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Investigate the effect of process variables on the mechanical behavior of aluminum composites using the Friction Stir Process

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Abstract

The aim of this research is to provide a thorough elaboration of metal matrix composite manufacturing using various combinations of reinforcements and the principles of friction stir technique, as well as the effect of the input process parameter on material characteristics, as conducted by various research groups. The investigators began to look for a link between the experimental parameters and the output responses. Friction stir welding and processing use a fraction of the energy of other processes. The metal matrix composites replace regular used materials for many engineering applications with their unique mechanical and metallurgical properties, strength, durability, corrosion resistance. The friction stir process's process parameters, which include rotational speed, tilt angle, feed rate, and deposition rate, have a significant impact on the mechanical properties of fabricated composite surfaces. The solid state nature of the processing method has resulted in an improvement in various properties in surface composites. The pin profile also affects mechanical characteristics significantly. On surface composites, the current study will provide a concept for a defect-free weld with higher and improved mechanical properties.

Keywords: Governing parameters, FSP, Al-Composites.

I. Introduction

In the automotive and aerospace industries, popular materials like iron and steel are increasingly replaced by light materials like magnesium or aluminum alloys to obtain a special strength-to-weight ratio [1]. However, due to their low stiffness, aluminum and magnesium alloys are not suitable for structural applications. Consequently, the benefits in structural design are limited by the use of lightweight aluminum or magnesium alloys. To overcome this concern, an attempt has been made to construct MMC using lightweight metal as the matrix [2]. Carbonate, SiC, TiC, oxides, boride, and carbon materials are frequently used as reinforcements in the fabrication of MMC and are used in the form of particles, fangs, and filaments [3]. The mechanical, metallurgical, and tribological properties and characteristics of the manufactured metal matrices will be improved by carefully collecting the form, scale, and volume of reinforcements [4]. This often reacts well to structural weight reduction and increased strength and stiffness.

Metal composites have received a great deal of attention for a variety of applications, primarily in the aerospace, naval, and transportation sectors [5]. Metal composites can be made using a variety of fabrication techniques, including hot rolling, casting, and friction stir manufacturing. Due to welding issues, the use of metal composites is restricted, particularly if aluminum alloy is a metal matrix using standard soldering techniques. Improper parent and filler mixing, high porosity in the weld metal, crystallization slippage, focus on the core cracking, disruption and stiffening of sheet metal due to high stress concentration are the main challenges in arc welding composites. Although the brazing method is successful in combining metal composites, it necessitates the use of costly filler metals and strict regulation of processing parameters while fabricating sound joints in order to achieve the desired material properties.

II. Impact of FSP processing parameters

Metal composites have surpassed pure metals such as aluminum, magnesium, and copper in meeting the increasing demand for reducing overall mass of structures, especially in aircraft components, thanks to their unique properties such as stiffness and strength. Friction stir welding has successfully used, along with different refractory alloys in large part, low power energy than regularly used fusion welding processes for connection between MMC and lower resistance materials such as magnesium, aluminum and copper. To change the properties of alloys in the production of surface composites, FSW can be used in a bead-on-plate structure known as the friction stir process. Friction welding could also be used to make metal composites using fine reinforced materials and stirring them into the metal matrix, preventing defects like porosity, inclusions, and solidification discontinuities. It uses very little power and uses commonly used filler metals like tungsten and metal inert, brazing, and traditional arc soldering.

FSP is a well-known surface composite production method. Surface composites are required for engineering applications because of their unique characteristics, properties and stability. The researchers re-examined the effect of various input parameters and FSP pin profiles on various metals. This study examines FSP's development of surface composites and the evaluation of their various properties for the applications in question. The effects of tool speeds, tilt angle, feed, and pin profile on mechanical properties are investigated in this study.

