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Friction Stir Processing of Aluminum Alloys (6063): A Review

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Abstract: ***As we know aluminum and its different kinds of alloys are suffering from different kind of confines like high strength, cost, time used in production and also reduction in ductility.Material having fine and homogenous grain structure accompanied high ductility and high strength. That is why there is requirement arises from the development of a new and different technique which is useful to produce a material with a fine grain structure, high wear strength, ductility and fine grain structure. FSP (Friction Stir Processing) is a fresh and new method, but still in the research phase.***

Keywords: Friction Stir Processing, Principal, Aluminum alloy, Rotational speed, Microstructure

I. INRODUCTION

Due to their high strength, good corrosive resistance, high strength to wear ratio and high ductility aluminum alloy is widely used in space industries, automobile company's, and, aircraft manufacturing and fabrication industries. The main disadvantage of aluminum from an engineering point of view is relatively low modulus of elasticity , about one –third of steel. Component made of aluminum defects three times as steel component at same design and at an identical loading.

In Aircraft and automotive industries selection of material according to their specific properties is the key factor. The properties of a material like high strength, good wear resistance may suffer from different restriction, i.e. cost &time of production,apart from the reduction in ductility. If material having fine grain &homogenous grain structure, it is easy to achieve high strength and ductility. Hence, to fulfill their condition i.e (having small grain size, high strength&ductility and also satisfies the necessities of cost and time of manufacturing) there is a requirement to develop a new and unique technique.

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Friction Stir Processing (FSP) expands the improvement of FSW (Friction Stir Welding).FSW is build up in Welding Institute (TWI) OF the United Kingdom in 1991. FSP is a new thermo mechanical technique to achieve good performance with less production cost in a min. Time and its also achieve better microstructure &mechanical properties in a single pass.

FSP has many recompense in excess of the convention and also the unique techniques of material dispensation which contain being a single step process, using of easy & economical tool, less time consuming finishing process constraint, not as much of processing time, use of accessible and with good grace obtainable machine tool technology, appropriateness to automation, flexibility to robot use, being energy capable & ecological welcoming. In friction stir processing a particular type of cylindrical tool is designed, which is plunged into a chosen area of the sheet while revolving.

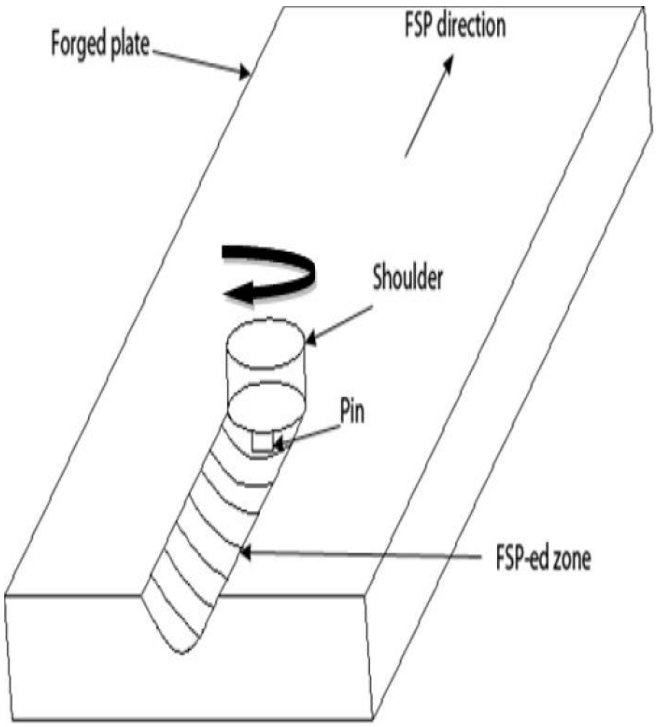

Fig.1 Principle of FSP

In Friction stir processing (Figure 1),Special tool is designed for FSP,it is a cylindrical tool which is plunged in the chosen area of the sheet while rotating. The tool is having a concentric large diameter Shoulder with a small diameter Pin. When the process is started the tool plunged into the sheet, so that the revolving pin links the face&due to this friction between the surface of the sheet and shoulder rapidly heat and a small area of metal is softened.

