Additive Friction Processing on AA-7075 for Defence Applications

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Abstract— **This is a review paper on FSP and its techniques followed to produce a hybrid composite Materials. Composites are materials in which two phases are combined, usually with strong interfaces between them. They usually consist of a continuous phase called matrix and discontinuous phase in the form of fibers, whiskers or particles called the reinforcement. Considerable interest in composites has been generated in the past because of their outstanding properties especially low weight high strength. The objective of this exertion is to manufacture the Aluminium based hybrid composite by using Friction Stir Processing (FSP). The Hybrid composites are known as it contains more than one fiber or one matrix system in a laminate. Aluminium and its alloys are commonly used in Marine, Concrete, aircraft structures and transportation industries because of their high strength to weight ratio.A7075 and its reinforcements particles reinforced metal matrix composites (PRMMC) was produced by friction stir processing (FSP). The optical microscopy, hardness tests used to characterize the samples. The results indicated that the uniform distribution of reinforcements in A7075 matrix by FSP process and heat treated this can be improve the mechanical properties of samples. Therefore pretending the mechanical performance of a composite plate is very important to assess the protection of the plate.**

Keywords— Friction stir processing, Friction Stir welding, FSP, FSW, CNT, Aluminium-7075

I. INTRODUCTION

In this review paper the attempts made for producing hybrid composites are explained up to the limit. Composites fabricated by using Friction Stir Process Technique Aluminum alloys are generally classified as non-weld able because of the poor solidification microstructure and porosity in the fusion zone. Also, the loss in mechanical properties as compared to the base material is very significant. These factors make the joining of these alloys by conventional welding processes unattractive. Some aluminum alloys can be resistance welded, but the surface preparation is expensive, with surface oxide being a major problem. As Aluminium alloys are soft, conventional fusion welding of these alloys involves various defects like wider weld beads, coarse grains, high distortion and residual stress state of the joint, porosity and corrosion stress cracking. Friction Stir Welding process is an emerging solid state joining process in which the material that is being welded does not melt and recast. This process uses a non-consumable tool to generate frictional heat in the abutting surfaces. The welding parameters and tool pin profile play major roles in deciding the weld quality. It has many advantages over the conventional welding techniques some of which include very low distortion, no fumes, porosity or spatter, no consumables (no filler wire), no special surface treatment and no shielding gas requirements. FSW joints have improved mechanical properties and are free from porosity or blowholes compared to conventionally welded materials.

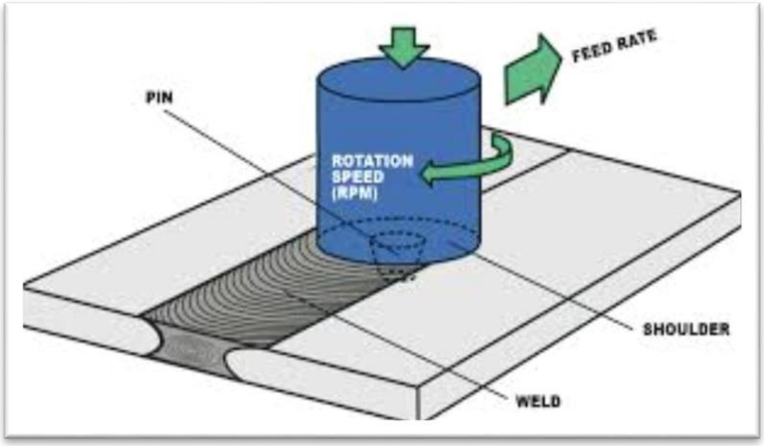


Fig 1. Basic Principle for FSW/FSP[1]

II. FRICTION STIR PROCESS

Friction stir welding (FSW) is a relatively new solid-state joining process. This joining technique is energy efficient, environment friendly, and versatile. In particular, it can be used to join high-strength aerospace aluminum alloys and other metallic alloys that are hard to weld by conventional fusion welding. FSW is considered to be the most significant development in metal joining in a decade. Recently, friction stir processing (FSP) was developed for micro structural modification of metallic materials.[1] A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint. The tool serves two primary functions: (a) heating of work piece, and (b) movement of material to produce the joint. The heating is accomplished by friction between the tool and the work piece and plastic deformation of work piece.

