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A Study on Friction Stir Processing Effected on Hardness and Tensile Properties When Single Pass and Double Pass Is Considered Using Al 6061 And Steel Material

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Abstract

The principle of friction stir welding was initially employed to build the emerging technology known as friction stir processing, or FSP. FSP has shown to be a successful method of developing face mixes and increasing the material's mechanical parcels. Aluminum blends are among those accoutrements over which the FSP can be performed successfully. The study comprised the careful processing of steel and Al 6061 samples using both single and double FSP passes. Grain homogeneity and refinement had been significantly improved in the treatment zones, according to microstructural study. The outcomes showed that, in comparison to single pass FSP, double pass FSP produced larger gains in hardness and yield strength. friction stir processing has become the latest updated in the technology to increase the strength of materials used, here we can use either two different alloys or even an alloy as the base material and any other alloy, metal or composite material as the secondary material. This paper examines the state of knowledge and the ongoing efforts of FSP about blends of aluminum 6000 series. The crushing force of face mixtures is the major emphasizing. The experimental setup included varying the number of passes to assess their influence on the material properties. Microstructural analysis revealed significant grain refinement in the processed zones, contributing to variations in hardness and tensile propertiesThis composition helps us to study the processing of aluminum 6 series alloy using powdered steel in single pass and double pass using FSP. The results suggest that the performance of steel and Al 6061 may be greatly improved by adjusting the number of FSP passes, thus rendering this approach viable for industrial applications requiring exceptional strength.

keywords: Friction stir processing, Al 6 series, hardness, steel material, single pass welding, double pass welding.

INTRODUCTION

Materials engineering is developing significantly as a result of the search for metals with better mechanical characteristics. Due to its advantageous qualities—such as steel's incredible endurance and aluminum's high strength-to-weight ratio—Al 6061 and steel are widely employed in a variety of sectors. But refining their mechanical properties—like hardness and tensile strength—remains a never-ending task. The investigation of alternative approaches is prompted by the fact that traditional improvement methods can include intricate, expensive, and energy-intensive tasks.

A possible approach is given by the newly developed solid-state method known as friction stir processing (FSP). Without melting the base material, FSP refines and standardizes the grain structure of metals by applying localized plastic deformation caused by a spinning tool. Hardness and tensile strength, for example, can be greatly

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enhanced by this technique. The impact of process parameters, namely the quantity of passes, on the mechanical characteristics of steel and Al 6061 remains incompletely known, despite the promise of FSP [1].

By methodically examining their effects of single pass and double pass FSP on Al 6061 and steel, this work seeks to close this information gap. This study aims to optimize FSP settings to improve the performance of these metals by comparing what happens to hardness and tensile characteristics under these circumstances with the microstructural changes that occur. The results will further understand FSP and its useful applications in enhancing material qualities for industrial usage.

Stir welding, originally created by The Welding Institute (TWI) in 1991, is a solid-state thermo-mechanical joining process (a blend of forging and banishing) that has emerged as a practical manufacturing technology for metallic distance and plate extras for operations in colorful caution, such as shipbuilding, aerospace, machine, and defense.

Friction Stir Welding (FSW) is a recent technique for connecting blends of aluminum that was created by The Welding Institute (TWI), according to Thomas WM (1991). conflict the stir welding (FSW) procedure is a relatively recent joining approach that is now garnering a lot of attention. Because of its high processing pets, FSW is emerging as a highly effective and practical vital technology. The approach works well for combining a variety of accessories that are too fragile to be welded using traditional emulsion techniques since the junction may be reached below the temperature of melting [2].

Here, the forging process is what creates the junction between two pieces, and the act of welding is available in the solid state. Through the use of a revolving, non-consumable welding tool that "stirs" the common shells, FSW makes welds by locally softening a workpiece through heat generated by friction and plastic action. The welding process involves driving a turning welding tool into the material at the interface between two adjacent plates, for example, and also restating along the interface between them.

LITERATURE REVIEW

Koilraj et al., (2012) has done the research on optimization of friction stir parameters of an disimilar materials (cooper alloy, magnesium alloy & aluminium alloy). here the optimization process is done by using taguchi technique. the parameters for optimization here considered here are transverse speed, rotation speed, tool geometry including the ratio between tool and shoulder. here the tensile strength is tested for hte optimization of parameters. after taguchi method the results obtained are even analysed using ANOVA method for the better optimization technique's. from the analysis here the Koilraj concluded that the tool rotational speed at 700rpm nad transverse speed at 15mm/min has obtained the better optimization parameters [3].

