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Parametric Study of Variation in Peak Temperature for Different Tool Material in AA6061 FSW Welded Butt Joint Using Altair Hyperweld

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Abstract: Friction Stir Welding (FSW) is an emerging solid-state joining technology that is being developed since last two decades. In this present study, three dimensional nonlinear virtual experiments is conducted using ALTAIR Hyperweld FSW software module for the butt joint of Al6061 taking three different tool materials like Tungsten, Molybdenum and Tool Steel. Also during FSW simulation tool rotational speed is varied from 600 rpm to 1500 rpm with range of 300 rpm in case of each tool material. Then the thermal distribution for each simulation is analysed critically. This virtual experiment presents the temperature field in FSW process with variation in tool material, tool rpm and their comparative effects on workpiece on the basis of obtained contours which suggest the best rpm and type of tool material that is best suitable for FSW of Al6061. Altair hyper weld module is a new generation speedy tool for the analysis of the welded joint and the welding industries can be benefitted a lot. Also it is a best tool to conduct the virtual experiments to get the prediction of the various results prior to conduct the actual experiment or production in order to reduce to economical testing cost.
Keywords: Friction stir welding, Al6061, simulation, Thermal analysis, virtual experiments, Butt joint.

I. INTRODUCTION

There are varieties of process used in welding, but the most advanced technique to join is the Friction Stir Welding (FSW). In this process metals joint fields are plastic in nature, so not reaching the melting temperature and consequently the liquid state as it happen in traditional welding processes [1]. Firstly it was applied to aluminum alloys but in today scenario it is also applied to other materials also like copper, steel etc.

The advantages of FSW technique is that it is environment friendly, energy efficient, gas shielding for welding aluminum [2]. Mechanical properties as proven by fatigue, tensile tests are excellent[3]. Generally, during FSW no fume is generated, no porosityappliedno spatter and low shrinkage of the metal[4]. Joining dissimilar and previously unweldable metals can be attempted by this unique process[5]. Studies had been conducted on FSW of precipitation harden able and non-heat treatable aluminum alloys with respect to microstructure characterization, and the effect of welding parameters on mechanical properties[6]. Hardness fatigue, strength residual stress and microstructure evolution, various effects by welding has been emphasized [7]. However, there is not much information available on correlation of welding parameters with evolution of defect free weld. In order to have a defect free weld the optimization of welding parameters is extremely important[8]. In analyzing the mechanics of friction stir welding and processing (FSW/P), researchers have used experimental and numerical techniques to study the flow and consolidation of materials under the shoulder [9]. Heat generation during friction-stir welding arises from two main sources: friction at the surface of the tool and the deformation of the material around the tool [10]. The heat generation is often assumed to occur predominantly under the shoulder, due to its greater surface area, and to be equal to power required to overcome the contact forces between the tool and the work piece [11]. The contact condition under the shoulder can be described by sliding friction, using a friction coefficient μ and interfacial pressure P, or sticking friction, based on the interfacial shear strength at an appropriate temperature and strain rate [12]. Mathematical approximations for the total heat generated by the tool shoulder Q_{total} have been developed using both sliding and sticking friction models:

Q(total) = $\frac{2}{3}P\mu w(R^3 shoulder - R^3 pin)(sliding)$ … … … … … … … .1

Q(total) = $\frac{2}{3}P\mu w(R^3 shoulder - R^3 pin)$(sticking) ………………….. 2

Where w is the angular velocity of the tool, $R_{shoulder}$ is the radius of the tool shoulder and R_{pin} that of the pin [13]. Several other equations have been proposed to account for factors such as the pin but general approach remains the same.

II. MODELING

The simulation was completed in Altair's Hyper-Weld Friction Welding (FSW). In this present study, aluminum Al6061 is used as weld material with 6.35 mm of thickness, 305 mm of length and 227 mm of width. Figure 2 shows mesh modeling for Butt joint. The Friction Stir Weld-tool is taken of H-13 hot-die steel, Tungsten and Molybdenum respectively. The tool rotation speed is varied from 600 rpm till 1500 rpm.