The localized heating softens the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to the back of the pin.[2] As a result of this process a joint is produced in 'solid state'. Because of various geometrical features of the tool, the material movement around the pin can be quite complex. During FSW process, the material undergoes intense plastic deformation at elevated temperature, resulting in generation of fine and equaled recrystallized grains. The fine microstructure in friction stir welds produces good mechanical properties.[3]

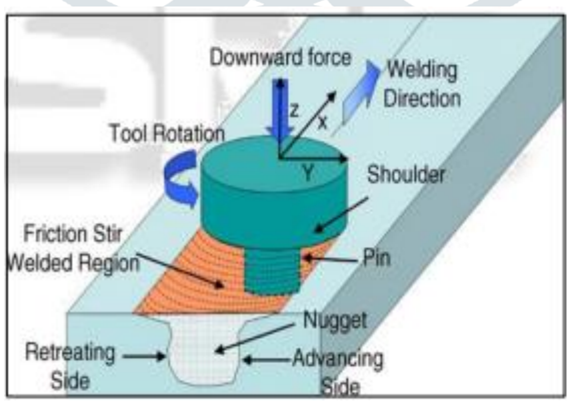


Fig. 2: Friction Stir Process[19]

III. BENEFITS OF FRICTION STIR PROCESSING

Solid phase process ,Low distortion of workpiece ,Good dimensional stability and repeatability ,No loss of alloying elements ,Excellent metallurgical properties in the joint area, Fine microstructure, Absence of cracking,Replace multiple parts joined by fasteners, Decreased fuel consumption in light weight aircraft, automotive and ship applications.[4]

IV. TOOL DESIGN

A friction stir process (FSP) tool is obviously a critical component to the success of the process. The tool typically consists of a rotating round concave shoulder and a conical pin that heats the work piece, mostly by friction, and moves the softened alloy around it to form the joint.[5]

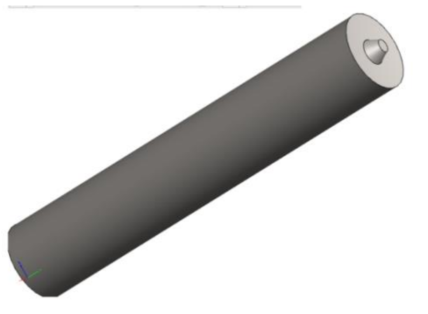
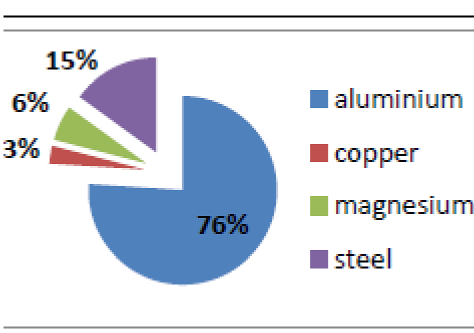
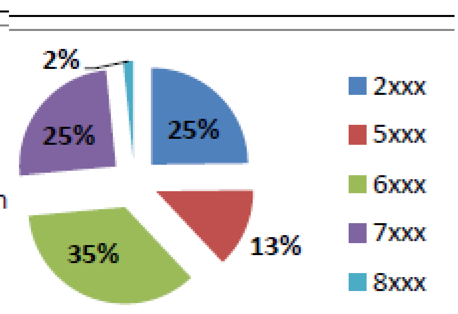


Fig.3: Actually designed FSP Tool

V. LITERATURE REVIEW

In present day scenario the application of high strength, low weight metal alloys are increasing very rapidly in the arena of aerospace, aircraft, marine, etc. Producing sound joints in these materials employing existing welding techniques is major concern. FSW process owing to its unique characteristics is emerging as an alternative welding technique. According to available literatures FSW technique is capable of joining similar or dissimilar metals or alloys and the list of workpiece materials can be joined by FSW technique includes aluminium, magnesium, copper, steel, zinc, nickel and its alloys. A comparative study of published research work on FSW of different materials is illustrated in Fig. It is obvious from Fig. 5 that most of the research work is concentrated on aluminium owing to its industrial applications and difficulties experienced by researchers during fusion welding of aluminium. In this paper an attempt has been made to summarize the work already carried out and to provide a guideline for future research work. A brief overview of different aspects of FSW process is presented here. [1.]





