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OPTIMIZE THE TOOL PIN PROFILE ON ALUMINIUM AA6063 FRICTION STIR WELDED BUTT JOINT

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Abstract: In this study, aluminium AA6063 plate of 6mm thickness plate were welded by friction stir butt joint using different tool probe of cylinder and pentagon with constant parameter of rotational speed transverse speed and axial force of 1600 rpm, 25 mm/min and 5kN.The effect of welding parameter was evaluated in different mechanical properties of hardness distribution and tensile properties for axial weld zone. The significant optimal transverse feed is achieved with high weld quality and excellent joint properties when compared to cylinder tool. In this Pentagon tool gives the excellent result was obtained both tensile strength as well as hardness in order to improve productivity.

Keywords— *Friction stir welding, Aluminum Alloy 6063, Tool probe, Tensile strength, Hardness*

1. Introduction

The friction stir welding (FSW) process is a solid state joining process which utilizes frictional heat of a rotating tool and the stirring effect of the tool probe for solid state joining. The FSW process was invented at the Welding Institute at Cambridge in the early 1990s. Over the years FSW has gained significance for joining aluminum alloys.

Welding defects like porosity, oxidation and hot cracking are not produced in FSW process. FSW techniques are used to weld high strength alloys (2xxx, 6xxx, 7xxx and 8xxx serious) for aerospace, automotive, and marine application. FSW process produces four different type of region in the weld upon Base metal, Heat affected zone (HAZ), thermo mechanical affected zone (TMAZ), Weld zone. The tool and pin profile contribute the major role in the investigation. In marine application mostly used marine grade steel for hull and super structures but the weight and material cost is very high comparing to the aluminum alloy commercial grade. Aluminum alloy commercial grade 5xxx and 6xxx series replaced the marine grade steel [2, 3].

2. EXPRIMENTAL PROCEDURES

In the present work, commercial-grade aluminum plates were used. The chemical composition of the plate is given in Table 1. Two aluminum plates of 100×50×6 mm (length, width, and thickness, respectively) were placed on a flat aluminum plate before placing the plates, the edges of the plates were properly cleaned by using acetone. Plates were then clamped rigidly to avoid separation during welding from the joint line. The rotating FSW tool was pressed against the joint line. The welding was carried out at a constant load by controlling the penetration depth of the tool into the joint line. The ratio of diameters of the shoulder and pin was maintained in order to make the required pressure not only for reconsolidation of material but also to avoid the escape of material during welding.

Table 1 chemical composition (wt. %) of the base metal

Element	Al	Si	Fe	Mg	Mn	Zn	Cu
WT %	97.93	0.561	0.286	0.853	0.093	0.082	0.053

2.1 Configuration of the tool geometry.

There are two tools to be considered in friction-stir welding. These two tools have considerable importance and must be chosen with care to ensure a successful and efficient welding cycle. The relationship between the welding speeds and the heat input during welding is complex but, in general, it can be said that increasing the rotation speed or decreasing the traverse speed will result in a hotter weld. Two different pin profiles are considered. One is cylinder pin and another one is pentagon pin. Out of various tool materials like tool steel, high speed steel, high carbon high chromium steel (HCHCr),carbide, and carbon boron nitride, HCHCr steel is chosen as tool material because of its high strength, high hot hardness, easy to process, easily available and low cost. The FSW tools are manufactured using CNC Turning center and wire cut EDM (WEDM) machine. The tools are oil hardened to obtain a hardness of 60–62 HRC.

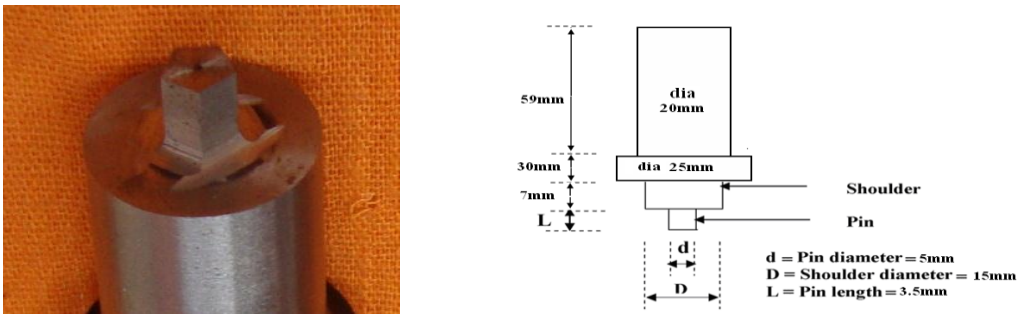

Fig. 1 The two different tool pin profile used this investigation

2.2 Specimen preparation

The tensile specimens are taken perpendicular to the direction of weld. Tensile test specimens are prepared as per ASTM E8 standard and tensile properties such as tensile strength, percentage of elongation and joint efficiency of the FS welded joints are evaluated using computerized (Universal Testing Machine) UTM. For each welded plate, three specimens are prepared and tested.

