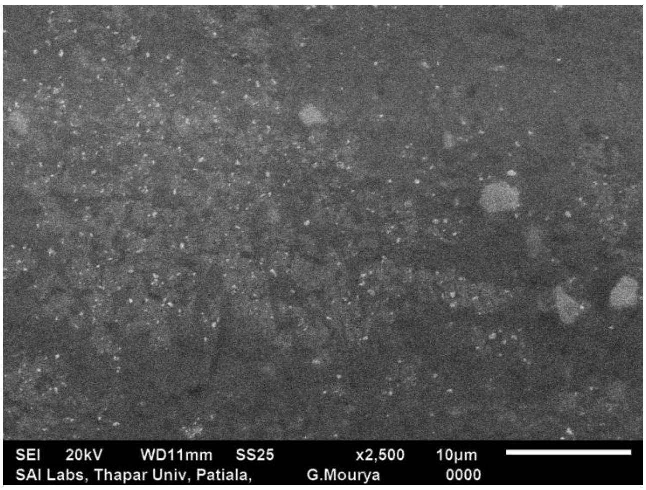

Figure 2 (a) SEM image of specimen-2 having 1.25 mm slot size

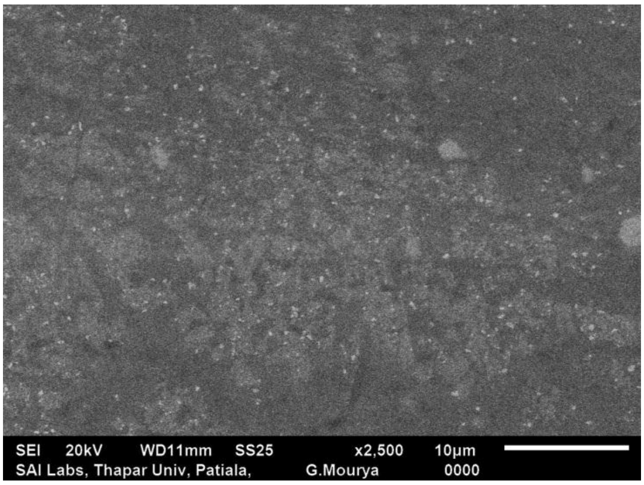

Figure 2 (a) SEM image of specimen-3 having 1.5 mm slot size

5. CONCLUSIONS

1. The grain structure of material will be refined by FSP.
2. Nickel will be improve the strength at elevated temperature and to reduce the Coefficient of expansion.
3. The average grain size of 4 – 5 µm is calculated in the specimen.

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