Influences of Tool Pin Profile and Mechanical Properties of AA 6061-T6 Welded Joint by Friction Stir Welding

R. Manikandan, G. Elatharasan, G. Karthikeyan

1Research Scholar, Department of Mechanical Engineering, University College of Engineering Pattukkottai, Anna University, Rajamadam – 614701, Tamilnadu, India.
2Assistant professor, Department of Mechanical Engineering, University College of Engineering, Pattukkottai Anna University, Rajamadam – 614701, Tamilnadu, India.

Received 28 February 2017; Accepted 22 May 2017; Available online 6 June 2017

ABSTRACT

In this investigation of Friction Stir Welding carried out by the similar AA 6061 and influencing various pin profile in CNC vertical milling machine. The plate dimension (150×150×6) mm thickness was welded by the various process parameters such as rotational speed, transverse speed and mechanical load. The investigated various pin profile named by square, triangle and hexagonal with the PCBN tool material. And the mechanical properties of friction stir welded joint of tensile strength, and hardness investigated. The effect of process parameter can be selected by the required tool pin profile. And the pin and shoulder to an integral part of the Friction Stir Welding, the dimension as Pin dia 3mm and shoulder dia 18 mm respectively. The process parameter has been carried out by the welding speed 20–80 mm/min and rotational speed range from the 800–2000 rpm and axial load 4–10KN. From the experiment analysis clearly observed for the optimized process parameter and effect of various pin geometry examined. These joint properties friction stir welding would be used in future trends in automobile industry.

KEYWORDS: Friction stir welding, PCBN, milling machine, Process parameter.

INTRODUCTION

Friction stir welding Invented by TWI industry in 1991 in which both similar and dissimilar joint welded [1–2]. It is a solid state welding technique using non-consumable tool using third body as a heat generating element. The tool pin and shoulder is an integral part of the Friction Stir Welding. To create a frictional heat between the work piece and tool shoulder and creating a defect free weld. During the heat generation the plastic deformation will formed by the work piece and the movement of material from advancing side to the retracting side [3]. In which heat generation plastic behavior formed by the local heating and results for movement a recrystallized grain structure. [4–7]. In recent researches of metal joining, it is an energy efficient method and user friendly. Al6061 is a used most widely used in wide variety of industrial applications such as automobile, Shipbuilding and aerospace etc.

This method of FSW used for to joining of aluminium alloys [8–9]. Effect of process parameter such as rotational speed, welding speed and mechanical load investigated in FSW [10]. Similarly the pin and shoulder has different shape such as square, cylinder, triangle and pentagon. This shape enhanced with the material flow under the various process parameter. Form the investigation the pin refine the grain size, and however to
increasing the number of sides the weld quality with the effect of increasing temperature. The different tool pin profile of material flow described by the Friction stir welding. The schematic representation of FSW as shown in figure 1.

This investigation mainly focused on mechanical properties of friction stir welded by the Al6061 alloy. And using various shapes of pin geometry such as square, triangle and Pentagon, examined the effect of various process parameter such as rotational speed (800-1200rpm) and Transverse speed (30-60 mm/min).

Fig. 1: Friction stir welding

And also examined the microstructure using SEM (Scanning Electron Microscope), the temperature histories also measured for the evaluation. However from the experimental results increasing rotational speed and decreasing welding speed, achieving the weld quality of Friction stir welded joint. It has good tensile strength compared to the base material and percentage of elongation more. And the material will have more hardness to increasing temperature of frictional heat also increased.

II. Experimental setup:
The rectangular plate as a dimension of 150X150x6 mm thick used by the Al6061 Friction stir welding and using plain carbon material (PCBN tool). It has high thermal conductivity and good resistance. This FSW process carried out by the vertical milling machine and clamped both side of the work piece assembled together. It enhanced with the residuals and holding the various frictional coefficients. Welding tool material having shoulder diameter 18mm, pin diameter 3mm and pin height 5.46 mm used in the FSW process. The Al6061 chemical and mechanical properties as shown in the table 1 and table 2.