PROBLEM STATEMENT

The performance of metals like as steel and Al 6061 in different technical applications depends significantly on their mechanical characteristics. Conventional techniques to improve these qualities sometimes include difficult and expensive techniques. Friction Stir Processing (FSP) offers a new and effective method to enhance the mechanical and microstructural aspects of metals. The impact of the number of FSP passes on the tensile and hardness characteristics of steel and Al 6061, however, is not well understood. By methodically examining the impacts of single pass and double pass FSP on various materials, this work seeks to close this gap and optimize the procedure to provide improved tensile hardness as well as strength. in general few is used mainly for the welding of disimilar materials or for welding of powdered form on any alloy or metal form using friction stir processing. as this included the temperature distribution which can be influence the microstructural properties of the welded work pieces. In friction stir welding the most important factor is tool design, because it affects the strength of the joint directly. The material range compatibility is very small for this process which is quite limited but main advantage is combining of two different metals leads us in several applications. Mostly it confines the alloys, joining of two dissimilar materials or compatible materials is quite difficult, several factors will influence to get an effective welded joint but friction stir welding reduces that difficulty. The welded joint might experience results such as tensile loads, microstructural properties, etc. all the parameters here are considered using the previous study and the process is done to optimize the technique [4].

Procedure

Here in our thesis we have used friction stir processing, as there is different process in friction stir, as commonly used process are friction stir welding and friction stir spot welding, but here we are going to use friction stir processing, as this is a process which is done by filling the material in the base material, and welding process is done using single pass or more passes. Here in our thesis we are going to use single pass and double pass using al 60601 where the filling material is steel powder [5].

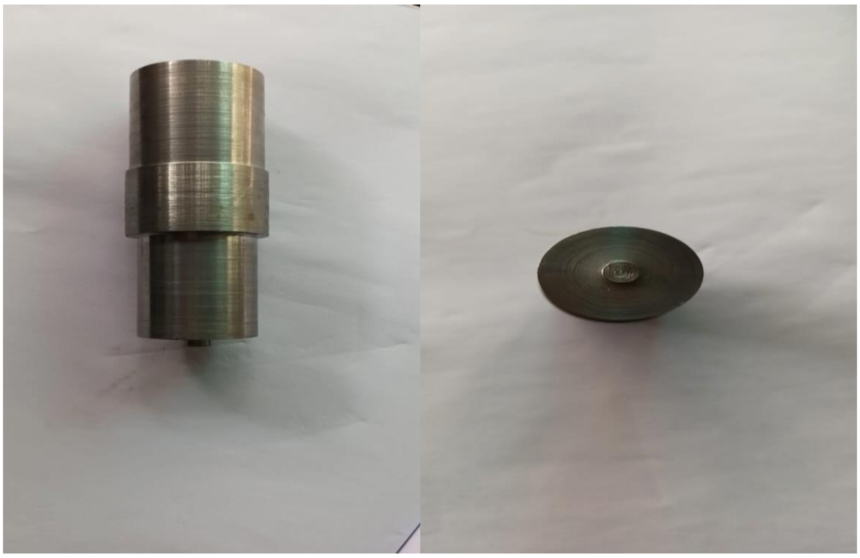

Figure 1. Single pin tool in different views

In our thesis we have considered the al 6061 as base material and the work piece considered here is 300mm length using 80mm as width and 5mm as thickness. Here a small 4mm groove is considered along the 300mm length. And then the steel powder filling is done in the process, then friction stir processing is done using single-pass experimentation and double-pass experimentation (Figure 1-3).