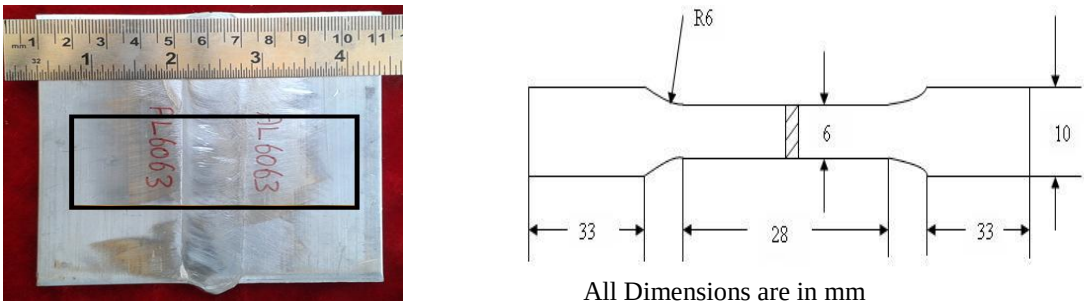

Fig.2 Location of Weld Direction in Tensile Test Specimen

3. RESULTS AND DISCUSSION

The first step to characterize the obtained weld is a visual inspection of roots and crowns. A circle of material that is deformed by the tool shoulder always remains. The appearance of this material provides information about the weld quality. Two pin profiles produced a complete circle around the hole. In FSW the interaction of a non-consumable and rotating tool with the work pieces being welded, creates a welded joint through frictional heating and plastic deformation at temperatures below the melting temperature of the alloys being joined.

The two different tool probes used in this study were cylinder and pentagon. The pentagon probe produced excellent mixing of friction stir weld and ultimate tensile strength reached up to the maximum level in this constant parameter. The weld zone area zinc particle was evenly distributed and also produces substantially

increase strength.

The cylindrical tool probe produce insufficient heat input and also affects the tensile properties. The figure 3 shows that the pentagon probe is the very fine result of ultimate tensile strength. In this parameter achieved that better joining performance and specimen welded shows that best behavior in the low cycle regime. This can significantly reduce extend of metallurgical transformation taking place during welding. The pentagon tool probe (figure 4) shows that increased the hardness. In the FSW process, tool probe contribute to the formation of the joints. The cylinder tool probe was effect the mechanical properties compared to the pentagon tool probe, considerable softening occurs throughout the weld zone due to the elimination of strain-hardening effect by dynamic re-crystallization. Hence, the hardness decreases in thermo mechanically affected zone towards the weld nugget as compared to the parent metal.

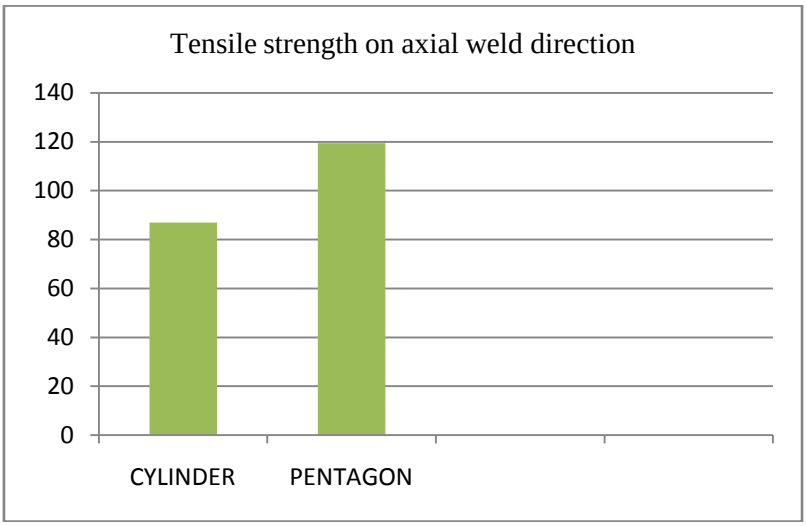

Fig. 3, TENSILE STRENGTH ON AXIAL WELD DIRECTION

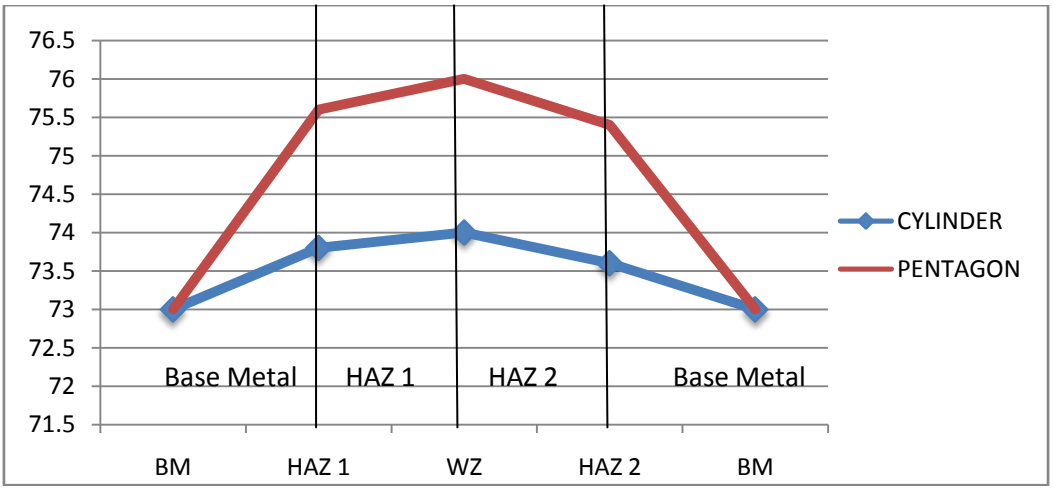

Fig. 4, Hardness Vs Probe

4. Conclusion

FSW of AA6063 joints was successfully accomplished for the different tool profile. The four different parameters involved in FSW such as tool rotational speed, transverse feed and axial force to be stable and the weld quality were studied. The different profiles involved in FSW such as cylinder and pentagon. The Pentagon tool profile gives more tensile strength and hardness when compared to cylindrical tool. In this study it was found that increasing the tool faces increases the mechanical properties. The Pentagon probe gives excellent mechanical properties and also achieved better mixing of material without any defect.

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