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RESEARCH ARTICLE

SIMULATION OF FLOW STRESS, TEMPERATURE AND PRESSURE ON FRICTION STIR WELDING OF EDGE JOINT ON SIMILAR ALUMINIUM ALLOYS 6061

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ABSTRACT

Friction stir welding process is used for joining material such as Aluminium, copper, magnesium etc., which are otherwise difficult to weld by the conventional welding processes. The tool pin profile plays a critical role in determining the end properties of the welding joint apart from other parameter like rotation speed, traverse speed, welding speed, and axial load. The purpose of the investigations was to elaborate a set of FSW parameters for connecting 6061 aluminium alloy sheets allowing to produce welds of highest strength. The results of present experiments are adding new information on FSW of the aluminium alloys, especially 6061 type. The applied welding parameters provide good quality of welds. The aim behind. In analysis we use AA6061 similar material for flow stress, temperature and pressure analysis with Hyper works *9.0*

INTRODUCTION

Friction stir welding (FSW) technology help joining aluminium sheets, without material preheating. The welding process takes place by a rotating FSW tool. The tool works within welded materials moving along their edges. The frictional heat generated due to rubbing of shoulder & work piece material results in plastic deformation and movement of material from advancing side to retreating side followed by formation of joint behind the tool shown in Figure 1. The friction stir welding results in substantial change in typical mechanical properties such as strength, ductility, fatigue and fracture toughness of the joint formed (Thomas *et al.,* 1991). Sato *et al.* (2005) investigated the transverse tensile properties of the friction stir weld of 6063-T5 aluminum. Effect of FSW parameters on tensile properties of 2024Al-T4 has been studied and ductility found to increase with increasing tool rotation rate by Biallas *et al.* (1955). A. von Strombeck *et al.* (2001) provided variation of tensile properties at different locations of FSW joints of 7075Al alloy and concluded that strength is almost constant in the nugget zone and the lowest strength is observed in HAZ. Mishra *et al.* (2005).

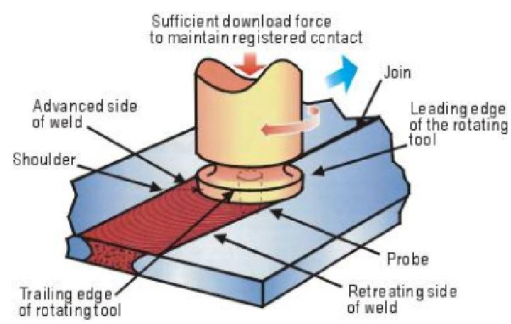

Fig. 1. Friction Stir Welding Schematic Set-up

Aluminium alloy 6061 is one of the most extensively used of the 6000 series aluminium alloys. It is a versatile heat treatable extruded alloy with medium to high strength capabilities. Alloy 6061 is known as a structural alloy. In plate form, 6061 is the alloy most commonly used for machining. Aluminium alloy 6061 is Good toughness, Good surface finish, Excellent corrosion resistance to atmospheric conditions, Good corrosion resistance to sea water, Can be anodized, Good weldability and brazability, Good workability, Widely available. This material is used for Air craft, Aero space component, Marine fitting Transport, Bicycle frames, Camera lenses, Driven shaft, Electrical fitting, Brake components, Valves, Coupling etc.

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Properties of work piece and tool materials

Table 1. Chemical composition of AA6061

Aluminium	Magnesium	Silicon	Iron	Copper	Zinc	Titanium	Manganese	Chromium	Others
Balance	0.8-1.2	0.4 – 0.8	Max. 0.7	0.15-0.40	Max. 0.25	Max. 0.15	Max. 0.15	0.04-0.35	0.05

Table 2. properties of AA6061-T6

Ultimate Tensile Strength (MPa)	260-310
0.2% Proof Stress (MPa)	240-276
Brinell Hardness (500kg load, 10mm ball)	95-97
Elongation 50mm dia (%)	9-13
Co-Efficient of Thermal Expansion (20-100°C)	23.5×10^{-6} m/m.°C
Thermal Conductivity	173 W/m.K
Electrical Resistivity:	$3.7 – 4.0 \times 10^{-6}$ Ω.cm
Density	2.7 g/cm^3
Melting Point	Approx 580°C
Modulus of Elasticity	70-80 GPa
Poissons Ratio	0.33

