Evaluation of FSW parameters on appearance and strength of AA 6061

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ABSTRACT: Friction stir welding (FSW) is a welding method in which heat generated by friction is used to form joint components under axial forces. The 6 mm thick of AA6061 has problems to be joined using conventional welding methods because produces a poor joint appearance and strength as a result of its thickness. Various combinations of welding parameters used, namely tool rotation speed of 660 rpm - 910 rpm and welding speed of 15 mm/ min - 25 mm/ min. The results of tensile strength that were welded at a rotational speed of 750 rpm and welding speed of 15 mm/min were 155.95 MPa, which recorded the highest results, and the welding surface also showed better than other welding parameters. In conclusion, AA6061 at a thickness of 6mm was successfully welded using the FSW method in which the solid weld nuggets without tunnels at the weld cross section showed ideal welding parameters.
Keywords: *welding parameter, strength, appearances*

1. INTRODUCTION

FSW is a mechanism of joining from heat generation against the connecting line two pieces material through friction of the interface of the rotating tool and the workpiece. The final welding efficiency depends on the dynamic combination of various process parameters such as tool rotation speed, tool movement speed, vertical force, tool design, and material properties [1-2]. FSW can reduce structure weight compared to other conventional welding methods, especially aerospace component structure. This method commonly used in the manufacture of automotive and marine components.

Advantages of FSW result, tensile strength got 19% higher than tungsten inert gas (TIG) welding method. It also compared against gas and arc welding method has recorded 19% and 22% higher, respectively [3]. FSW is a revolutionary application that provides the advantages of conventional friction welding forms. The mechanical properties of the AA6061 sheets depend on the welding parameter that comprises welding speed and rotational speed. In FSW, the relative velocity between the tool and the material increases the frictional pressure at the interface, which produces frictional heat and further produces high tensile strength and hardness. In addition, the ideal cutting speed and federate produce a smooth machining surface [4].

While, the workpiece in this research is AA 6061 aluminium alloy because this material is very popular in automotive, aerospace and shipbuilding. AA6061 is a light material weight ratio, strength and good corrosion resistance. Therefore, this AA6061 needs to be extended, its application to FSW by studying the welding parameters and their effect on tensile strength, hardness and joining appearance. This paper presents the FSW machine parameter to reveal the result of hardness, tensile strength and appearances of the parameter selected when welding on AA6061 alloys aluminum.

2. METHODOLOGY

The FSW experimental method carried out using a 3-axis milling machine branded Full Mark FVH260S. Rotational speed and welding speed are parameters that can significantly affect the welding strength. The welding parameters used are shown in Table 1 for the research work.

Table 1 Welding parameter

Parameter	Rotational speed (rpm)	Welding speed (mm/min)
1	660	15
2	660	20
3	660	25
4	750	15
5	750	20
6	750	25
7	910	15
8	910	20
9	910	25

Raw materials for FSW tool used type of H13 tool steel with a diameter of 25 mm and the overall length is 50.9 mm, while the taper of end tool is about 9.62 °. Figure 1 shows the design of a fabricated FSW tool.

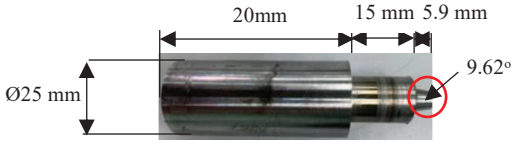

Figure 1 FSW tool

The workpiece for the FSW process is AA 6061 and the dimensions of the workpiece for the respective FSW

process are 100 mm x 160 mm x 16 mm in width, length and thickness, respectively. Table 2 shows the properties of AA 6061.

Table 2 AA 6061 properties

Density	Hardness	Strength	Modulus
2700 kg/m^3	50 HRB	275MPa	70GPa

3. RESULTS AND DISCUSSION

Tensile testing performed on AA 6061 following to ASTM E8M-04 standard to determine the tensile load and yield strength of the FSW element and Figure 2 shows a comparison graph on each FSW strength.

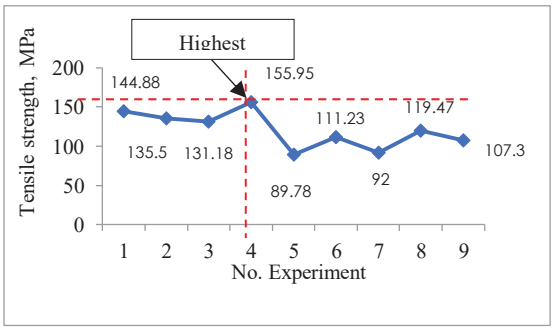

Figure 2 Tensile strength

Figure 3 (a) shows a specimen at a rotational speed of 750 rpm and a welding speed of 15 mm/min. Observations found that the tensile strength of the welded part increases as the welding speed increases. The strength of the joining depends on the welding parameters that applied to the workpiece [3]. Figure 3 (b) observed through a digital camera found the weld presents a very fine surface comprising regular streaks.

High tensile strength got up to 155.95 MPa, and this shows the rotational and welding speed are compatible to produce the ideal temperature occurring at AA6061, until the mixture thinly dispersed, homogeneous and produces a complete weld nugget.

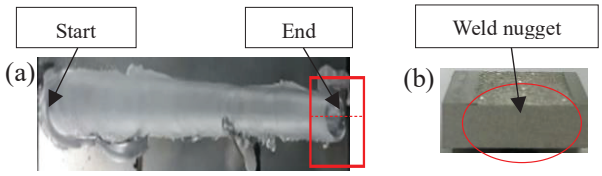

Figure 3 Weld surface when welded at (a) parameter 3 and (b) weld nugget

Figure 4 shows severe surface roughness and produces a low tensile strength value of 89.78 MPa at a welding speed of 20 mm/min. When the welding speed increases compared to welding rotation, it causes insufficient heat generation and affects the mixture in forming solid weld nuggets, resulting in the formation of tunnels as shown in Figure 5 and decreases the strength of the weld joint. The tunnel phenomenon on the inside of the weld is because of insufficient frictional heat generation. This occurs because of the lower strength of the weld joints causing from the lack of formation of homogeneous mixed areas in the welding zone and the fact that sufficient temperature not supplied to the joints.

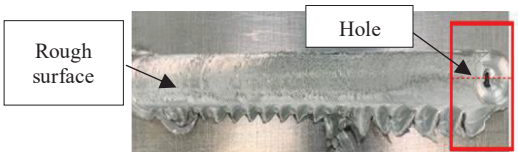

Figure 4 welding surface when welded at 750 rpm welding rotation and welding speed of 20 mm / min

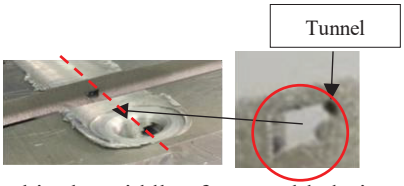

Figure 5 Tunnel in the middle of two welded pieces of AA6061

4. CONCLUSION

This paper presented the effect of welding parameters on tensile strength and surface appearance on AA6061. The best parameter that were identified are 750 rpm for welding rotation and 15 mm/min for welding speed. Observations of the cross sections at the joints of the weld parts show the same parameter as produce completed weld nuggets with no tunnels and showed high tensile strength that dominated the study results. Therefore, the objective of the study of obtaining ideal welding parameters against AA 6061 at 6mm thickness was achieved.

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