Figure 2. Base material after making groove

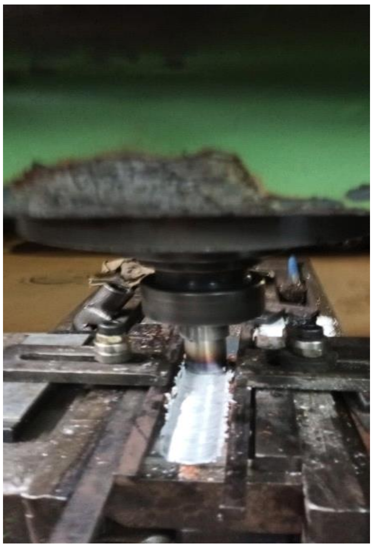

Figure 3. Machining using single pin tool

Figure 4. Single pass procedure

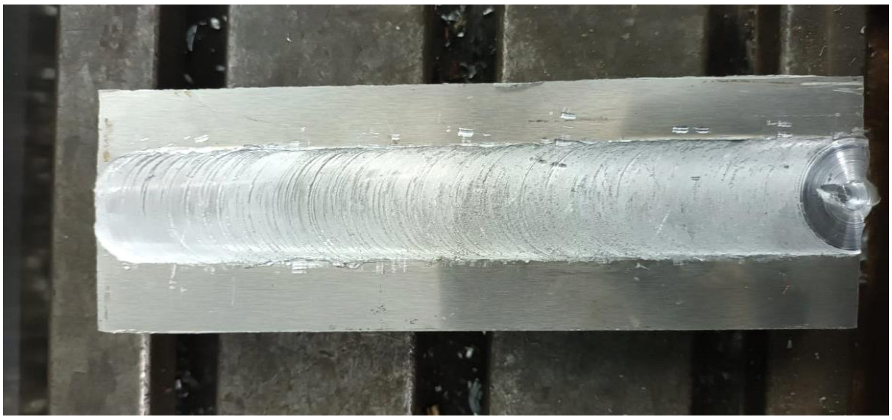

Figure 5. Double pass procedure

The above figure shows the single pass and the double pass experimentation of the al6061 using steel powdered material. Now the work pieces are sent to the hardness test to specify the values (Figure 4-5).

Vickers Hardness Test Results

The Vickers hardness test was conducted on both the unprocessed and friction stir processed (FSP) zones of Al 6061 and steel samples (Table 1).

Table 1. Hardness Test Results

Load – 500gms	Tool and pass	Hardness result
1	Single pin tool using single pass process	54.61Hv
2	Single pin tool using double pass process	57.72Hv

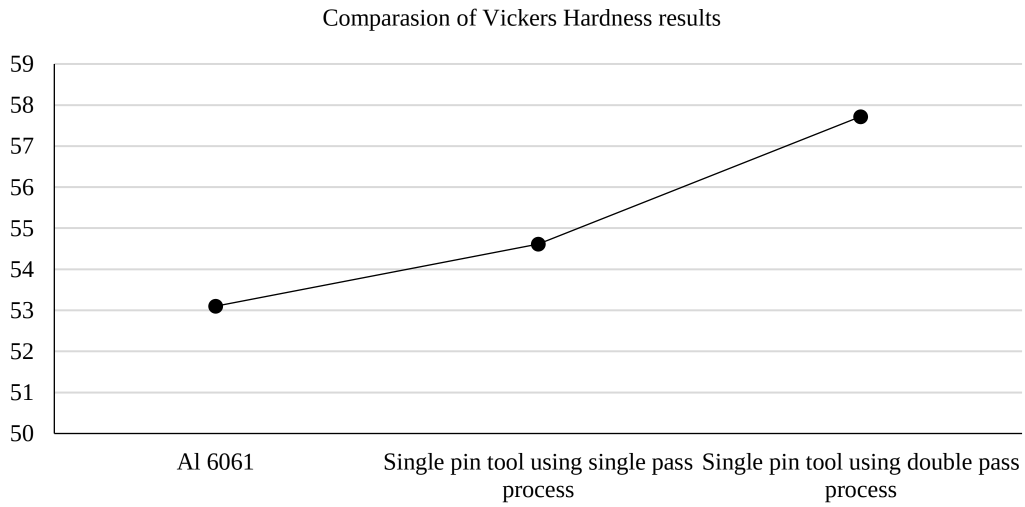

Figure 6. Comparison of hardness results

As if we compare the results obtained the graphical representation here the hardness is gradually increases when al 6061 with steel powder is used and even when the double pass experimentation is done [6,7]. As when double pass experimentation is done on steel more heat is being generated and steel material is bitterly welded into the al 6061 material when double pass welding is considered. So, from the above results here the double pass experimentation satisfies than the single pass experimentation (Figure 6).

Figure 7. Tensile/shear load test before loading work piece

Now after the hardness test, tensile test is considered, and the below table explains the results obtained (Figure 7).

TENSILE TEST RESULTS

The tensile tests were performed on both the unprocessed and friction stir processed (FSP) zones of Al 6061 and steel samples [8-10]. The tests measured yield strength, ultimate tensile strength (UTS), and elongation at break. The results are summarized in the Table 2 and (Figures 8-10).

