Study of Mechanical Properties and Microstructure of Friction Stir Welded 5083 Aluminium Alloy

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Abstract: Friction stir welding (FSW) process is a solid state welding method developed by The Welding Institute (TWI) and now it is increasingly used in Aluminium welding. A study has been made of the FSW of 4mm thick Aluminium alloy 5083 plates. By considering the two different tool rotation speeds and by changing the transverse feeds, the mechanical properties vary. It is observed that higher mechanical properties are obtained at a rotation speed of 710 rpm and welding speed of 80 mm/min. It is also observed that the fine microstructure obtained at the above mentioned condition. The mechanical properties were observed & correlated with the microstructure.

Keywords: Friction stir welding, tool, welding parameters, Mechanical Properties

I.Introduction

The 5083 aluminium alloy is exhibited good corrosion resistance to seawater, better mechanical properties. It has good formability, machinability and weldability. The 5083 aluminium alloy is used for providing of welded components for shipbuilding and railway vehicles. It has the highest strength of the non-heat treatable alloys. [1-2] It is not recommended for use in temperatures in excess of 650 c to a corrosive environment. [3] Many studies were made on the weld ability of 5083 aluminium alloy. [4-6]Aluminium alloys are friction-stir processed (FSP) then the properties of superplastic are obtained, as a consequence of grain refinement. [7] Friction stir processing (FSP) is used to transform a heterogeneous microstructure to a more homogeneous, refined microstructure before not reaching its melting temperature.

Table 1: Physical and Mechanical Properties of Aluminium 5083

Property	density	Tensile strength(*R*m/M Pa)	Yield stress(*R*p0.2/ M Pa)	$T_{sol}/^0c$	$T_{liq}/^0c$
AA5083	2.660	280	135	580	640

Property density Tensile strength(*R*m/M Pa) Yield stress(*R*p0.2/ M Pa) T sol/oc T liq/oc AA5083 2.660 280 135 580 640 In this study the investigation was done on weld ability of 5083 aluminum alloy using the technique of friction stir welding (FSW). The weld parameters like tool-rotation speed, the welding speed was considered in this study. The FSW is employed a tool-rotation speed from 710 r/min to 900 r/min.

II. Experimental Work

A. Dimensions and Composition of The Work Pieces

The standard EN-AW 5083 aluminium alloy with chemical composition in mass fractions: 4.34%Mg,0.51%Mn,0.14%Si,0.088%Cr,0.28%Fe,0.20%Zn,0.013%Ti and the remaining Al, and temper O, was used for testing. The work piece sizes were 150mm×75mm×4mm. The physical and mechanical properties as per standards were taken.

B. FSW Tool

A high speed steel tool was taken to fabricate the joints. A basic FSW tool geometry was used with a conical pin that was 3.7mm long, pin diameter 6mm and the flat shoulder diameter 24mm with D/d ratio maintained as 4 shown in Fig 1.