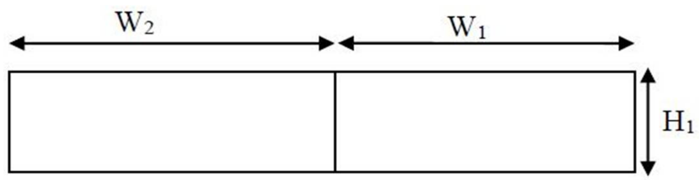

Fig.1 Schematic diagram of Butt Joint [17]

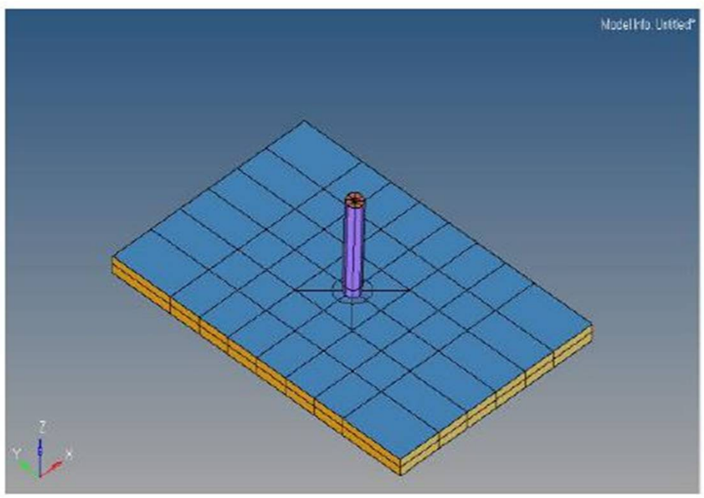

Fig.2 Mesh modeling for Butt joint

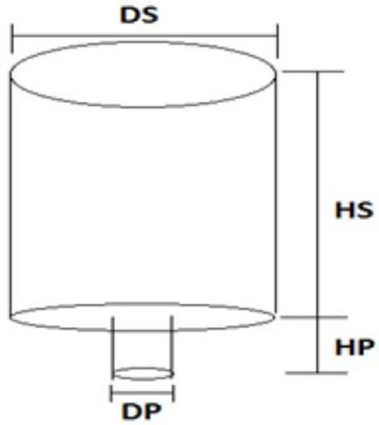

Fig.3 Schematic diagram of tool [17]

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III. METHODOLOGY

The methodology of the experimental work is explained through block diagram as shown in Fig.4

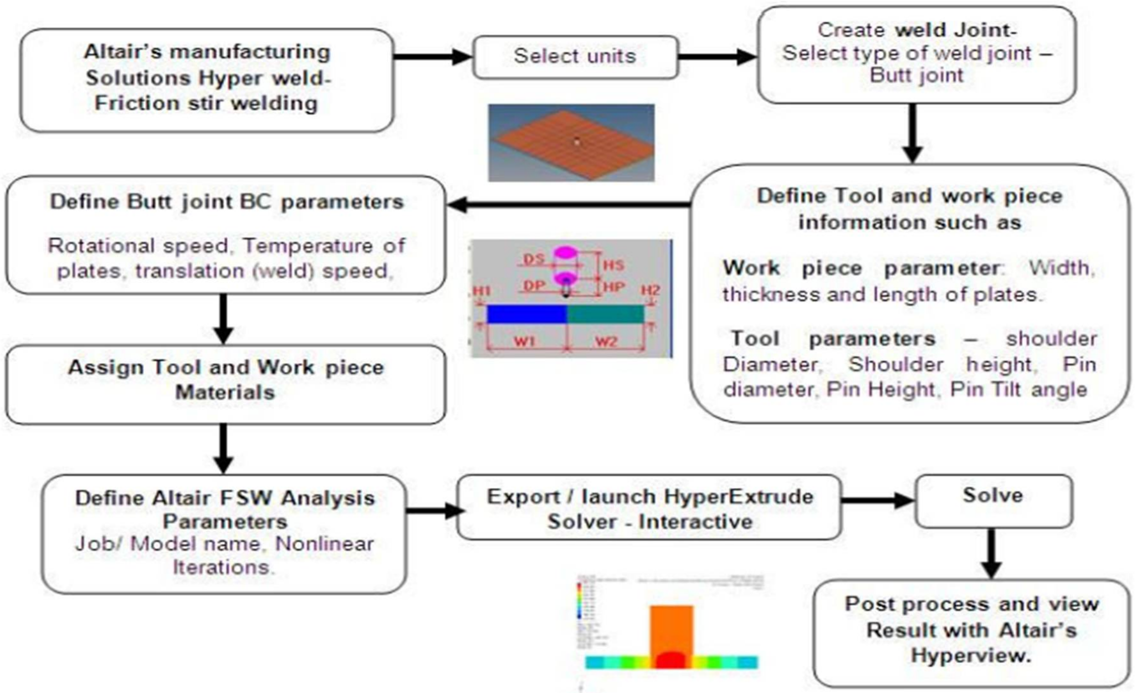

Fig.4 Block diagram for using Altair's Hyperweld [17]