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The depth of saturation is provided by the tool shoulder&length of the probe.To achieve a fine grain size of the whole selected area of the processed zone during FSP the tool is stimulated relative to each other that the tool traverse,with overlapping passes. As the tool passes, the processed zone started cooling and forming a defect free&fine grained microstructure.

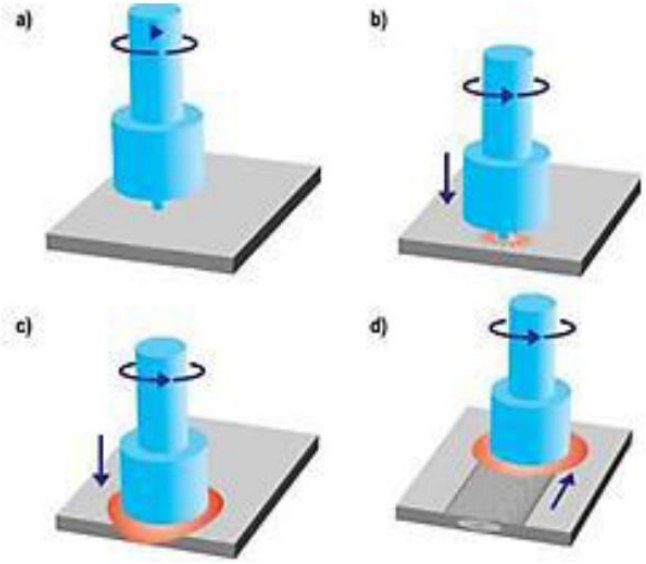

Fig. 2 Proper Working of Friction Stirs Processing

Table: 1. Effect of Various Parameters on FSP

Parameter	Effects
Rotational speed of tool	The material of the oxide layer broke and mingled, Stirring effect and frictional heat can be caused.
Tilt angle	For thinning and weld appearance.
Welding speed	Heat control and appearance.
Down force	Contact conditions maintained and frictional heat.

II. LITERATURE REVIEW

Kwon et. Al.(2003). In his research work he used Al1050 with the help of Friction Stir Processing, In his study author found that the hardness &tensile strength of Al1050 is increased while decreasing the tool rotation speed.At 500RPM there is an increase in grain refinement up to 37% as46% as compared to starting material.

Santella et al (2005) studies the effect of FSP on mechanical properties of A319 and A356 alloys. During this investigation It was established that the ductility and fatigue value and ultimate tensile strength is improved.

Darras et al (2015) investigated result of different friction stir allowance limit on thermal history and properties of AZ31B-H24 magnesium alloy sheet. It was found that in a single pass the microstructure is refinement and homogeneous . Control of heat input during dispensation and during severe plastic deformation fine grain size can be obtained in a single pass friction.

By Thomas et. Studied the rubbing action of two specimens with each other, causing friction for the purpose of providing heat. For the purpose of surfacing&processing technique,principle of this method is adapted from many traditional and novel friction welding. Any process is said to be good and eco-friendly when it does not produce filler wire, flux and no flames.

Mishra et. Al (3) Uses Al 5083 and aluminum 7075 in order to provide them super plastic, the FSW innovation <5µm is crystallized, equated & homogeneous. The disorientation is occurring at high angles ranging from 20° to 60°. To recognize the super plastic activities of FSP aluminum sheets they also performed high temp, tensile testing.

Sato et al. (4) Used FSW for an accumulated real-bonded (AR Bed) aluminum alloy 1100. The ArBed material shows the imitation of fine grain in the stir zone and also find tiny development of ultra fine grain, just outside the stir zone with the help of FSW. The function stir welding is reported to stop large reduction of hardness of ARBed material. Due to dynamic recrystallization and recovery the stir zone and TMAZ experiment small reduction of hardness.

Thomas et. Al. The friction stir welding(FSW) and friction plunge welding these are some of the new and fresh technique which are obtainable a review of friction for the material like stainless steel, aluminum and stainless steel to aluminum. Welding of unavoidable aluminum alloys and stainless steel feasible is made possible by FSP .Sheets up to 75mm thickness is welded with no trouble by this technology.

