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Investigation of Friction stir welded joint of AA6061 material using Altair Hyper Weld

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ABSTRACT

In the present work, three dimensional nonlinear thermal numerical simulations is conducted using Altair Hyper Weld Virtual experimental software module for the friction stir welded butt joint of AA6061 (aluminium alloy) material plates. FSW welding simulations were performed for seven different tool rotational speeds from 600 rpm to 1800 rpm with a step of 200 rpm and temperature distribution is analyzed. Result shows that the temperature field in the FSW process is symmetrically distributed along the welding line, increasing rotational speed increases temperature distribution. Virtual experimental data indicates that on the advancing side peak temperature is higher than the retreating side during the weld process. It is also noticed that the temperature in the FSW process is symmetrically distributed along the welding line.

Key Words: Friction stir welding, AA6061, Maximum Temperature, Modeling, Thermal analysis.

1. INTRODUCTION

Friction Stir Welding (FSW) is an efficient solid states joining process that have numerous potential applications in many domains including aerospace, automotive, marine and shipbuilding industries, as well as in the military. It combines frictional heating and stirring motion to soften and mix the interface between the two metal sheets, in order to produce fully amalgamated welds. One of its key potentials lies in the possibility of joining materials previously hard to weld, and to offer tremendous mechanical properties [1]. FSW is based on strong couplings of thermo-mechanical phenomena. It persuades very intricate material motions and large shear forces. The material temperature is raised up to about 80% of the melting temperature [2, 3].

The tool in FSW aids two primary functions: heating of the work piece, and the movement of material to yield the joint. The heating is accomplished by friction between the tool and the work piece and plastic deformation of the work piece. The confined heating softens the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to the back of the pin. As an effect of this process a joint is formed in 'solid state' [4]. FSW is considered to be the most substantial growth in metal joining in a decade and is a "green" technology due to its energy efficiency, environment friendliness, and versatility. FSW consumes considerably less energy as compared to the conventional welding techniques. No cover gas or flux is used, thus making the process environmentally friendly. The joining does not include use of any filler metal and hence any aluminum alloy can be joined without concern for the compatibility of composition, which is a problem in fusion welding. When required, dissimilar aluminum alloys and composites can be joined with equal ease [5, 6].

During the FSW process, temperature variations and its prediction are important. To understand thermal distribution in different zones of weld and material behavior during FSW process, thermal simulation using software and mathematical models can be utilized. [8] Measured thermal profile pertaining to FSW. They displayed that temperature distribution was symmetric around the weld center line, and the peak temperature at the weld center of Al 6061-T6 specimen was expected about 450°C. Experimental work is done considering heat transfer during FSW and determined that about 95% of heat produced from the friction was transferred into the work piece, and the rest flowed into the tool as well as about 80% of the plastic work was dissipated as heat of deformation[8].

The purpose of this study is to analyze temperature distribution of friction stir welded joint of aluminium alloy 6061. Altair's Hyper Weld Friction Stir Welding tool is used to conduct this virtual experimental work at Bipin Triphathi Kumaon Institute of Technology, Dwarahat and effects are achieved on thermal cycle and its distribution at various zones of weldment such as nugget zone, Thermo-mechanical Heat Affected Zone (TMHZ) and Heat Affected Zone (HAZ).

2. PROCESS METHODOLOGY

The virtual experimental work was completed using Altair's HyperWeld Friction Stir Welding. The work material employed in this present study is aluminium AA6061, measuring 5.0 mm for thickness, 350 mm for length and 227 mm for width. The butt joint configuration was modeled as shown in Figure 1.

