FRICTION STIR PROCESSING: A REVIEW

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Abstract: Friction stir processing (FSP) is technique to change the properties of materials by intense, localized plastic deformation. Friction stir processes are rapid, environmentally friendly and also founds its wide application in today's manufacturing industry such as aerospace, marine etc. The present study is done to observe the outcomes associated with friction stir processing. The overall contributions presented by different authors have been illustrated in the paper.

Index Terms **- Friction stir processing (FSP); Rotation speed (RS); Tool tip shape; Tool plunge depth.**

1. INTRODUCTION

In late world a load of delivering lighter things while using less vitality and doing less regular harm with lower cost and in a nutshell time extended. Different issues (shrinkage, solidifying breaking and porosity) associated with traditional mix welding frameworks ends up being colossal obstruction in meeting the models which lead to more wasting of material, time and money. To defeats different such issues, a need of new welding development rise which makes Friction stir or rubbing mix welding method. This welding system was structured by Wayne Thomas at The Welding Institute Ltd in 1991. Rubbing mix welding is a strong state process which fabricates first class welds even in difficult to weld materials. Rubbing mix welding procedure has gotten generally speaking thought, and today it is used for creation as a piece of different sections like avionics, railroad, vehicle, shipbuilding, heat exchangers, and nuclear waste compartments. In grinding mix welding process the material to be welded is cinched solidly, at that point the gadget is accomplished in work piece which is to be welded at certain point until the gadget shoulder contacts the outside of the work piece in within line. The material used as a tool is harder than the material to be welded. At the starting point tool is plunged and rotated without advancement to achieve the required temperature, once the temperature is attained feed is given. Due to raise of temperature the material gets smooth and stream towards the mechanical assembly turning heading and weld occurs. [1-3]

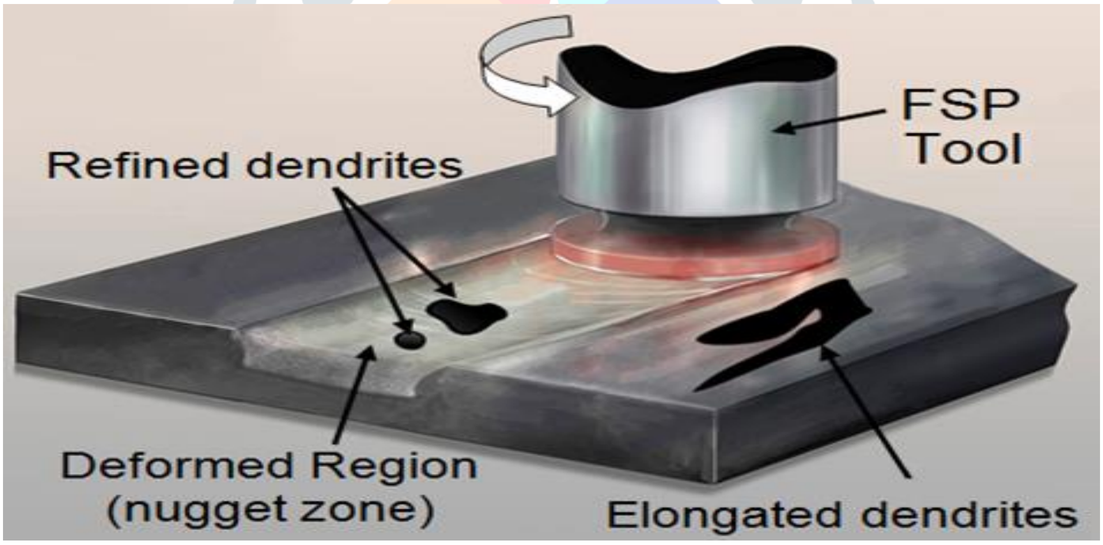

Fig: Friction Stir Processing [4]

2. LITERATURE REVIEW

Khodabakhshi et al. (2014) studied that effect based on tool travel speed (70,85,100 mm/min) on Al matrix nano-composite were forged by stir processing of Al-Mg alloy sheets with pre placed TiO_2 splinters causes in situ formation containing MgO and Al_3Ti nano-phases within an average size 50 nm. The adding of TiO_2 particles increased grain improvement of Al matrix during FSP.

Rajesh et al. (2014) studied that the effect based on tool traveling speed (20-60 mm/min) within Al6016 plate with 6 mm thickness**.** Different proportion of alumina and $Al(NO_3)^3$ powders were diverse and filled in channel to form Al plate . Tool of cylindrical pin and threaded profile was formed. The process parameters were traverse speed, axial load, rotational speed. Optical micrography displays that the exterior composite layers are superior bonded to Al alloy substrate and no defects were found at stir zone. By Friction stir processing the grain size was found out to be more refined. It was been observed that using single ceramic particle composite of hybrid surface shows more hardness than the surface composite.