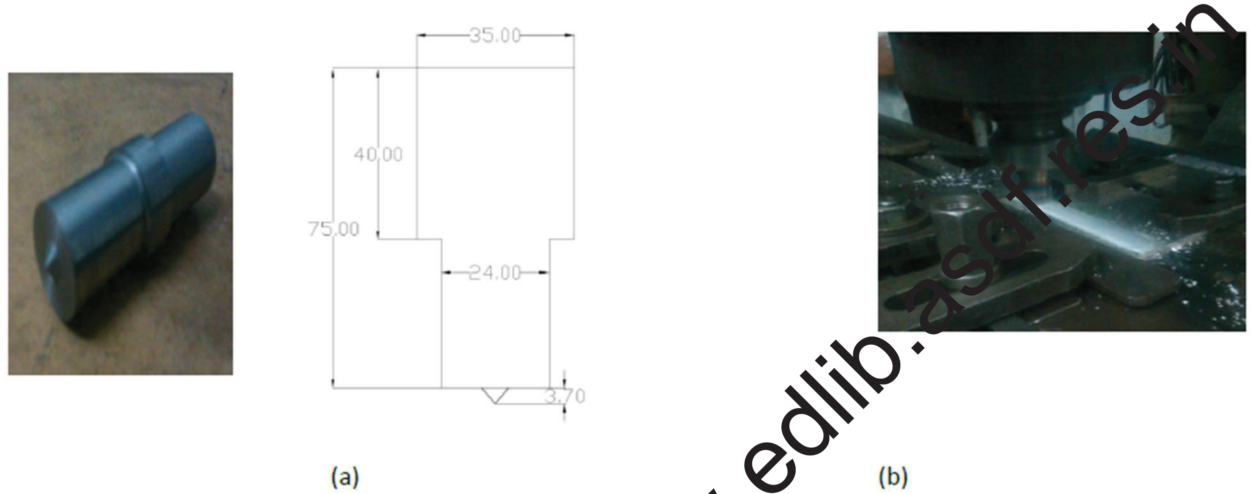

Figure 1: a) FSW tool geometry and b) experimental FSW

C. Specimen Preparation and Testing

The tensile test specimens were sectioned perpendicular to the welding direction from the welds. And weld crosssections for analysis of microstructure were prepared. The samples for analysis of microstructure were sectioned, grinded and polished. The samples for the macrostructure analysis were etched by using Keller reagent (1150 ml Hcl, 550ml HNO3, 200ml HF and 1500ml H2O) and the microstructure was analysed using an optical microscope.

III. Results and Discussions

A. Visual Assessment of Welds

The top views of the FSW welds were shown in Fig 2. A hole at the end of weld shows the negative of FSW tool pin. For this sample specimen the tool moved a little too much into the work piece, due to the higher frictional heat input, which then softened the material.

B. Tensile Properties

The tensile strength of the base metal alloy was measured and presented in (Table 1). The tensile strength was observed at the stir zone welds at different tool rotation speeds i.e.710r/min,900r/min and welding speeds of 40mm/min, 80mm/min, 125mm/min and 160mm/min. The tensile strength and yield stress reduced with increase of tool rotation speed, whereas the strength increases with the increase with the increase of welding speed. The results of friction stir welded 5083 aluminium alloy are shown in Table 2.

i. Effect of tool rotation speed on hardness:

Hardness value reduces with the increase of the tool rotation speed. Whereas hardness increases with the increase of welding speed, shown in Fig3.

Figure2: The top view of the welds

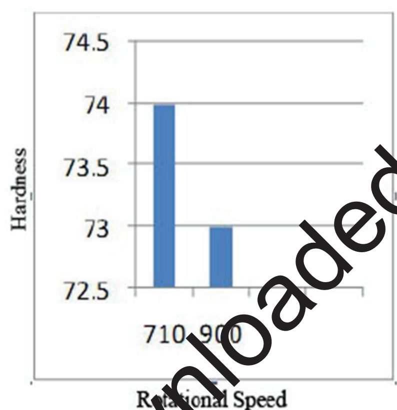

Fig3. Hardness Vs rotational speed

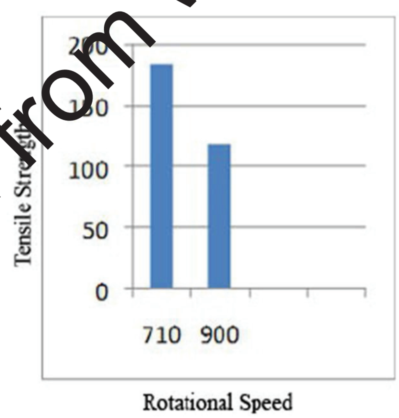

Fig4. Tensile strength Vs rotational speed

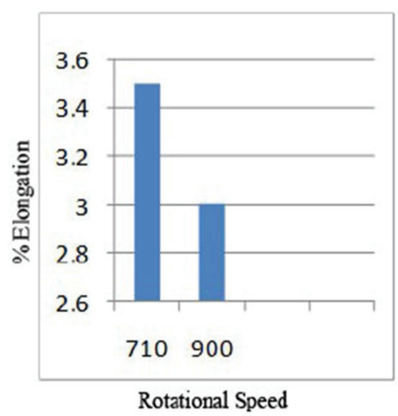

Fig 5. Elongation Vs rotational speed

ii. Effect of tool rotation speed on tensile strength:

The tensile strength decreases as the tool rotation increases. At 710r/min the strength was 185 M Pa and at 900r/min the strength shows 120MPa, shown in Fig 4.

iii. Effect of tool rotation speed on elongation:

The elongation (%) achieved maximum at the tool rotation speed 710r/min with welding speed 80mm/min was 4.56% shown in Fig 5.