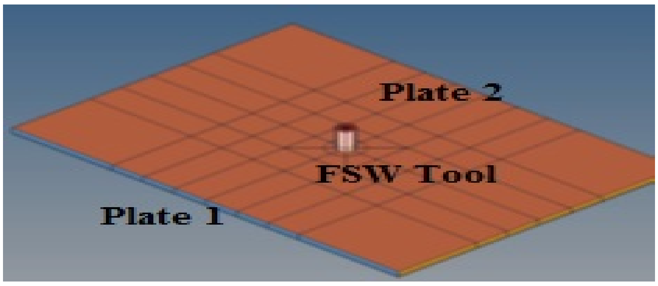

Figure 1: Butt Joint Configuration

The Friction Stir Weld-tool was considered made from H-13 hot-die steel material. The shoulder diameter, D, the pin diameter, d, and the pin length, l, was 15.0 mm, 6.0 mm and 4 mm, respectively. The welding speed is kept constant for all the experiment as 60 mm/min whereas the tool rotation speed is varied as 600, 800, 1000, 1200, 1400, 1600, 1800 rpm. The Methodology of this experimental work in Altair's HyperWeld FSW is more clearly explained with the help of the block diagram as presented in Figure 2.

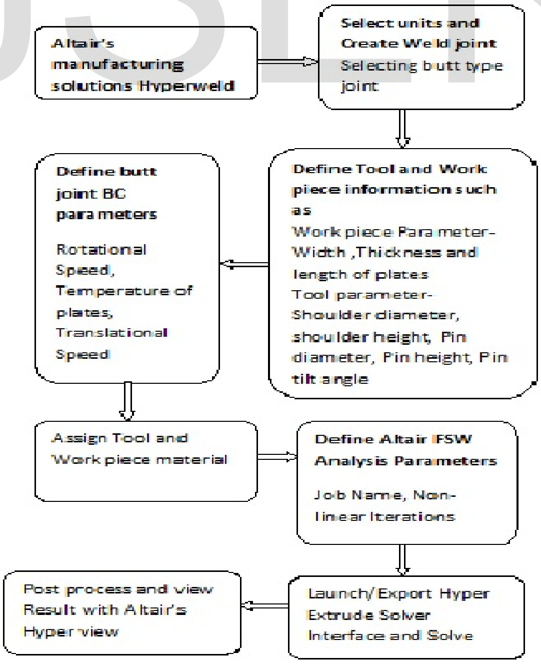

Figure 2: Block Diagram of Virtual experiment process of FSW.

3. RESULTS AND DISCUSSION

In this present work the finite element weld simulation is performed to investigate the effect of different tool rotational speed on peak temperature at HAZ of weldment for welding of AA6061 plates. Temperature contours are predicted and shown from Figure 3 to Figure 9 for different rotational speed of tool.