Table 3. Tool properties (Molybdenum material)

Tensile strength. (Mpa)	324
Shear Stress(Mpa)	500
Modulus of elasticity(Gpa)	330
Poisson ratio	0.38
Hardness(load/10mm)	225
Thermal conductivity(W/m.k)	138
Melting point(C^0)	2625

MATERIALS AND METHODS

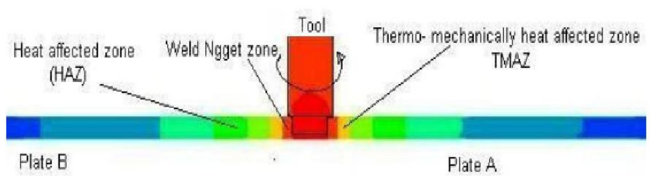

Figure 2. Different Temperature Zones During FSW Process (Sandeep Patel *et al.*, 2012)

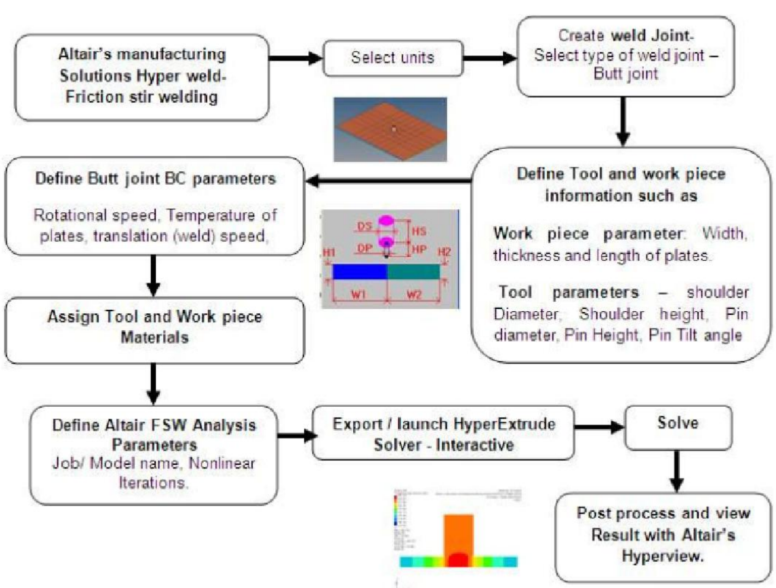

Figure 3. Methodology to conduct virtual experiment using Altair's Hyperweld FSW (Sandeep Patel *et al.*, 2012)

