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RESEARCH ARTICLE

EFFECT OF FRICTION STIR PROCESSING PARAMETERS ON THE TENSILE STRENGTH OF SURFACE COMPOSITE ALUMINUM ALLOY.

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Abstract

In the current study, the surface composite sheet of AA2024/al203 has been fabricated using friction stir processing technique. The processing parameters during fabrication process; such as rotation speed, travel speed and number of passes have been investigated. The number of passes has a significant effect on the mechanical properties through tensile test. The results revealed that tensile strength improved with increasing passes number.

Introduction:-

Increasing demand for improving the properties of surfaces in order to meet with design and functional requirements. Friction stir processing (FSP) is one of the techniques for fabricating surface composites and modifying microstructural features, furthermore the improvement of mechanical properties. Process parameters are the key art of Friction Stir Processing. The stirring conditions (rotational and translational speeds) are important issues in FSP to obtain the desired mechanical properties.

Many researchers were discussed the relation between the process parameters and the quality of welded or processed metals according to [1,2,3,4]. The Tensile strength is found to be increased with increasing the rotational speed up to specified limit for AA6351 Al alloys as reported by [5].The tensile properties and fracture locations have been investigated by many authors [6,7,8] they are fabricated metal sheets alloy using FSP. The results are revealed that the rotational speed has a significant influence on the tensile strength as a result of improving grain refinement of the material. The mechanisms of particle refinement during FSP of pure Al, and the effect of various processing parameters on the particle refinement have been studied by [9]. The investigators reported, that amount of heat generation during FSP was increased when rotational speed increase and decrease when transverse speed increase. Fabricating AA1050/SiC surface composite using FSP technique has been investigated by [10] the author concluded that , the formation of defects are causing at higher tool rotational speeds. The surface composite sheets are investigated by [11,12,13,14,15,16], they are concluded that tool rotation speed has a major effect on the mechanical properties and microstructure refinement.

The effect of multi-pass FSP on the, microstructure, micro hardness and tensile strength on the metal alloy and composites have been studied by [17,18,19,20,21,22].Multi pass FSP not only improve the mechanical properties , but also get defect-free weld through adjusting the Welding parameters, including tool rotation rate, traverse speed, spindle tilt angle, and target depth [23] . multi-pass with even step (2, 4 up to 8-pass) FSP with 100% overlap was performed by [24] The results reported that multi-pass FSP were improved tensile properties of composites including UTS, yield strength (YS) and elongation. The authors were reasoned this improvement because of reduced

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porosity contents.CNT/2009Al is fabricated by combination of Powder Metallurgy and FSP by [25]. It was observed that as the FSP passes increased, there was good dispersion for CNT in the matrix, and the maximum tensile strength increased with increasing the passes number.

In the current investigation the aim of this work is to fabricate a surface composite sheet from AA2024 aluminum sheet and alumina nanoparticles, in order to enhance the tensile properties though overlap multi pass friction stir processing.

Experimental work:-

The wrought alloy sheets of AA2024 has been prepared and the Annealing is done at 410 ˚C for 2 hours, followed by slow cooling in the furnace to relief the remaining residuals stresses after clod and hot sheet metal working and improve ductility and dimensional stability. A rectangle slotted groves are machined in each plate. The alumina nanoparticles are filled the grooves, then the friction stir processing has been carried out to fabricate the desired surface composite. The chemical composition for AA2024 wrought alloy is given in (Table 1). An automatic milling machine is used to perform FSP at different combination of processing parameters. The tool rotation speed was vary at different four rotation speed 900, 1100, 1500, 1800 rpm. Processing travel speed was chosen at three speeds (10, 15, and 20) mm/min, the last factor that effect on the process is the number of passes, and it is design to be processed at three overlap level.

Table 1:- Chemical composition of the as received AA2024 alloy (weight %)

Element	Cu	Mg	Mn	Zn	Fe	Si	Pb	Al
%	4.89	1.45	0.616	0.156	0.11	0.107	0.0193	Remain

Tensile Test:-

Tension test has been performed by MTS machine as shown in "Fig. 1". According to ASTM B557 with standard specimens along the processing zone as shown in "Fig. 2". The samples are tested in order to evaluate the tensile properties such as young's modulus, ultimate tensile strength (UTS) and yield stress (YS).