Thangarasu et al. (2014) AA1050/TiC SMMC was made-up using Friction Stir Processing the forged AA1050/TiC mixture coat was good-bonded to Al substrate. Homogeneous circulation of TiC particles in the stir zone. The micro-hardness of the Friction Stir Processing zone was increased through 45%, TiC particles improved the hardness of aluminum alloy. The middle hardness of zone is 45% higher as compare to base metal at 1200 rpm and 60 mm/min with force 10 KN.

Yadav et al. (2014) proposed that the effect of reinforced particles on AL6082/Cu through thickness of plate 6 mm. The UTS of the base metal (314 MPa) falls after processing lacking composite (133-152 MPa). It was explained that the UTS of samples procedure using cylindrical threaded tool profile (152 MPa) is further than that of square profile (133 MPa). For sample processed with copper composite using the threaded cylindrical tool pin profile through1000 rpm and 16 mm/min, UTS of 161 MPa while for the processing using square profile tool through composite, UTS of 156 MPa was measured. Superior hardness values were obtain for plates processed by composite (77 HRB – 84 HRB) compared to those measured for non composite processed plates (64 HRB- 70 HRB). It was also detected that the percentage elongation in the specimen lacking composite (30.9%-33.4%) were superior than those by composite. The Al-6082–Cu MMC can have achievable applications in fields requiring more surface hardness values, mainly for localized treatment of machine components that undergo extensive wear through service. Also the non composite FSP Al- 6082 can have wide-ranging applications in fields like aerospace, automotive, and other metal forming factors that desire more plasticity as get through out application of Friction Stir Processing. But the best values of the procedure parameters require to be selected so as to avoid degradation in tensile properties.

Langlade et al. (2014) proposed that the effect of transverse speed and tool rotational speed of stirred coating on 316L steel produced by FSP. Process parameters were rotational speed (1000,710 rpm) and transverse speed (20,40,56mm/min). In this nanostructure materials are recognized to exhibits good properties, specifically in mechanical area where the hardness is in higher interest. The processed films have been distinguished in term of micro-hardness and microstructure and these solutions were related to Friction Stir Processing parameters. Best value of hardness 130 Hv is obtained at 40 mm/min.

Gupta et al. (2013) concluded that the surface of Al5083 matrix which was refined by SiC nano particles by friction stir processing was investigated and then compared with Al5083 alloy on the bases of microstructure, hardness and wear condition. The current study shows that doping of AL5083 through SiC particles with Friction Stir Processed leads to raise the micro-hardness of the composite produced on Friction Stir Processing sample layer. The micro-hardness is maximum at SZ 155 HV at 60 mm/min and rotational speed 500 rpm. Wear resistance of the weld was inferior for Al5083 despite of higher hardness.

Sathiskumar et al. (2012) investigated B_4C particulate reinforced copper as outside composite and they created defect-free composites. The parameters used were traverse speed (20,30,40,50,60 mm/min) and rotational speed (1000,1100,1200 rpm). The area of the outside composite raised while rotational speed increases and reduces when the traverse speed increases due to the heat generation and area of outside composite decreases with increases in groove width. The maximum hardness 132 Hv at 1200 rpm was observed.

Jerome et al. (2012) proposed that the effect of tool rotational speed on outside composite formed by single pass Friction Stir Processing through groove design, the middle hardness together with top outside was formed to improve by 22.72%as compared to base metal whereas in case of double pass friction stir processing in same and opposite direction, the middle hardness together with top outside was established and was enlarged by 25% and 27.27% as compared to base metal. Parameters are used as 1400 rpm, 1120 rpm and 900 rpm through 6 mm/min transverse speed. The highest average depth of 250 μm in hole-design was found in surface composite. It was observed that with raising tool rotational speed hardness also enlarge and best value is 108 Hv at 1400 rpm.

Davidson et al. (2012) observed that the effect of rotational speed on the micro structural modify and the mechanical properties of FSP Mg AZ31B alloy sheets has been considered. FSP was carried out at rotational speeds in the variety of 900 to 1400 rpm within an unvarying traverse speed of 32 mm/min. The results show that the rotational speed has an important effect on the microstructures as well as on the mechanical properties of the processed material and establish that the optimal rotational speed provides maximum mechanical properties.

Kanimozhi et al. (2011) proposed that the FSP of AA6082 combination with an assortment of extent of Silicon – Graphite composite was affirmed out right now their hardness esteem is determined. The most elevated hardness of 140 BHN was acquired through the traverse speed of 60 mm/min at 500 rpm. The reinforcement percentage has 8% Si and 0.5% Gr half breed composite without fault and sound outside composites were created inside the assortment of chose parameters.

Salehi et al. (2011) proposed that effect tool travel speed (20,40,60 mm/min) rotational speed (900,1600,1900 rpm) and pin profile (cylindrical threaded and square tool pin) on AA6061/Sic nano composites made by FSP. The FSP procedure parameters were upgraded to augment the rigidity of ASNCs. The best type of the rotational speed, transverse speed, apparatus entrance profundity, and pin profile were seen as 1600 rpm, 40 mm/min, 0.30 mm and strung sort in a specific order.

