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A Review paper by Using Friction Stir Processing of Adding Alloys to Aluminum

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ABSTRACT
The ever-increasing demand for light weighted hard materials for transportation industries encouraged researchers to develop composites with excellent mechanical properties which can transform it into more economical and eco-friendly. Reinforcing the metals with carbonaceous nanomaterials is progressively in focus due to their excellent capability to inculcate and tailor the properties of MMCs. There are different processing techniques that would produce a material with small grain size that satisfies the requirements of strength and hardness. New processing techniques like Friction Stir Processing (FSP), Equal Channel Angular Extrusion (ECAE), are being developed for this purpose in addition to the improvements in grain size, strength, hardness etc. In this paper review on Friction Stir Processing (FSP) is delivered. Friction stir processing (FSP) technique is preferable over other conventional surface modification techniques because of its capability to produce relatively strong and defect free surfaces. Friction Stir Processing (FSP) is the one way to improve the formability is to refine and homogenize the microstructure and improve other properties. Friction Stir Processing (FSP) can be used to effectively to produce ultrafine grain and improvement in the mechanical properties.
KEY WORD: Friction Stir Processing (FSP), Grain structure, Mechanical properties

I. INTRODUCTION

Friction Stir Processing (FSP) is a new micro structural modifications technique; recently it FSP has become an efficient tool for homogenizing and refining the grain structure of metal plate. Friction stir processing is believed to have a great potential in the field of super plasticity. Results have been reported that FSP greatly enhances super plasticity in many Al alloy [1-5]. Friction stir processing is based on friction stir welding (FSW) which was invited by The Welding Institute (TWI) of United Kingdom in 1991 [6, 7].

FSP is a solid-state process which means that at any time of the processing the material is in the solid state. In FSP a specially designed rotating cylindrical tool that comprises of a pin and shoulder that have dimensions proportional to the plate thickness. The pin of the rotating tool is plunged into the plate material and the shoulder comes into contact with the surface of the plate, and then traverses in the desired direction. The contact between the rotating tool and the plate generate heat which softens the material below the melting point of the plate and with the mechanical stirring caused by the pin, the material within the processed zone undergoes intense plastic deformation yielding a dynamically-recrystallized fine grain microstructure.

1.1 Principle of Friction Stir Processing

To friction stir process a plate a specially designed cylindrical tool is used, the tool consists of a pin and a concentric larger diameter shoulder as shown in figure 1

While the tool is rotating the pin is plunged into the plate and the shoulder comes in contact with the surface of the plate as shown in figure 2. The friction between the tool and the plate generates heat which softens the material without reaching the melting temperature of the material; that is why it is a solid state process. Then the tool is transverse in the desire direction while it is rotating. The rotation of the pin does the stirring action of the softened material which makes the material undergo intense plastic deformation yielding a dynamically recrystallized fine, equiaxed, and defect free grain structure.