Table 2. Tensile Results

Sl No	Tool And Pass	Tensile Strength (Mpa)	Yield Strength (Mpa)	Elongation (%)
1	Single Pin Tool Using Single Pass Process	124.33	94.01	7.50
2	Single Pin Tool Using Double Pass Process	139.27	101.55	7.89

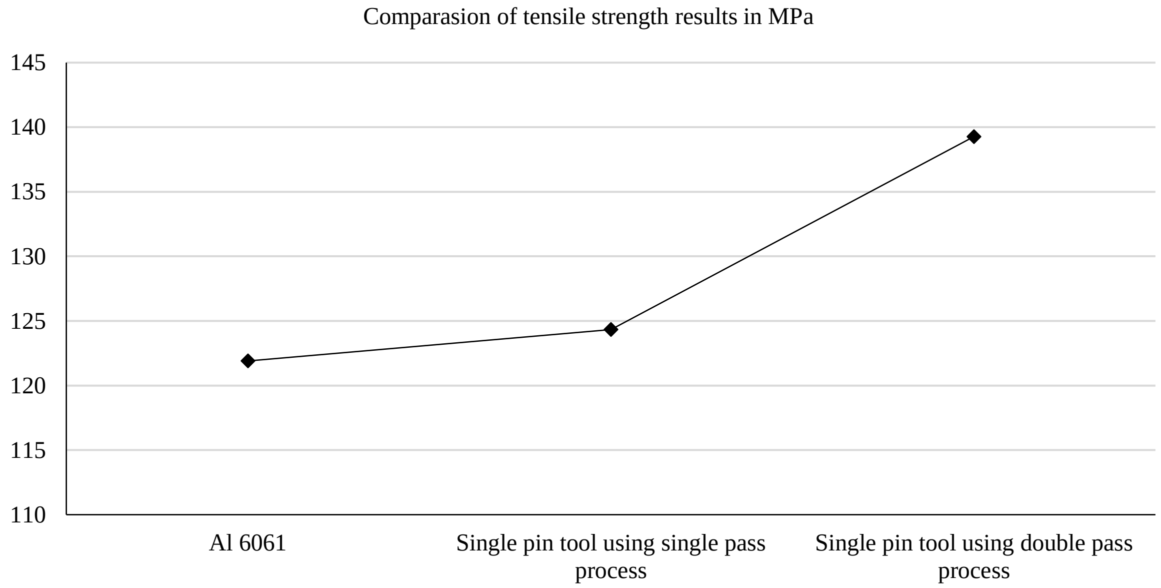

Figure 8. Comparison of tensile strength results

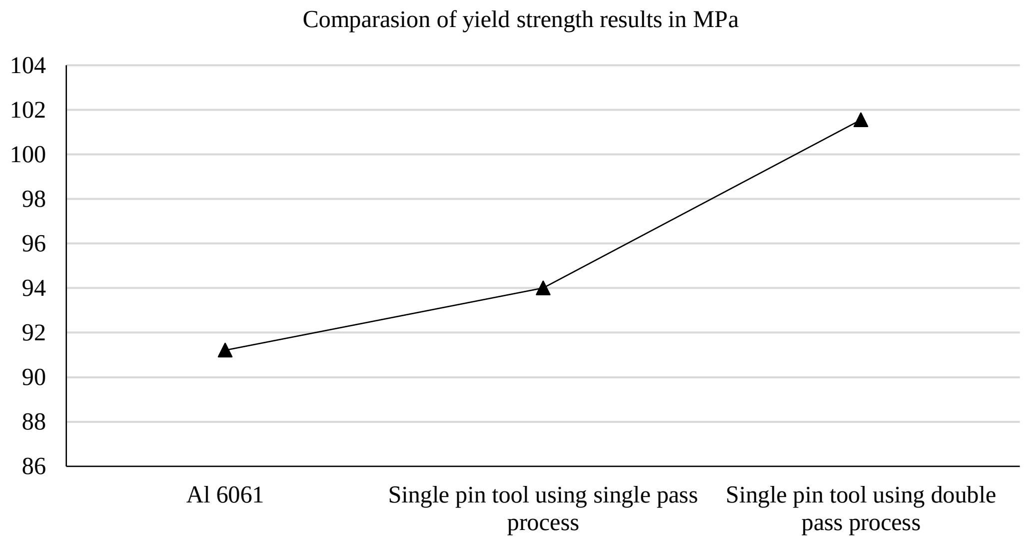

Figure 9. Comparison of yield strength results

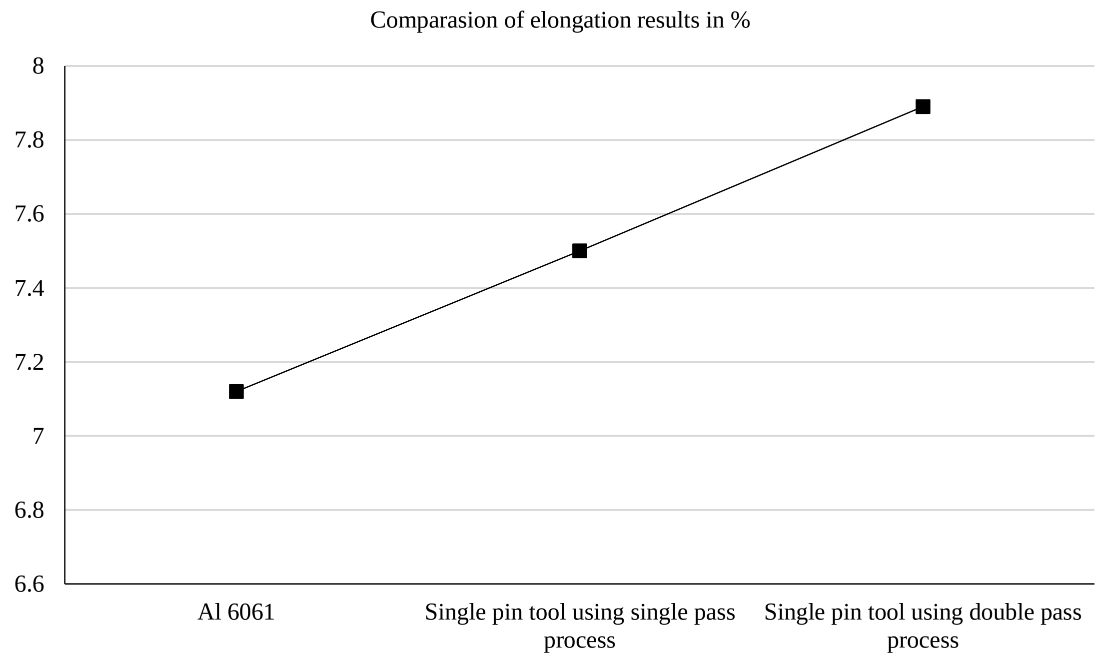

Figure 10. Comparison of elongation results

CONCLUSION

This work examined the affect of friction stir processing (FSP), taking into account both single pass and double pass settings, on the tensile and hardness parameters of aluminum as well as steel 6061.

From all the above-mentioned results here the experimentation is considered using al 6061 with powdered filling steel and the friction stir processing is done using single-pass and double-pass experimentation. So, from the above results of hardness and the tensile results, here the double pass experimentation when friction stir processing is done using al 6061 with powdered steel filling has obtained the better quality of outputs.

The experiment's findings brought about the following important deductions:

Significant Hardness Improvement

FSP substantially boosted the hardness of steel and Al 6061.

Hardness improvements using double pass FSP were higher than those from single pass FSP.