Fig 1:- Universal tension test machine

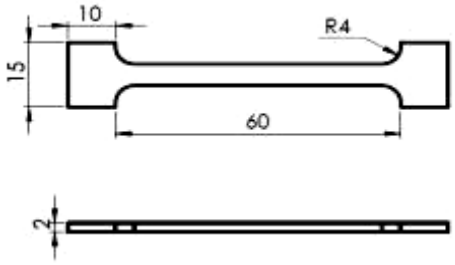

Fig 2:- Schematic drawing for standard tension test sample

Results and Discussions:-

The mechanical properties and material flow pattern are influenced with the Processing parameters such as tool rotation speed, longitudinal traverse speed and number of passes .The tool rotation speed effect on the tensile stress, but the ductility is decreased by 50% with respect to the base metal as shown in "Fig.3". As-received alloy has the highest elongation. The results reveal that, although the addition of Al_2O_3 Nano powder increases the strength, it decreases the ductility which it was congruent with [26].

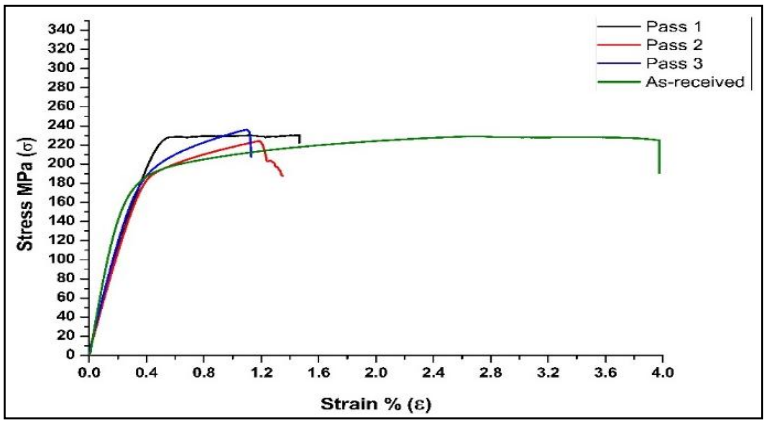

Fig 3:- Tensile strength samples tested at 900 rpm with 10 mm/min travel speed

Higher tool rotation speed increases the heat produced during friction stirring action, the high temperature in this metal matrix causes defects during processing specially in the first pass. The rotation speed 1500rpm and 1800 rpm resulting poor surface composite. The tensile strength curves show preference of low rotation speed rather than using higher speeds as shown in "Fig.4" and "Fig.5". The first pass noticed that, it is insufficient to improve the mechanical properties because some voids or defects are remained in the matrix. These results are in accordance to the previous results [27, 28, 29, 30].

Enhanced results for these metal matrixes composite are obtained at relatively low speeds with 10 mm/min and 15 mm/min traverse speed as shown in "Fig. 6". The improvement in the surface tensile properties is explained due to provide the sufficient heat during stirring process.

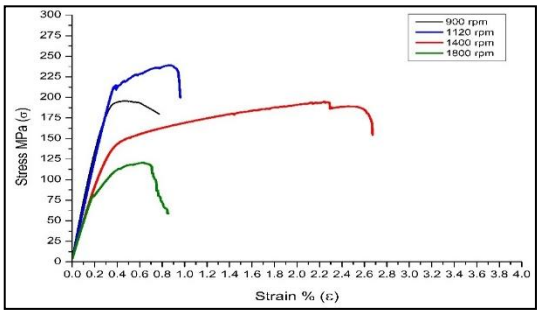

Fig 4:- Effect of rotational speed on tensile strength at 10 mm/min travel speed for the 1st pass.