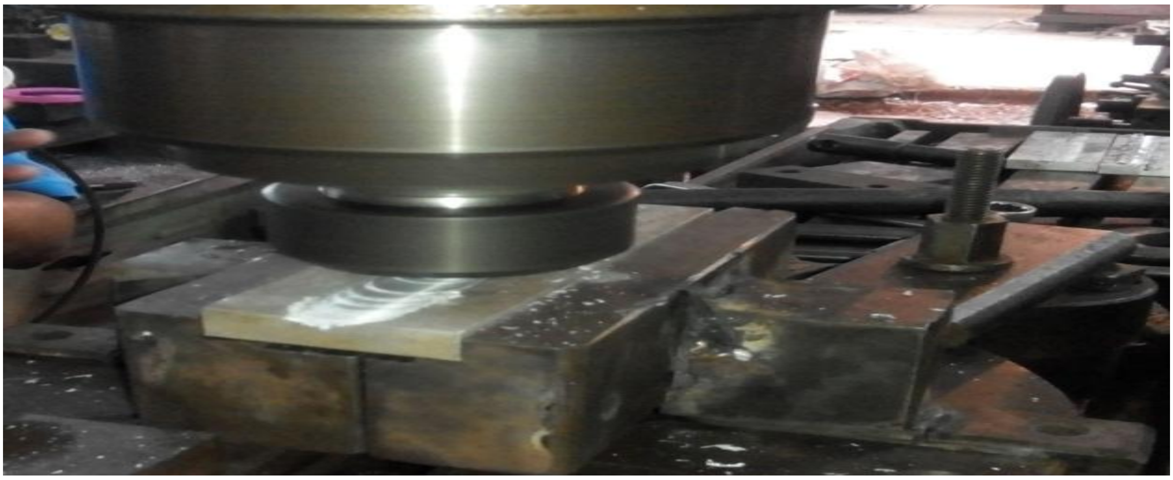


Figure 1 Schematic of the Friction Stir Processing

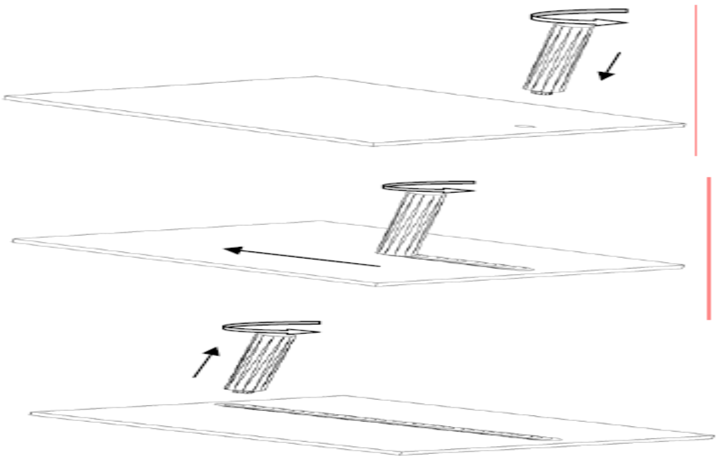


Figure 2 Schematics of the stages of friction stir processing (FSP)

II. LITERATURE REVIEWED

A .Thangarasu et al (8) investigated a fairly homogeneous in the composition irrespective of the volume fraction. AA6082/TiCs exhibited a reduction in the grain size during FSP. The wear resistance is also improved. The rate of wear resistance was found to be 0.00693 mg/m at 0 vol. % and 0.00303 mg/m at 22 vol. %.

A .Thangarasu et al (9) investigated the typical crown appearance of friction stir processed aluminum with TiC Particle. He found that there is no imperfection such as voids, cracks etc. on the surface. The top surface appears to be even and fine finish with no depression.

A.Shafiei-Zarghani et al (10) investigated that the contribution of particle size and volume fraction of reinforcement in FSP fabricated Ti/Al_2O_3 Nano composites. The introduction of Nano scale reinforcing particle has dramatically reduced Ti matrix grain size to ultra-fine range. The trend in grain size reduction was found to be best described by the Rios equation rather than Zener pinning model. The yield strength of the material is increased from 351 MPa in pure Ti after FSP, to 494 MPa when 20nm- Al_2O_3 particles are dispersed through the Ti Matrix.

M. Lotfollahi et al (11) investigated the erosion –corrosion rate of the sample of Nickel- aluminum. It is found that under 0.45 µJ kinetic energy at wide range of impact angle was higher than cast sample and it more obvious in 30º due to bigger scales. Also the SEM investigation is done of the specimen shows that on cast sample surface, there were just scars of plastic deformation mechanism and some sign of brittle fracture were seen.

P. Xue et al. (12) investigated commercially pure Ni was successfully friction stir processing using the tool made of common tool steel under additional water cooling. The FSP Ni exhibited sound processing surface and no obvious tool abrasion was observed. The FSP Ni exhibited a good combination of strength and ductility, which showed a large uniform elongation of_12% and high YS of about 500 MPa.