Mishra and Mahoney study about “High strain super plasticity in (FSP) of7075 aluminum alloys. In this study it outcome in considerable enhancement of superplastic properties. Observation of optimum superplastic strain rate 10^{-2} s^{-} at 490°c. The maximum elongation is about 10%. The average grain size is determined by mean linear intercept technique (grain size=1.78% linear intercept) and approximate 3.3±0.4µm.

In this study by MA et.al the commercial 7075 aluminum rolled plates are processed by FSP with different parameter and it results in Two fine grained 7075 aluminum alloy with a grain size 3.8 and 7.5 µm. In this process it is observed that the heat treating of FS sheets at 490°C for an hour it shows that fine grain microstructer are stable at high temperature. The temp. Range of 420-530°C. For superplastic investigation and the strain rate range of 1×10^{-3} - 1×10^{-1} s^{-1} was carried out. It is also observed that for the 3.8 µm 7075 aluminum alloy, superplastic elongation of > 1250% is obtained at 480°C with strain range of 3×10^{-3} - 3×10^{-2} $S^{-1.}$ Where as the 7.5 µm the maximum ductility is 1042% at 500°C and 3×10^{-3} S^{-1}. The conclusion is that the sliding mechanism was responsible for superplatic behavior.

Karthikeyan et al (2009) study the property of Friction stir processing on Cast 2285 alloy and accomplished that due to FSP the mechanical properties and microstructure are better. 30% enhancement in yield and tensile strengths were recorded and ductility greater than before around 4 times. He fulfilled that this development in mechanical properties was due to compact porosity and grain size.

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Sharma et al (2004) investigates the fatigue performance of friction stir processed A356 alloy. They found a reduction in silicon particle size and the compact porosity volume fraction in the FSP A356 alloy. An amplifying in the fatigue strength porch stress by >80% over the parent material following friction stir processing was reported. They have also found that FSP is used as a tool to locally adapt the microstructures in region achieving high fatigue loading and thus notably humanizing the overall presentation of aluminum castings.

Cavalier (2006) used aluminum alloy2014 with FSP. Sheet are similar to extrusion route&tensile properties are evaluated at room temperature. An electro-mechanical testing machine at a steady load up to 250Hz is used for the purpose of fatigue staying power(S-N).

Elangovan and Balasubramanian (2007) investigate dissimilar tool pin profiles like square, tapered, straight, threaded and triangular .The speed of all the FSP tools is different. The configuration of FSP zone is analyzed & tensile properties of the joints have been examined and linked with the FSP zone configuration. Examination is found that pin profile of square tool produces mechanically echo and metallurgically free of fault welds compared to other tool pin profiles.

Magdy and Ehab (2012) have investigated the effect multi-pass FSP process to study the mechanical and micro structural properties of aluminum alloy 6082. The amount of passes is more dominant on the DRX of grain size of the SZ than the traverse speed dials. They found that if the number of passes is increase it led to an raise the SZ-grain size.

III. CONCLUSION

Idea of FSP is relatively new. Many areas, which need through examination to study and make it commercially viable. On the basis of the text reviewed it has been experimentally that still there is limited investigate studies on optimizing the development parameters of friction stir processing. Optimization any development is very vital to recognize the result of method parameters on the properties of the processed material. In categorize to obtain the preferred finer grain size, convinced process parameters, like rotational and translation speeds, tool geometry etc. are to be forbidden.

IV. FUTURE WORK

As per studied in above it is found that FSPis a new and unique technique and there are many aspects that can be investigated for the purpose of establish good relation between process parameter, resulting force and grain size to optimize FSP process that can be applied for industrial.

- If the samples that can be used for FSPare preheated they might reduce forces significantly &due to this finer grain are optimized.
- IN FSP tool plays an important role so modification in tool design and material is also an area of research.
- Investigation on the force generated in a single pass and multiple pass at different process parameters and for different alloys is also a future work.
- Testing of FS processed sheets like deformation mapping,tensile test at high temperature,and microhardness testing are some other area of interest.

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