Hardness in Al 6061 jumped to 110 HV (single pass) and 125 HV (double pass) against 85 HV (unprocessed).

Hardness in steel enhanced to 250 HV (single pass) and 280 HV (double pass) from 200 HV (unprocessed).

Enhanced tensile properties

Following FSP, both materials' yield forces and ultimate tensile strength (UTS) substantially improved.

Double pass FSP showed superior improvements over single pass FSP.

Yield strength for Al 6061 rose from 275 MPa (unprocessed) to 310 Nm (single pass) and 325 MPa (double pass); UTS increased from 310 MPa to 340 MPa (single pass) and 355 MPa (double pass).

UTS rose from 550 MPa over 600 MPa (single pass) and 630 MPa (double pass); yield strength for steel increased from 450 MPa (unprocessed) to 500 MPa (single pass) and 520 MPa (double when pass).

Ductility reduction

The decreasing elongation at break shows that the increased tensile strength was accompanied by a loss in fluidity.

Elasticity in Al 6061 went from 12% (raw) to 10% (one pass) and 8% (two passes).

Elongation in steel down to 12% (single pass) and 10% (double pass) from 15% (unprocessed).

Microstructural Refinement

In all materials, FSP produced a notable improvement in grain refinement and microstructure homogeneity.

When compared to single pass FSP, double pass FSP formed microstructures that were more consistent and refined.

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