Machine, tool design, and material variables are the three major types of process variables [6]. The tool-related machine process parameters are rotational speed, transverse speed, plunge depth, and tilt angle. There are two types of tool design parameters: shoulder and probe. The diameter and profile of the shoulder and probe, as well as the height of the probe, are related parameters. Mechanical and thermal properties are the two types of material properties. The range of processing parameters for the FSP is determined by the various properties of the parent metal, as is the amount of heat required for surface modification [7]. Thermal conductivity, for example, determines how much heat is lost from the work piece during the process [8], resulting in an increase in heat input [9]. This review paper focuses solely on tool rotational and transverse speeds. These two variables control the amount of heat produced in the surface to be processed [10]. To produce a defect-free FS processed surface, a sufficient percentage of heat input in the Stirred Zone (SZ) is needed [11]. The fine grain refinement in SZ, on the other hand, needs a lower amount of heat [12]. The higher the tool speeds needed, the more feedback required to break up the group of reinforcement particles in order to disperse them evenly in the zone in the preparation of surface composite. An optimized speed is needed to balance these conditions [13, 14] and mechanical properties. The influence of FS processing parameters on the consistency of processed surfaces. As criteria, they looked at spindle torque and force acting on the tool. The efficiency of the FSP zone is good within the desired range of process parameters, according to their findings. They also discovered that as the tool's rotation speed increases, heat is produced, resulting in a decrease in spindle torque [15]. The FSP method was used to investigate the impact of tool rotational speed on the mechanical properties of welded joints made of 7075 T6-Al alloys. The rotation speed of the tool was varied between 600 and 1550 rpm. They discovered that as rotational speed increased, so did heat input, resulting in a larger heat affected zone along grain coarsening. They discovered that at a medium speed of 825 rpm, strong mechanical properties can be obtained, with an ultimate tensile strength of 405 MPa and a 6.1 percent elongation [16]. Using FSP, two different surface composites were created by incorporating graphite and Al_2O_3 powder into the base material A390. They investigated the effect of tool speeds, both rotational and transverse, on the MMC surface's microstructure, wear, and other mechanical properties. They concluded that as the rotational speed of the tool increases, so does the hardness of the MMC layers. They also concluded that, when compared to tool rotational speed, traverse speed has a less significant effect on the hardness of the MMC layer. They discovered that A390/Al_2O_3 MMC surface composites were harder than A390/graphite composites [17]. The effect of process parameters on FSP-made Al-TiC composite surface wear resistance They created a variety of specimens by varying process parameters such as tool rotational speed and feed rate. To estimate wear resistance properties, they used an optical and scanning electron microscope to examine microstructures and good combination of 1200 rpm and 100 mm/min for medium tool rotational speed and feed rate [18]. The influence of tool transverse speed on the microstructural and mechanical properties of an AA6082-TiC sur-face composite fabricated via the FSP route was investigated. They made specimens at three different transverse speeds of 40, 60, and 80mm/min while keeping all other process parameters the same. Optical and scanning electron microscopic experiments were used to examine micro hardness and wear resistance [19]. FSP was used to reinforce AA5083 alloy surface composites with silicon carbide particles using various FSP strategies such as process parameter variation, dual-tool processing, and tool offset overlapping. The main goal of their research is to find the best strategy for uniform particle distribution and a defect-free surface [20]. Impacts on mechanical properties of the FSP surface composite made of AA2014-T6 and nano B_4C from rotational rate and volumetric nano powder percentage. The speeds used for the rotation were 1500, 1600 and 1800 rpm, and the volume of nano-powder was 2, 4 and 6. They found that the maximum speed is 1600 rpm at a transverse velocity of 20mm/min, and the volume is 2. At optimum setting they measured a maximum voltage of 208.8 MPa.

III. Conclusions

With its different principles, easy manufacture of surface composites and metal matrix composites, the processing method of friction stir stands out. In surface composites produced by the FSP method, the strength and other mechanical properties are improved. Number of researchers report the effect of input process parameters on mechanical characteristics. In the production of surface composites, the pin profile has an impact on mechanical properties and the form of the pin profile is also a key factor. The friction processing method is found to be defect free and enhanced ductility in the joint among all the manufacturing techniques. For further prediction of working ranges of processes parameters and output responses, optimal conditions for process parameters also investigated by the researchers and response equations are presented.

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