RESULTS

1) Flow stress

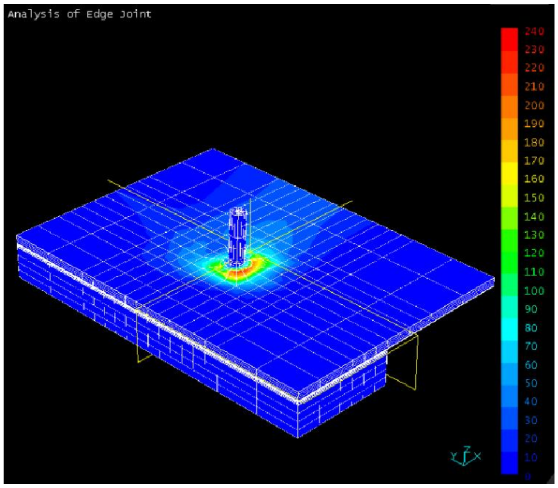

Figure 4. Flow stress at 600rpm

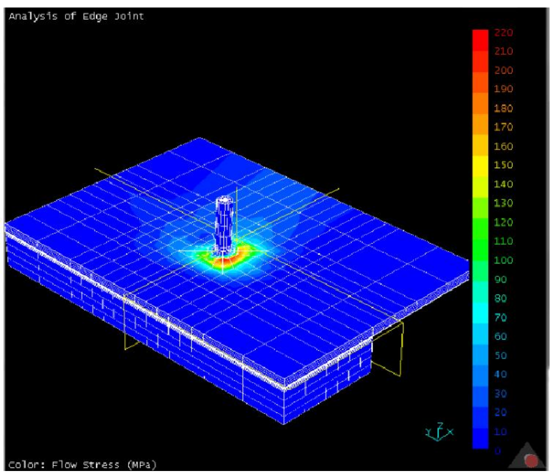

Figure 5. Flow stress at 700rpm

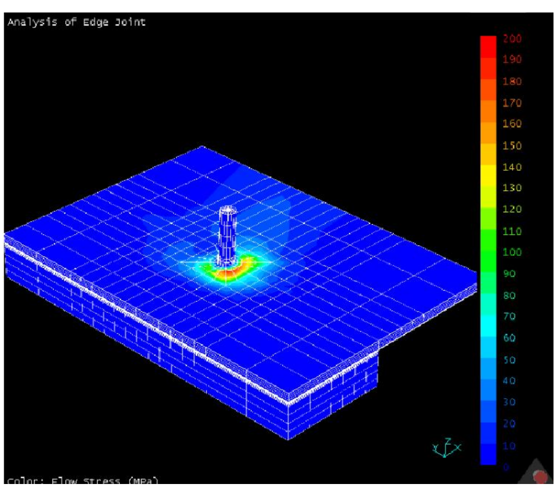

Figure 6. Flow stress at 800rpm

2) Temperature

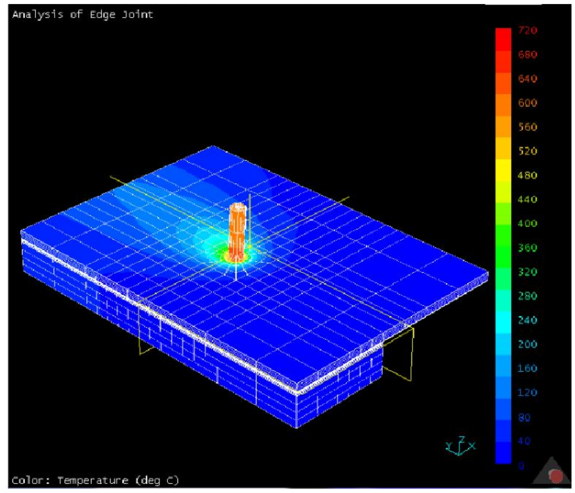

Figure 7. Temperature at 600rpm

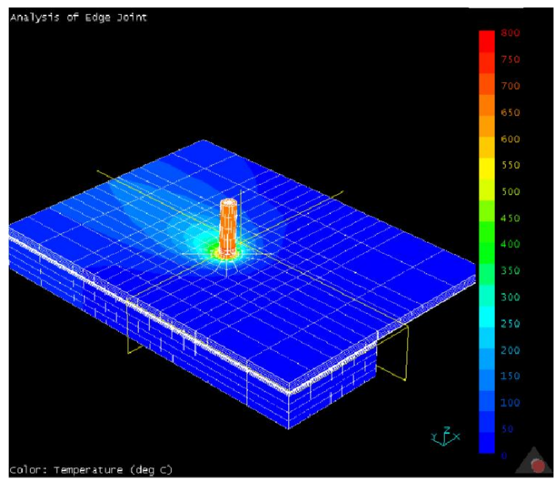

Figure 8. Temperature at 700rpm

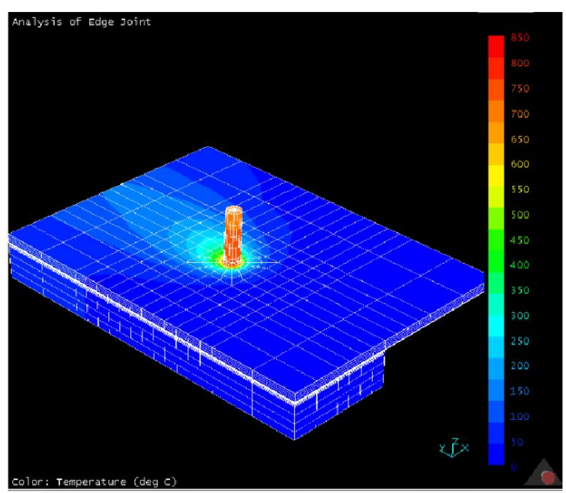

Figure 9. Temperature at 800rpm

3) Pressure

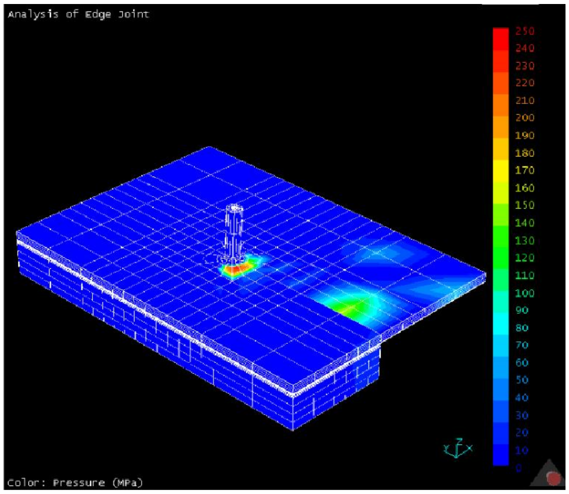

Figure 10. Pressure at 600rpm

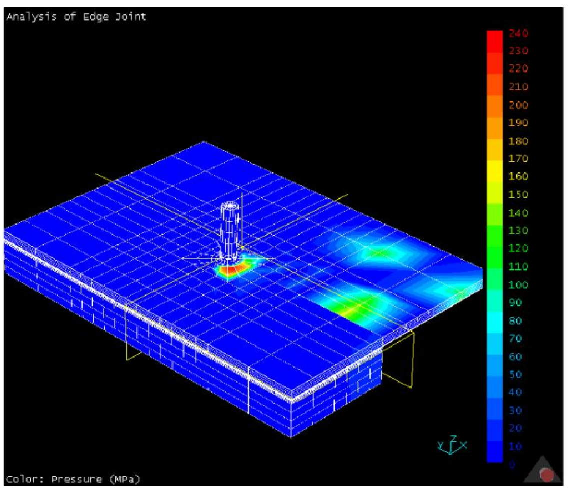

Figure 11. Pressure at 700rpm

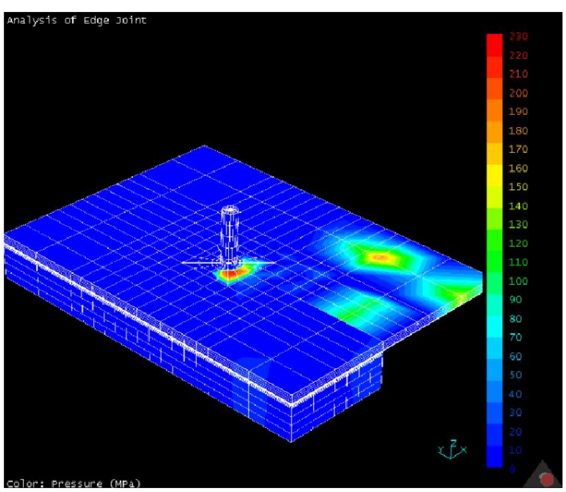

Figure 12. Pressure at 800rpm

Result table

Tool speed (rpm)	Traverse speed (mm/sec)	Flow stress (Mpa)	Temperature (c^0)	Pressure (Mpa)
600	4.23	234	687	242
700	4.23	219	757	237
800	4.23	197	835	228

Conclusion

(1) For simulation AA6061, If we are increasing the speed of tool than Flow stress, Pressure will decrease and Temperature will increase.

(2) We are increasing tool speed with constant traverse speed than Flow stress, Pressure will be decrease and Temperature will be increase.

Future scope

By Changing the traverse speed and use different tool profile we can increase weld quality.

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