Aluminium and its alloys are widely used in aerospace, marine and automobile applications owing to their unique characteristics: high strength to weight ratio, high corrosion resistance, high ductility, etc. But joining of aluminium and its alloys by fusion technique is troublesome which establishes the necessity of FSW technique for joining of aluminium and its alloys.It is evident that after Friction stir processing of aluminium, there is a notable increase in its mechanical properties. But for defence applications, better properties are required, thus creating a need for addition of filler materials during FSP. Carbon and its allotropes have a great impact on strength of materials while being economical.CarbonNanotubes have high strength to weight ratio (almost equivalent to Kevlar), high fatigue resistance making it the most suitable additive for this application. Other carbon based additives like Carbon black and Carbon Fibres also make for excellent additives.

SiC particles were used as fillers on AA6061-T6 rolled plate. The SiC particles were distributed uniformly within the nugget zone with zero defect. Tensile properties increased 50% by applying the post-process artificial aging treatment at at 170oC for soaking amount of 16hr.[2] Post-processing heat treatment on the microstructure and microhardness of water-submerged friction stir processed 2219-T6 aluminium alloy was studied during this paper. The post-processing aging treatment over-aged the watersubmerged friction stir processed samples, that resulted in any decrease of the microhardness within the stirred zone. The softened region within the water-submerged friction stir processed sample was eliminated by the post-processing solutionizing followed by water quenching and aging treatment. [3] The enhancement of mechanical properties via Cyclic Solution Treatment was attributed to the repetitive partial dissolution of enormous MgZn2 precipitates and formation of fine metastable MgAlCu precipitates. The preservation of the fine grain structure and therefore the dispersion of fine stable MgAlCu precipitates when aged subsequently for twenty-four hours at one hundred thirty ˚C caused a big improvement in hardness (~ thirty-nine %), yield stress (~ eleven %), and ultimate tensile strength (~ ten %) of the joints without a considerable change in the ductility compared with the base plate in T6 condition. [4] The aging induces the hardness to extend by about 30% in stir zone with reference to the as-FSPed material, whereas, the FSP combined with aging treatment ends up in about 80% improvement within the hardness of base material. The wear and tear rate is reduced by artificial aging of Al alloy that continues to decrease more and more by aging following the FSP method. Based on the TEM observations, the properties are improved following the duplex FSP−aging method which will be attributed to the precipitation of terribly fine particles. [5]. The necking zone occurred typically at the HAZ, wherever dynamic recrystallization occurred, and consequently, a lower hardness was obtained. From the multivariate analysis results it's proverbial that the temperatures within the pin may be considered an even distribution which the warmth transfer starts from the rim of the pin to the sting of the piece of work, some following a second-order polynomial equation. [6] At any instant throughout welding, forces are conveyed on the pin by the material flowing around it. The position of the resultant force helps predict the incidence of voids within the lump. If the heat index of the method will increase, the magnitude of the resultant force falls. For nuggets without defects, the resultant force acts within the region between the trailing edge and advancing side. [7] There's a rise within the variety of studies of FSW of high strength materials whose temperature of transition to the plastic state is more than that of Al alloys (steel, titanium, metal and copper alloys). There's additionally increase the amount of studies allotted to enhance the welding tool. The FSW method has been developed most expansively for the fastening of Al structures. [8] The residual stresses occurring in FSP operations are primarily because of the thermal flux generated by the work done by the resistance forces decaying into heat, specifically the shoulder–workpiece interface is that the most related active heat source; on the opposite hand, the stirring action of the tool pin results negligible as regards to residual stresses. In process quenching permits to enhance the standard of the final product with lower values of residual longitudinal stresses.[9] There area unit 3 sorts of FSW/P tools ,i.e. fixed, adjustable and self-reacting, The fixed probe tool corresponds to one piece comprising each the shoulder and probe. This tool will solely weld a work-piece with a relentless thickness because of the fixed probe length. The adjustable tool consists of 2 freelance items, i.e. separate shoulder and probe, to permit adjustment of the probe length throughout FS. The spool kind tool is created of 3 pieces: high shoulder, probe and bottom shoulder.[10] In each series of welds made by different tools, increasing rotational speed and decreasing welding speed result in weaker welds and coarser grain size in the weld nugget. In all the welds, the hardness profile on the AA 6061 side shows an abrupt decrease. However, this hardness variation is smoother in samples welded by the tool with a concave shoulder and a conical probe.[11] Tool deformation and wear occurs because of the high temperature and loading forces during welding. The tool wear occurs for two main reasons, i.e. plastic deformation of the tool and by physical wear of the surfaces. The mechanical deformation is affected by complex thermo-mechanical loading conditions and the material properties at high temperature. The physical wear is often affected by the particulates in the base material and also chemical interaction between the material being welded and the tool materials.[12] Kim et al. studied the combinations of different process parameters on friction stir welded aluminum alloy. He proposed the optimum welding window for the process parameters to avoid the defects formation during welding. Ramulu et al. proposed a criterion based on axial force, torque and process parameters for identifying defects in friction stir welding of 6061 aluminum alloy. Fractal theory states the inherent irregularity of the natural objects. Higuchi‟s algorithm is implemented in order to estimate the fractal dimensions of the signal. The estimated fractal dimensions show higher values for defective cases than the signals for the cases which are defects free. Appreciable difference between the defective and defect free fractal dimensions point that fractal dimension of signals can be an effective single valued indicator for detecting the presence of defects and hence monitoring of friction stir welding process.[13] Formation of tunnel defects: If the process conditions, i.e. weld travel speed, tool rotation, etc., fail to come up with the desired heat for bonding, inadequate material combination and stirring will occur, leading to the formation of tunnel defects (Grujicic et al. 2010). A weld made beneath too cold attachment conditions becomes macroscopically laborious and fracture will occur through the defect.[14] Formation of flash defects: the material being welded experiences very popular process conditions because the tool pin rotates at terribly high speeds. Therefore, excessive heat generated, thermally softens the fabric close to the boundary of the tool-shoulder and expels giant volumes of fabric within the kind of surface flash. Excessive tool shoulder resistance heat softening of the fabric is that the reason for the formation of the flash.[14] Formation of voids: The presence of voids within the weld could be a common defect in friction-stir welds. The fluid dynamics related to plastic flow within the weld hunk plays a key role within the formation of such voids. More increase in speed results in the formation of larger hollow defects[14].