Weiping et al. (2011) proposed that carbon nano-tubes (CNTs) strengthened AL matrix composite was sorted out by FSP. The impact of CNTs substance wearing performance and hardness of AL grid composite was contemplated. Results demonstrate that CNTs strengthened AA1100 and AA6101 grid composites through Friction Stir Processing are to create a well scattering of CNTs in the network and to get a well blend through the framework. The edge of CNTs and pure aluminum lattice is smooth, no deformities and is one sort of mechanical boding interface. There are overwhelming quantities of disengagements. CNTs can quality the grid composites productively and clearly show signs of improvement the hardness of the composites. With raising CNTs content, CNTs can likewise show signs of improvement the wear introduction of the network composites.

Hamed Seifiyan et al. (2019) studied corrosion behavior of AZ31B Mg alloy on friction stir processing conditions. The welding parameters were tool tilt angle (3°), penetration depth (0.4mm), tool rotational speed (800,1000,1250,1600rpm), traverse speed (50,80mm/min) with number of FPS passes were (1-3). The optimum results of microstructural analysis show that stir zone has fine grains as result from dynamic recrystallisation. The corrosion analysis shows that at 1000rpm and 50mm/min, corrosion behavior was maximum. The R_{ct} value increases from 313.3Ωcm^2 to 1081 and 1629Ωcm^2 from as-received alloy to 1-pass and 3-pass sample

Namrata Gangil et al. (2019) investigated on AA7050-T7451 friction stir welded through friction stir processing. The friction processing parameters were rotational speed (710rpm), traverse speed (63mm/min), tool tilt angle (2°) and FSP pass (1). The optimum results were observed as the grain refinement from 130μm to 5-8μm in stir zone due to dynamic recrystallization during friction stir processing. The micro-hardness was enhanced the defects like tunneling defect and incomplete root penetration was found. The tensile strength reduced due to the defects. The highest joint efficiency 69.53% was found at 710rpm.

Sipokazi Mabuwa et al. (2019) investigated AA1050-H14 and AA6082-T6 friction stir welded joint on the bases of friction stir processing. The friction stir welding and friction stir processing parameters were rotational speed (1200rpm), travelling speed (40mm/min), tilt angle (2°). The optimum results were the tensile strength 82.2MPa and yield strength 61.1MPa increases with FPS technique. The maximum microhardness of 80Hv was observed. The friction stirs processed joint shows ductile failure based on fractured surfaces.

C. Chanakyan et al. (2019) investigated AA6082 plate using response surface methodology. The process parameters were rotational speed (900,1100,1300rpm), transverse speed (33,45.5,58mm/min), axial load (4,5,6kN). The optimum result of the mechanical properties like tensile strength and hardness were the maximum tensile strength was 144.5MPa at rotational speed(1300rpm), transverse speed 58mm/m. The maximum hardness of 93.01HV was found at 1300rpm and transverse speed 58mm/min.

Dwarakesh S. et al. (2019) investigated friction stir processed composite AA7050/$SrCO_3$. The process parameters were spindle speed(1000,1200,1400rpm), feed rate (15,20,25mm/min) and penetration depth (0.2,0.25,0.3mm). The optimum results of the process are that the spindle speed 1200rpm, penetration depth(0.25mm) and federate 20mm/min were optimum parameters which didn't show any defects. The maximum tensile strength shown by composite is 213.36MPa which is slight lower than base metal. The maximum hardness of 153VHN was observed. The microstructural analysis shows fine distribution of SrCO3 on AA7075 plate.

Vikram Kumar S. Jain et al. (2019) investigated on Al5083-CNTs SiC composites on the bases of friction stir processing. The process parameters were rotational speed (1600rpm), traverse speed (20mm/min). Different samples like AL5083 alloy, Al5083-SiC, Al5083-SiC/CNTs and Al5083-CNTs were examined. The optimum results from the experiment were the average gain size of different samples was 5.83μm-6.36μm. The tensile strength of 361MPa was highest for AL5083-SiC/CNTs. The average microhardness 124.50±6.22Hv, 112.50±5.62Hv and 107.50±5.37Hv for AL5083-SiC, Al5083-SiC/CNTs and AL5083-CNTs respectively.

Nan Xu et al. (2019) investigated on AZ31B Mg alloy on CSA friction stir processing. The process parameters were traverse speed (400mm/min), rotational speed (600rpm), tool tilt angle (3°) and plunge depth (0.2mm). The optimum results were like the top surface of stir zone shows highest hardness and tensile strength. The maximum hardness of 84Hv was found which more than base metal was. The maximum tensile strength, yield strength and elongation were 235MPa, 88MPa and 21% respectively.

3. CONCLUSIONS

- Tool rotation speed increase parallel increase the tensile value till the critical point, further it starts declining.
- Dissimilar and similar materials can be processed or welded easily and effectively.
- Hardness of materials reduces due to thermal softening.
- It's a non consumable tool process.

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