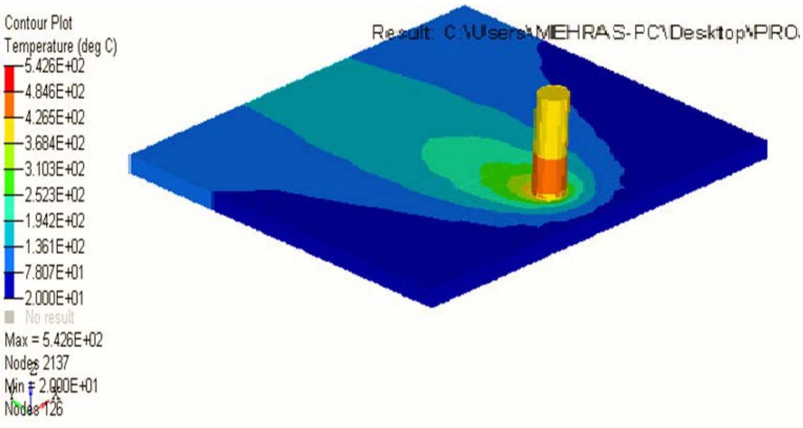

Figure 3: Temperature Contour for 600 rpm

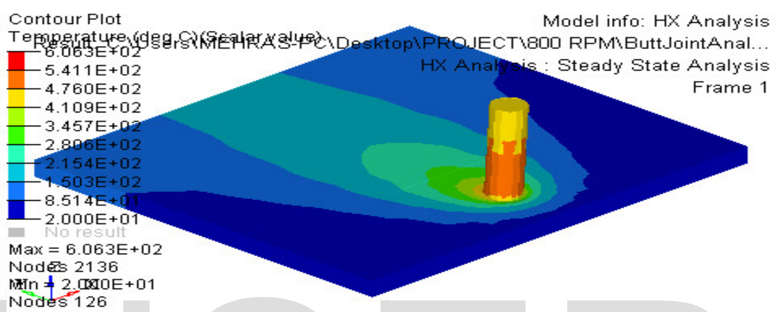

Figure 4: Temperature Contour for 800 rpm

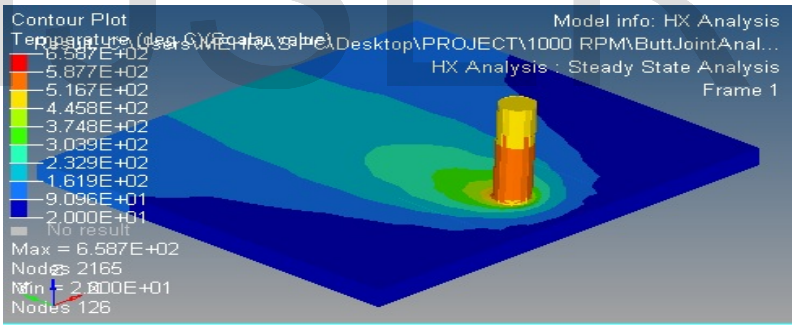

Figure 5: Temperature Contour for 1000 rpm

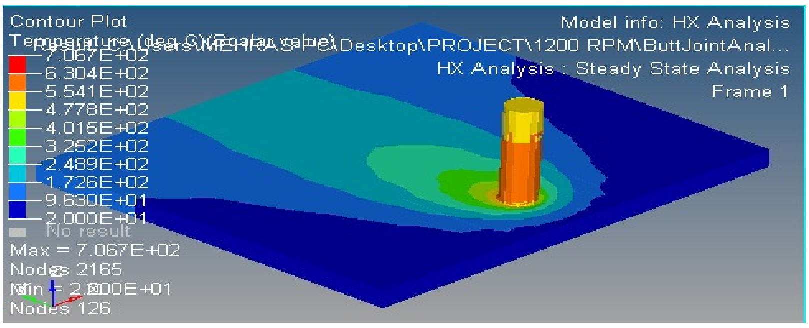

Figure 6: Temperature Contour for 1200 rpm

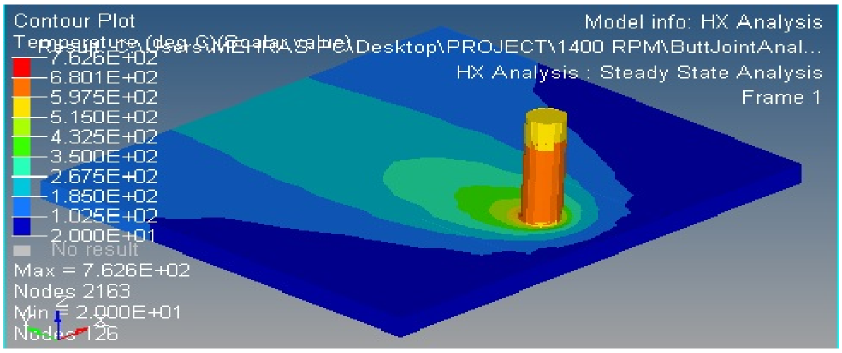

Figure 7 Temperature Contour for 1400 rpm

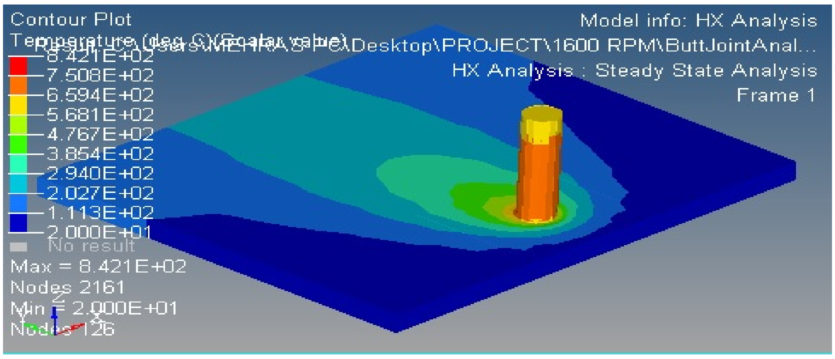

Figure 8 Temperature Contour for 1600 rpm

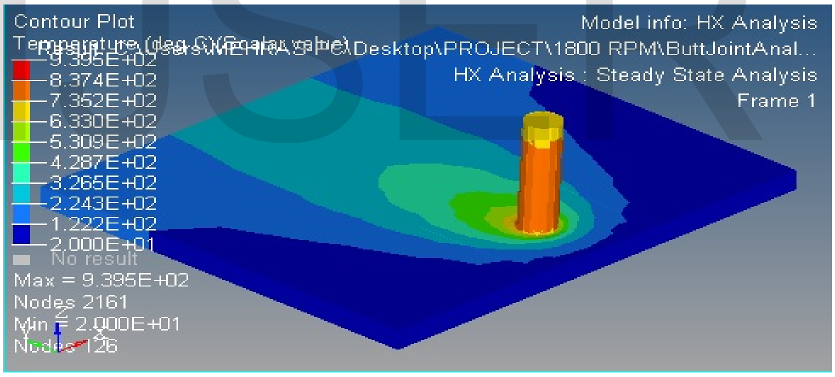

Figure 9 Temperature Contour for 1800 rpm

The results obtained for peak temperatures with different tool rotational speed are concluded in the Table 1.

Table 1: Values of Peak Temperature for different tool rotational speed

Tool Rotational Speed (rpm)	**Peak Temperature (°C)**
600	542.6
800	606.3
1000	658.7
1200	706.7
1400	762.6
1600	842.1
1800	939.5

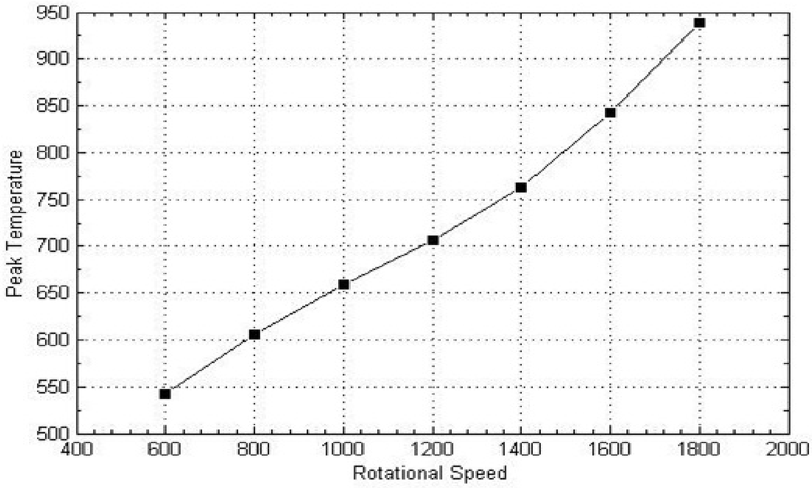

Figure 10: Variation of Peak Temperature (℃) with rotational speed (rpm)

Figure 9 displays the variation of peak temperature with rotational speed. It is observed that as the rotational speed increases the peak temperature of weld increases.

4. CONCLUSIONS

Friction stir welding simulation realized on Altair's HyperWeld FSW has released new skyline of modeling and simulation of joining processes. As a part of virtual laboratory, this software can be used to predict temperature distribution at different zones for different parameters. The virtual experimental data specifies that the temperature increases with increase in tool rotational speed. The result also indicates that the temperature at advanced side is higher than retract side.

Altair's Hyperweld Friction Stir Welding module is faster tool for the examination of welded joints and the welding industries can be benefited a lot. Also it is the best suitable package to conduct virtual experiments to predict different useful results prior to conduct actual experiment or production.

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