VI. TESTING PARAMETERS

By analyzing the specimen with SEM test, Mechanical Characteristics and corrosion behavior and XRD and EDAX test and also with the corrosion behavior we can justify the specimen with its reinforcement which is suitable for the specified applications.

VII. CONCLUSION AND FUTURE SCOPE- In this paper, a critical review of different aspects of FSW technique has been demonstrated. Following points can be concluded:

Friction stir welding owing to its unique characteristics: low distortion and shrinkage even in long welds, free of arc, filler metal, and shielding gas, low HAZ, free of spatter and porosity defect is emerging as an alternative to fusion welding. FSW is found suitable for joining similar or dissimilar metals or alloys including aluminium, magnesium, copper, steel, zinc, nickel and its alloys, plastics, etc. It is evident that FSW process parameters: tool rotation rate, traverse speed, spindle tilt angle influence the mechanical and metallurgical behaviour of joints and hence, are crucial to produce sound and defect-free weld. The influences of the input process parameters on process performance characteristics and interaction effects are not significantly explored. In-detail study of contribution of the individual input process parameters on process performance characteristics is lacking in literature. In-detail study is required to explore the effect of preheating, nanoparticle inclusion and quenching on mechanical and metallurgical behaviour of FSW joints. No proper guideline in terms of mathematical/theoretical model of process performance parameters of FSW is available for selecting input parameters to obtain desired output.

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