Karthikeyan Selvam et. al. (13) in the current investigation, submerged friction stir processing was utilized to develop tailored microstructures in stainless steel. High strain-rate processing at 1800 rpm resulted in nearly single-phase microstructure with average grain size of 0.9 μm while lower strain-rate processing at 388 resulted in a two-phase microstructure with average grain size of nearly 0.6 μm. Depending on the microstructure, the processed sample demonstrated 4–6 times higher cavitation erosion resistance. Both the processed sample was able to maintain their superior performance in erosion-corrosion environment as well. The remarkable improvement in erosion-corrosion behavior of processed samples was explained by surface strengthening, higher strain-hardening and larger recoverable indentation work. Processed samples also demonstrated higher corrosion resistance in standalone corrosion testing which was attributed to faster passivation kinetics of fine grained structure and higher pitting resistance. The post-eroded samples showed decrease in corrosion rates which signifies corrosion induced erosion to have larger contribution in material degradation rather than erosion induced corrosion.

Nitinkumar Pol et. al. (14) Different surface composites made of 25B4C -75TiB2, 50B4C -50TiB2 and 75B4C -25TiB2 reinforcement particles are successfully fabricated on AA7005 alloy surface using friction stir processing. Surface hardness of the base alloy, FSP sample and 25TiB2-75B4C composite is found to be 90,120 and 150 HV, respectively. It is found that micro-hardness of the different surface composites are nearly the same and this might be due to the similar particle sizes of the reinforcing powders. Depth of penetration of the steel projectile on the base alloy, 25B4C -75TiB2, 50B4C -50TiB2 and 75B4C -25TiB2 surface composites is found to be 37, 26, 24, and 20 mm, respectively. The enhancement in ballistic resistance is attributed to the presence of hard ceramic reinforcement particles in the surface composite and the tough core of the matrix. The mass efficiency factor of 75B4C -25TiB2 surface composite is found to be 1.6 times that of base alloy. Thus, the present work is demonstrated that surface composite fabricated by friction stir processing is an effective method to improve the ballistic resistance of aluminium alloys.

Sandeep Shrama et. al. (21) 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.

Sipokazi Mabuwa∗, Velaphi Msomi (22) The friction stir welded dissimilar aluminium alloy joints were successfully friction stir processed under two unique conditions i.e. air (normal) and underwater (submerged). It should be noted due to no available literature on SFSP and NFSP of friction stir welded dissimilar joints, the obtained results were referenced to SFSP and NFSP of the single surface materials as well as SFSW. Based on the results of this study, the following conclusion can be drawn The SFSP technique played a significant role in the grain refinement compared to the NFSP technique and this is linked to cooling rate that is facilitated by water.• The submerged friction stir processed joints were found to be more ductile than the normal friction stir processed ones.• The SFSP technique produced joints with an improved ten-sile properties than those produced by NFSP. It was also observed that SFSP can be used as the mechanism of enhancing the joint's UTS and percentage elongation•

Lorraine M. Sithole, and Nkosinathi Madushele (23) Mg AZ61 alloy based surface metal matrix composite was fabricated by application FSP and using non sized stainless steel powder. The main objective of this paper was to investigate the effects of conducting FSP and using the stainless steel powder on the microstructural and mechanical properties of the samples. From the experiments conducted, it was deduced that: i. The non-sized stainless steel powder was uniformly distributed on the surface of the fabricated Mg AZ61 alloy metal matrix composite. ii. The micro-hardness of the Mg AZ61 alloy based metal matrix composite improved by average of 12.01% than that of the original Mg AZ61 alloy. iii. The Mg AZ61 alloy based metal matrix composite has improved resistance to corrosion by 10% to 20% than the original Mg AZ61 alloy. iv. Thus the mechanical and microstructural properties of the Mg AZ61 alloy based metal composite have improved and as such, the application of the FSP and use of stainless steel powder to form the Mg AZ61 alloy metal matrix composite was effective.

III. EFFECT OF ADDING ALLOYING ELEMENTS TO ALUMINIUM

1. **Silicon (15)** Silicon (Si) is the most important single alloying element used in majority of aluminum casting alloys. It is primarily responsible for so –called good cast ability (high fluidity, low shrinkage),low density(2.34g/cm3)which may be advantage in reducing total weight of cast component and has very low solubility in Aluminum therefore precipitates as virtually pure Si which is hard and improve the abrasion resistance.