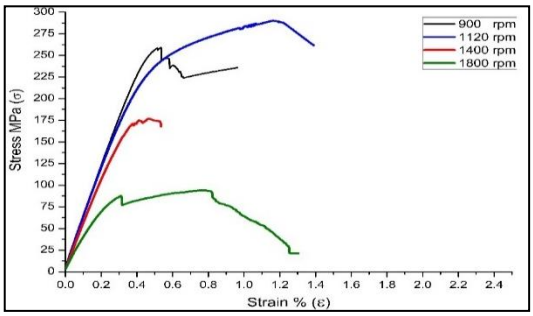

Fig 5: -Effect of rotational speed on tensile strength at 15 mm/min travel speed for the 1st pass

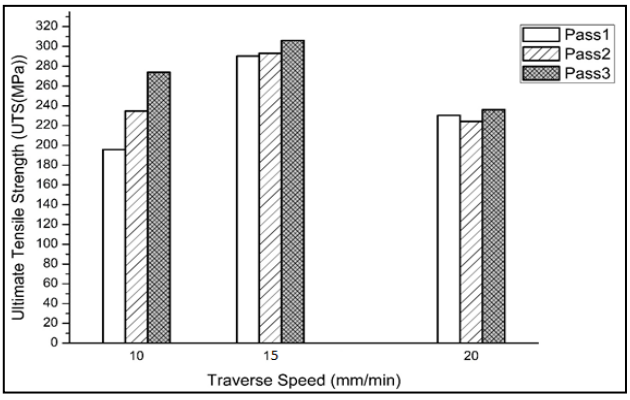

Fig 6:- Effect of traverse speed on the ultimate tensile strength at constant rotation speed 900 rpm.

Ultimate tensile strength (UTS) results are represented in the comparison curves which, illustrates the effect of rotation speed on the ultimate tensile strength throughout different passes number as shown in "Fig.7" and "Fig. 8". Tool rotations speed performed at 900-rpm and 1100-rpm have a higher ultimate tensile strength than other speed specially when processed at 10 mm/min and 15 mm/min traverse speeds. Third pass causes an improvement in the tensile strength which, the maximum value for UTS is improved by 27 % rather than base metal. Tool rotation speed at 1800-rpm remarked that, having a lower UTS.

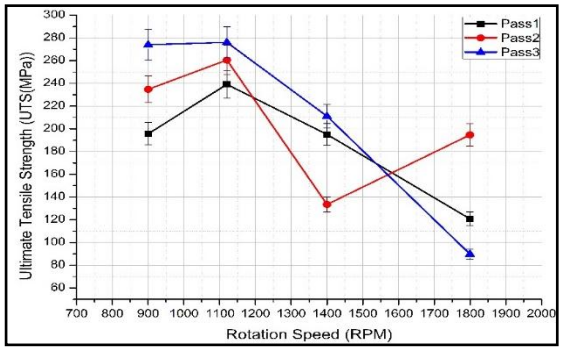

Fig 7:- Effect of rotational speed on UTS at 10 mm/min travel.

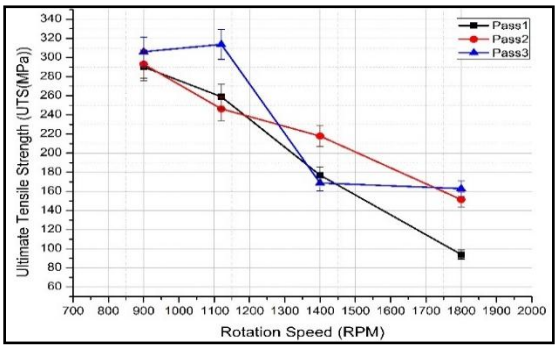

Fig 8:- Effect of rotational speed on UTS at 15 mm/min travel.

Conclusion:-

This paper present the effect of processing parameters on the tensile properties of surface composite alloy fabricated by friction stir process. The results are concluded that:

- The average tensile strength of friction stirring processed specimen are improved by 10% as compared to the base metal
- The ductility of resultant metal matrix composite was decreased by 50% due to presence of alumina particles in the matrix.
- The superior tensile strength is achieved at low rotational speeds of 900-rpm and 1100 -rpm with medium travel speed 15 mm/min.
- Increasing the number of FSP passes lead to refinement the grain, furthermore good distribution of alumina nanoparticles in the composite matrix.

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