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<th>Table 1: Chemical properties of composite materials</th>
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<th>Table 2: Mechanical properties of composite materials</th>
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Three more different pin geometry used in this investigation. Such as Square, triangle, and pentagon. The welding parameter was chosen 800, 1000, 1200 rpm and transverse speed 30, 45,60mm/min respective form the literature survey. Microstructure investigation has done by the optical electron microscope. The welded region of Al6061 to cut specified position and build with this investigation. Brinell hardness test were examined under the load 100kgf with this various affected welded region. And the tensile test was carried out by the universal testing machine for the specimen prepared according to the ASTM E8M and figure shown in below.
RESULT AND DISCUSSIONS

Microstructure:
The friction stir welded Al6061 alloy namely affected by the different zones. Such as heat affected zone (HAZ), nugget zone and thermo mechanical affected zone (TMAZ) due to frictional heat generation between the tool and work piece. During the heat generation plastic deformation occurs in the nugget zone along with the distance of shoulder surfaces the range -18 to 18mm diameter. This temperature behaviour has been controlled by the rotating speed, transverse speed and plunge depth. Similarly we are using three different profiles to enhance the material flow behaviour of electric energy into their form of plastic deformation. The refinement of grain size it will lead to the weld quality. Square profile Compared to the triangle is to create a large surface to the nugget zones during the friction stir welding. When the process the frictional heat of recrystallized structure varied to the rotational speed. Using optical electron microscope investigated the various rotational, clearly observed various grain sizes as shown in figure 3. From the figure 3 is an important evident for the grain structure evenly equiaxed for the various rotational speed and transverse speed. Very fine grains are formed due to dynamically re-crystallization compared to weld stir zone made with other pin profile as shown in Fig. 4 C.

![Fig. 2: ASTM E8M Tensile Specimen](image)
![Tool design](image)

Fig. 4: String zone speed 1200rpm (a) Square (b) triangle
Fig. 3: Grain structure for rotational speed 800, 1000 rpm. (a, b) Square profile (c, d) Triangle Profile (e,f) Pentagon

Temperature histories

Fig. 4: Square profile
However the tool rotational speed increases the temperature also increases and refinement of dynamic crystallization behavior. The high temperature leads to defect free weld and good weldment quality.

**Mechanical properties:**

Brinell hardness test was carried out by the friction welded region. The hardness has evaluated for all the three different types of tool pin profile. For the effect of tool rotational speed and transverse speed, the hardness as shown in figure.

![Rotational sped 800 rpm](image)
The joint fabricated Al 6061 alloy of high hardness value achieved by the square profile for the effect of tool rotational speed and welding speed. The hardness of stirring zone varied for varies heat input. However increasing rotational speed and decreasing welding speed, hardness also increased.

Tensile test was carried out by the three set of specimen tested for the every rotational speed. The model tensile value monitored as shown in below. The highest ultimate tensile strength observed at 1000 rpm and 30 mm/min for stir zone produced by square pin profile then by hexagonal and the lowest value obtained for joints produced by triangle pin profile. However the effect of the rotational speed on the ultimate tensile strength shows the joints produced by triangle pin profile has highest strength at rotational speed of 800 rpm then starts to decrease for further increase in rotational speed. This is because as triangular pin has highest shoulder area so it generates sufficient heat for welding at 900 rpm and produces defect free joint.
Fig. 11: Tensile strength

**Conclusion:**
- The present investigation compared to the microstructure of refinement of grain size increasing rotational speed and decreasing the welding speed to achieve the high strength weld.
- Tensile highest strength was obtained for the square profile, the optimum parameter 1000 rpm and transverse speed 30 mm/min.
- Advancing side and retracting side for the grain size equiaxed with the grain structure.
- Square pin profile predicted highest hardness value.
- The increasing tool rotational speed and transverse speed the temperature also increases to achieve the defect free weld.

**REFERENCES**