2. **Copper (15, 16)** Copper (Cu) affects the strength and hardness of aluminum casting alloys, both heat treated and not heat treated and at both ambient and elevated service temperature. It also improves the machinability of alloys by increasing matrix hardness. On the down side, copper generally it reduces the corrosion resistance of aluminum and in certain alloys and tempers, it increase stress corrosion susceptibility.

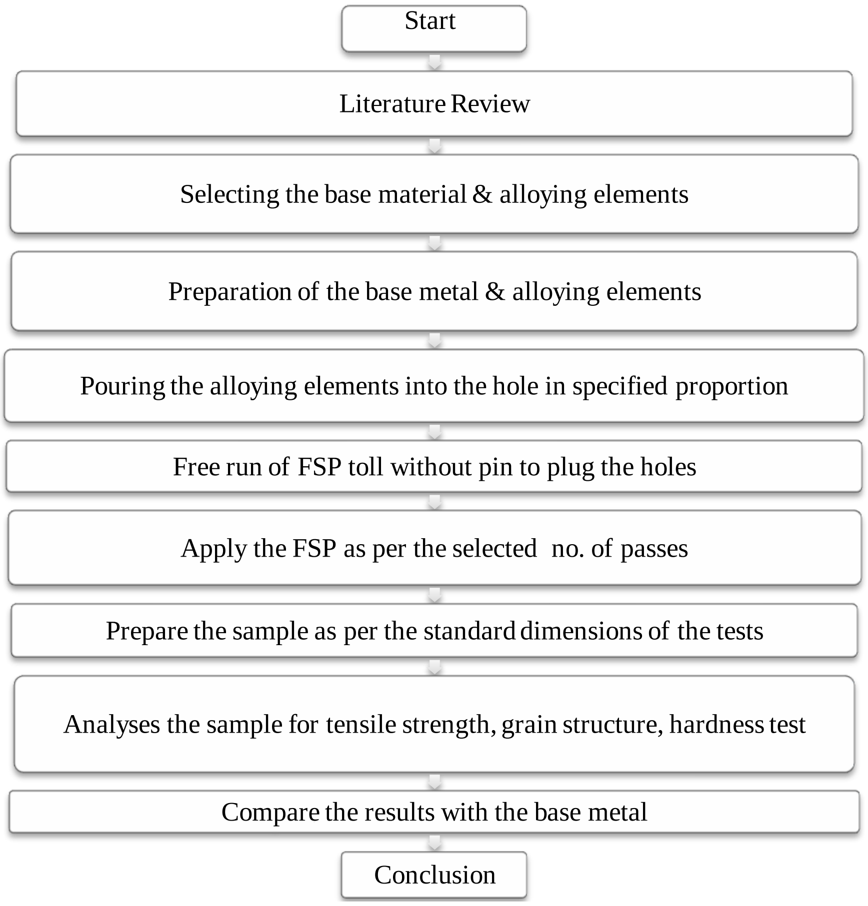
3. **Magnesium (17, 18)** Magnesium (Mg) provides substantial strengthening and improvement of the work hardening characteristics of aluminum. It can impart good corrosion resistance and weld ability or extremely high Strength.

4. **Nickel (19)** Nickel (Ni) effect on hot hardness of aluminum alloys it is shown that nickel can be utilized to improve the hot hardness (up to 600 F) of aluminum-silicon (10 to 16 per cent silicon) casting and forging alloys.

5. **Tin (15)** Tin (Sn) used in aluminum casting alloys for reducing friction in bearing and bushing applications. Alloying element Tin in emergency conditions can provide short-term liquid lubrication to rubbing surfaces if such bearings/bushings severely overheat in service.

6. **Titanium (20)** Titanium (Ti) additions on the microstructure of the aluminums alloys. Some improved corrosion properties can be obtained from increasing the Ti contents in aluminums alloys to a level above the normal practice for grain refinement.

IV. RESEARCH METHODOLOGY



V. RESULTS

1. The grain structure of the metal will be more refined by FSP
2. The mechanical properties of the material will be improved by adding alloys to the aluminums and using FSP
3. The corrosion resistance of material will also be improved.

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