Mechanical Behaviour of Friction Stir Welding Joints of Aluminium alloy of AA6351 with AA6351 and AA6351 with AA5083

G.Gopala Krishna ¹, P.Ram Reddy², M.Manzoor Hussain³

¹Associate Professor, Department of Mechanical Engineering, J.B. Institute of Engineering and Technology (Autonomous), Hyderabad-500 075, Andhra Pradesh, India,
²Director, Malla Reddy Engineering College, Secunderabad, A.P., India,
³Principal, JNTUH College of Engineering, Sulthanpur, Medak Dist, A.P., India.

Abstract— Modern structural application demands reduction in both the weight and as well as cost of the fabrication and production of materials. Aluminium alloys are the best choice for the reduction of weight, cost and replacing steels in many applications and Friction Stir Welding (FSW) process efficient and cost effective process. FSW is solid state welding process in which material is not melted during welding process so it overcomes many welding defects compared to conventional fusion welding process which is initially used for low melting materials. This process is initially developed for low melting materials like Aluminium, Magnesium, Zinc but now process is useful for high melting materials like steel and also for composites materials. The present study describes the effect of FSW process involving butt joining of similar Aluminium alloy combinations of AA6351 with AA6351 and dissimilar Aluminium alloy combinations of AA6351 with AA5083 on the tensile, hardness and impact behaviour.

Keywords— Friction Stir Welding, Tensile behaviour, Hardness behaviour, Impact strength, Aluminium alloys AA6351 and AA5083.

I. INTRODUCTION

Friction Stir Welding (FSW) is a solid state welding process developed and patented by The Welding Institute (TWI) in 1991. It is emerged as a novel welding technique to be used in high strength alloys that were difficult to join with conventional welding techniques [1]. The process were initially developed for aluminium alloys [2-10], but since then FSW was found suitable for joining other materials like magnesium [11,12], steel [13,14], titanium [15], copper [16,17] and also composites [18].

The basic principle of FSW process is remarkably simple. Instead of a conventional welding torch, friction stir welding uses a non consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edge of the two parts to be welded and traversed along the line of the joint as shown in Fig.1. The heating is localised and generated by friction between the rotating tool and work piece, with additional adiabatic heating from metal deformation. The pin and shoulder of tool can be modified in number of ways to influence material flow and microstructural formation.

II. EXPERIMENTAL PROCEDURE

A. Material

The materials used for this investigation are aluminium alloys AA6351 and AA5083 of size 150 X 60 X 5 mm. The standard chemical composition and base materials used for this experiment chemical composition are listed in table no.1 and 2 respectively. A vertical CNC (Computer Numerically Controlled) milling machine is converted in to friction stir welding machine for welding process. Mechanical properties of aluminium alloy AA6351 and AA5083 are represented in table 3.
frictional heating and results more intense stirring of mixing material.

### C. Tensile Testing

The tensile tests were conducted to determine the tensile properties of similar aluminium alloys of AA6351 with AA6351 and dissimilar aluminium alloy of AA6351 with AA5083 friction stir weldments at different rotational speed of the tool (1000 rpm to 1500 rpm) in a Universal Testing Machine (UTM) as per ASTM standards.

### D. Hardness Testing

Brinell and Rockwell hardness tests were performed to determine hardness of FS weldments of similar alloy combinations and similar alloy combinations at different rotational speed of the tool i.e., from 1000 rpm to 1500 rpm.

### E. Impact Testing

The Charpy impact test was performed to determine the impact energy of similar aluminium alloys combinations of AA6351 with AA6351 and dissimilar aluminium alloy combinations of AA6351 with AA5083 friction stir weldments at different rotational speed of the tool (1000 rpm to 1500 rpm) as per ASTM standards.

### III. RESULTS AND DISCUSSIONS

#### A. Tensile Test

Tensile tests were performed to determine the tensile properties (yield strength, tensile strength and percentage elongation) of the aluminium alloy similar alloy combination of AA6351 with AA6351 and aluminium alloy dissimilar combination of AA6351 with AA5083. Fig.2, Fig.3 and Fig.4 shows the effect of rotational speed of the tool on tensile properties (yield strength, tensile strength and percentage elongation) of friction stir welded aluminium alloy AA6351 with AA6351 and aluminium alloy AA6351 with AA5083. It seen from these figures that at lower rotational speed of the tool (1000 rpm), lower tensile properties of the FSW welded joint were observed. When rotational speed increased from 1000 rpm onwards tensile properties were also increased and reaches maximum at 1300 rpm. If the rotational speed is increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has increased more than 1300 rpm, a reverse trend has been observed i.e. the tensile properties of the welded joint has
decreased. The optimum values observed at rotational speed of 1300 rpm were observed for both the cases. The tensile properties and fracture locations of the welded joints are dependent on rotational speed of the tool and other process parameters like rotational speed, welding speed and axial force of the tool, tool tilt angle etc. The lower rotational speed results lower heat input and defects like crack and pinholes in friction stir processed zone and resulted lower tensile values. On the other hand when the rotational speed increases (1400 rpm and 1500 rpm), the heat input also increases which results poor tensile properties due to rise in temperature, which increases grain growth, higher rotational speed also effects in the metallurgical change like re-precipitation, solubilisation and coarsening of strengthening precipitates at the weld zone area and lowering of dislocation density [19].

Similar aluminium alloy of AA6351 with AA6351 combinations yielded superior tensile properties as compared to dissimilar aluminium alloy of AA6351 with AA5083 combinations because proper mixing of material at weld location is not taking place of different melting points of AA6351 (melting point at solidus state is 554 °C and at liquidus state is 649 °C) and AA5083 (melting point at solidus state is 591°C and at liquidus state is 638°C).
standard hardness values are lower than aluminium alloy AA6351 so the combination of AA6351 with AA5083 results lower hardness values.

C. Impact Test

Charpy impact test was done to determine the impact energy of FS weld at a sudden load by using pendulum on V notch specimen. Fig.7 shows the effect of rotational speed of the tool on impact energy of friction stir welded aluminium alloy AA6351 with AA6351 and aluminium alloy AA6351 with AA5083. The impact energy of FS weld is lower when the rotational speed of the tool is lower (1000 rpm). When the rotational speed of the tool increases from 1000 rpm the impact energy decrease and reaches minimum at 1300 rpm. If the rotational speed of the tool is increased further beyond 1300 rpm then impact energy of the joint increased.

IV. CONCLUSIONS

The following conclusions arrived from the above experimental investigation.

- The results indicated strong relation between the rotational speed of tool and tensile properties of the welded joint. Yield strength, tensile strength and percentage of elongation of the joint decrease with the increase in speed of the tool and after reaching optimum values at 1300 rpm speed the values decreases with increase in speed of the tool.
- The results related hardness (both Brinell and Rockwell hardness) reveal that increase in hardness of welded joint with increase in speed of the tool and the value comes down with still increase in speed of the tool after reaching maximum value at 1300 rpm.
- The Charpy impact strength results shows that decrease in impact strength of welded joint with increase in speed of the tool and reaches minimum at 1300 rpm and value increase with further increase in speed of the tool.
- Tensile, hardness and impact properties of Aluminium alloy of similar alloy combinations exhibits better values compare to dissimilar alloy combinations.

REFERENCES