Table 2 Welded Conditions at Constant Rotational Speed of 710r/min AND 900r/min

Condition FSW (rpm/mm)	YS (M Pa)	TS (M Pa)	Elongation (%)	Rockwell's Hardness	Brinell's Hardness
710/80	136.258	185.090	4.56	74	72.4
710/160	104.926	131.255	2.54	73	76.3
900/40	85.56	112.127	3.54	72	76.3
900/125	94.855	120.038	3.08	72	72.4

C. Weld Microstructure

Based on the microstructure analysis under optical microscope across the welds it is to be observed that there were no defects and fine grains obtained. It is observed that the grain size reduced to half the size of base alloy due to the deformational hardening. The grains are equiaxed in the nugget zone shown in Fig 6. The microstructures of different conditions were shown in Fig 6. When welding of 710rpm with feed per minute(FPM) 80mm/min and 900rpm with FPM 40mm/min the grain size of welds were seems to be identical, due to the heat input was more

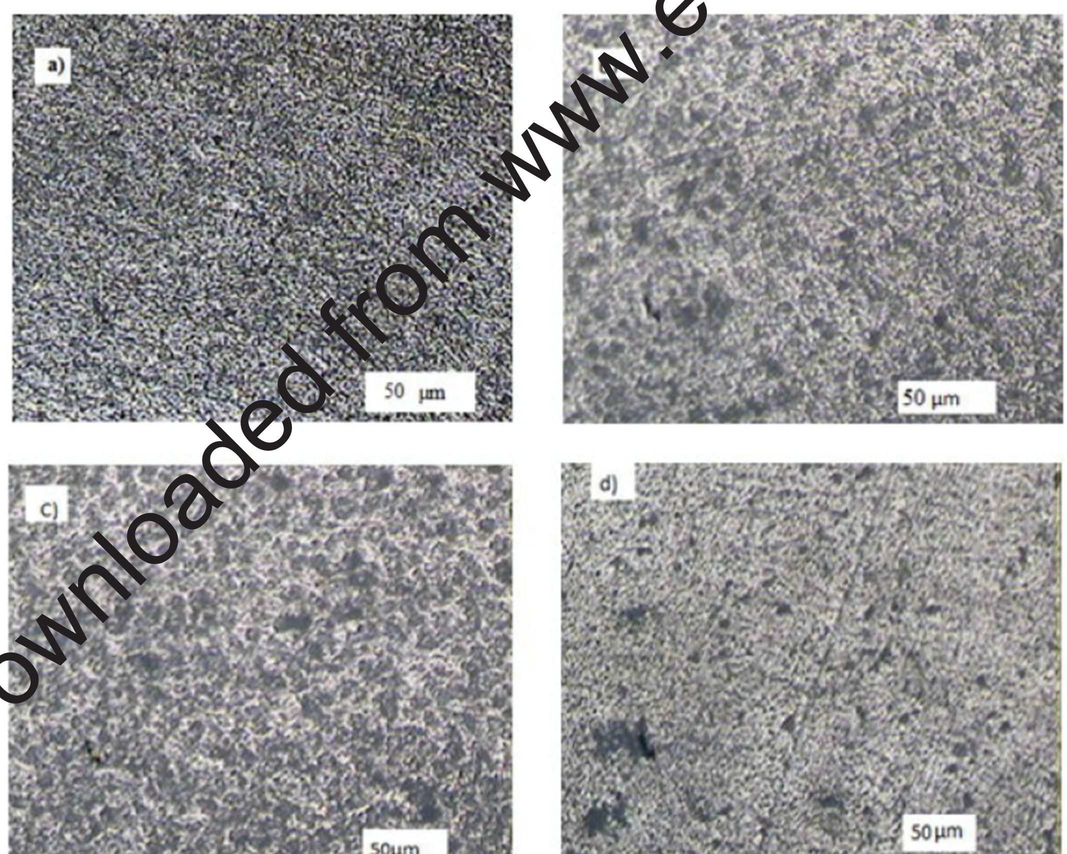

Figure 6.Microstructure of FSW weld produces at: a) 710rpm and welding speed 160mm/min b) 710rpm and welding speed 80mm/min c)900rpm and welding speed 40mm/min d) 900rpm and welding speed 125mm/min

(Figures 6b,c). When welding of 710rpm with FPM 160mm/min and 900rpm with 125mm/min the grain size was fine, because the heat input was very low, i.e., cold deformation had a great role in grain refinement. [9] In this case the grains were very small (Figure 6a, d).

Conclusions

Welding of AA5083 in FSW process successfully obtained for different welding speeds, rotation speeds and the tool profile. Based on the analysed results the following can be concluded.

1. It is observed that at rotation speed of 710 rpm, & 80 mm/min welding speed with conical profile resulted in good mechanical properties.
2. It is observed that at rotation speed of 900 rpm, 125 mm/min welding speed with conical tip profile resulted in good mechanical properties.
3. It is concluded that, at 710 rpm, the mechanical properties are better than at 900 rpm, this is due to sufficient heat is obtained at this condition. Hence weld with conditions 710 rpm & 80 mm/min gives the best results among all these welds.
4. It is to be concluded that for different welds of microstructure, 710rpm with 160mm/min and 900rpm with 125mm/min the grain size was very small. More grain refinement was there in this condition due to the cold deformation effect.

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