Peak Temperatures Contour for the Tungsten, Molybdenum, H-13 Tool Steel are shown below:

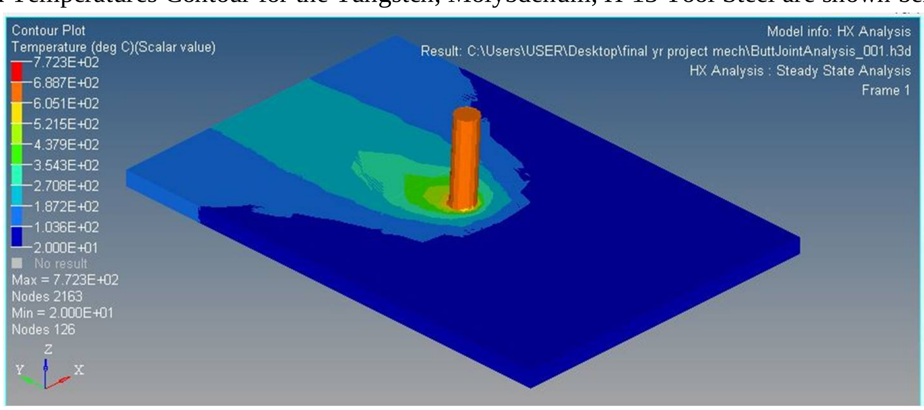

Fig.5 Temperature contour for Tungsten for 1500 rpm

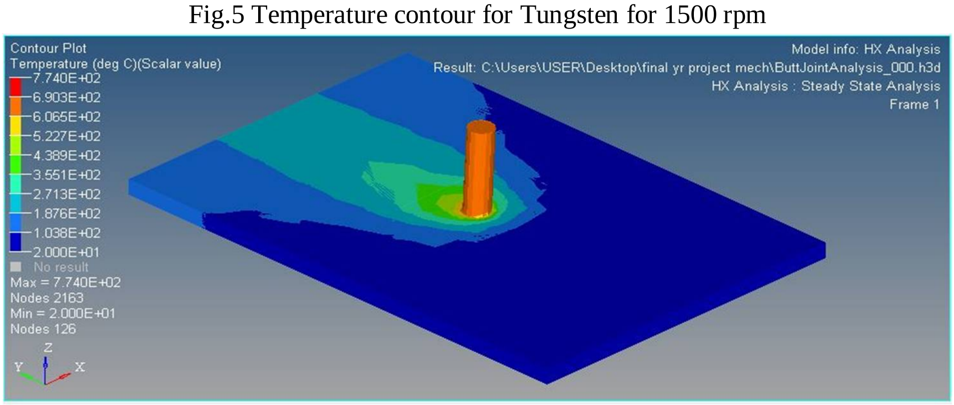

Fig.6 Temperature contour for Molybdenum for 1500 rpm

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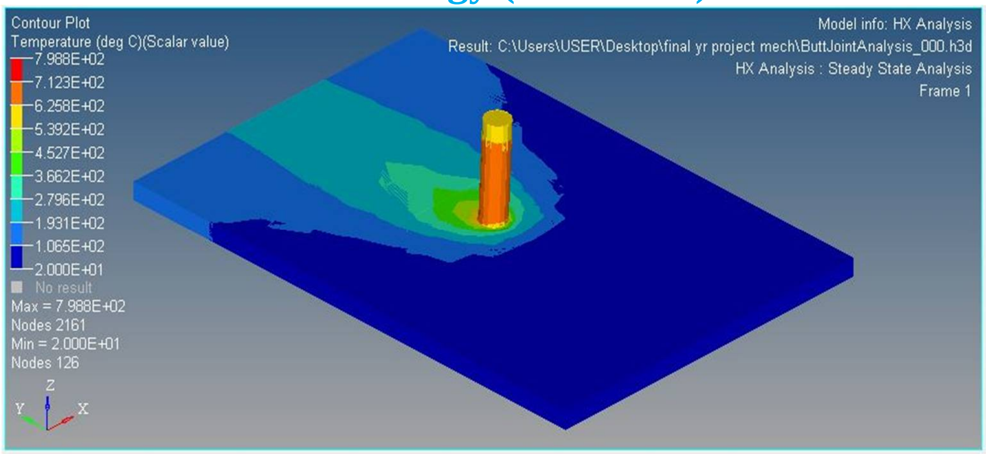
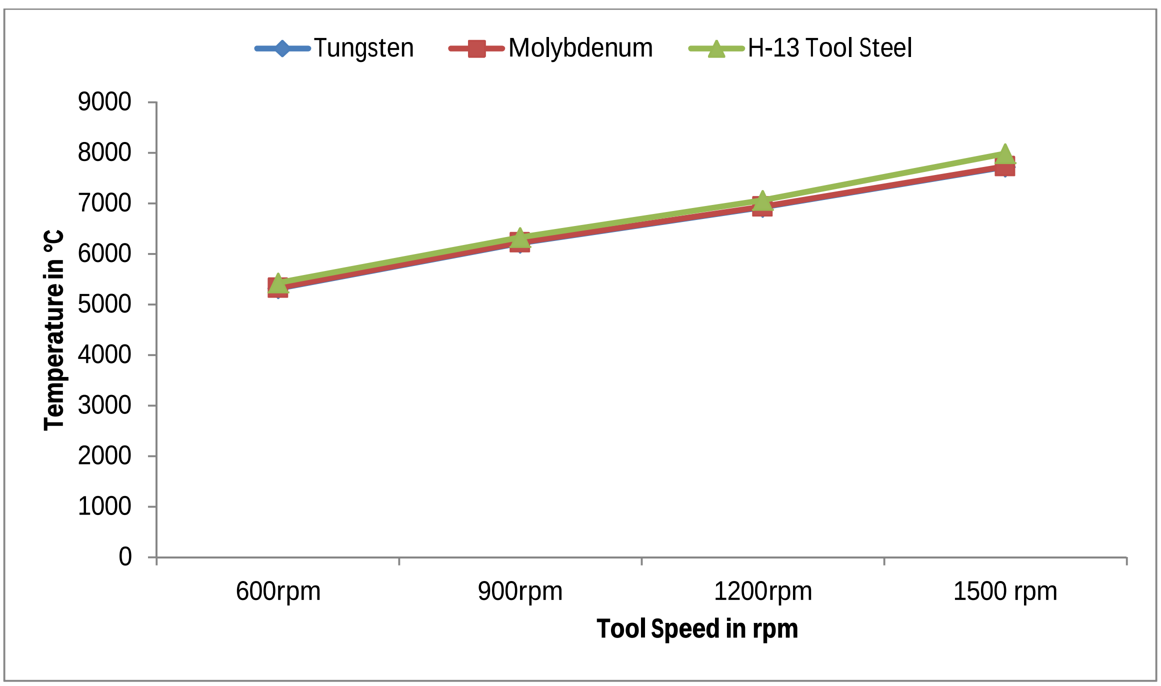


Fig.7 Temperature contour for H-13 Tool Steel for 1500 rpm

Comparative results for Tungsten, Molybdenum, H-13 Tool Steel

Rotation speed of Tool (rpm)	Tungsten ($T_{max.}$)°C	Molybdenum ($T_{max.}$)°C	H-13 Tool Steel ($T_{max.}$)°C
600	5315	5327	5426
900	6209	6222	6335
1200	6919	6932	7067
1500	7723	7740	7988



IV. CONCLUSION

Friction Stir welding simulation performed on Altair's Hyper Weld has opened 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 distribution zones for different parameters. The virtual experimental data indicates that the temperature of weld bead increases with increase in tool rotational speed and in Tool Steel, while the temperature decreases with increase in welding speed. The maximum temperature attained at 1500rpm. This result also indicates that the temperature in Tool Steel is higher than Tungsten and Molybdenum. Altair's Hyper-weld 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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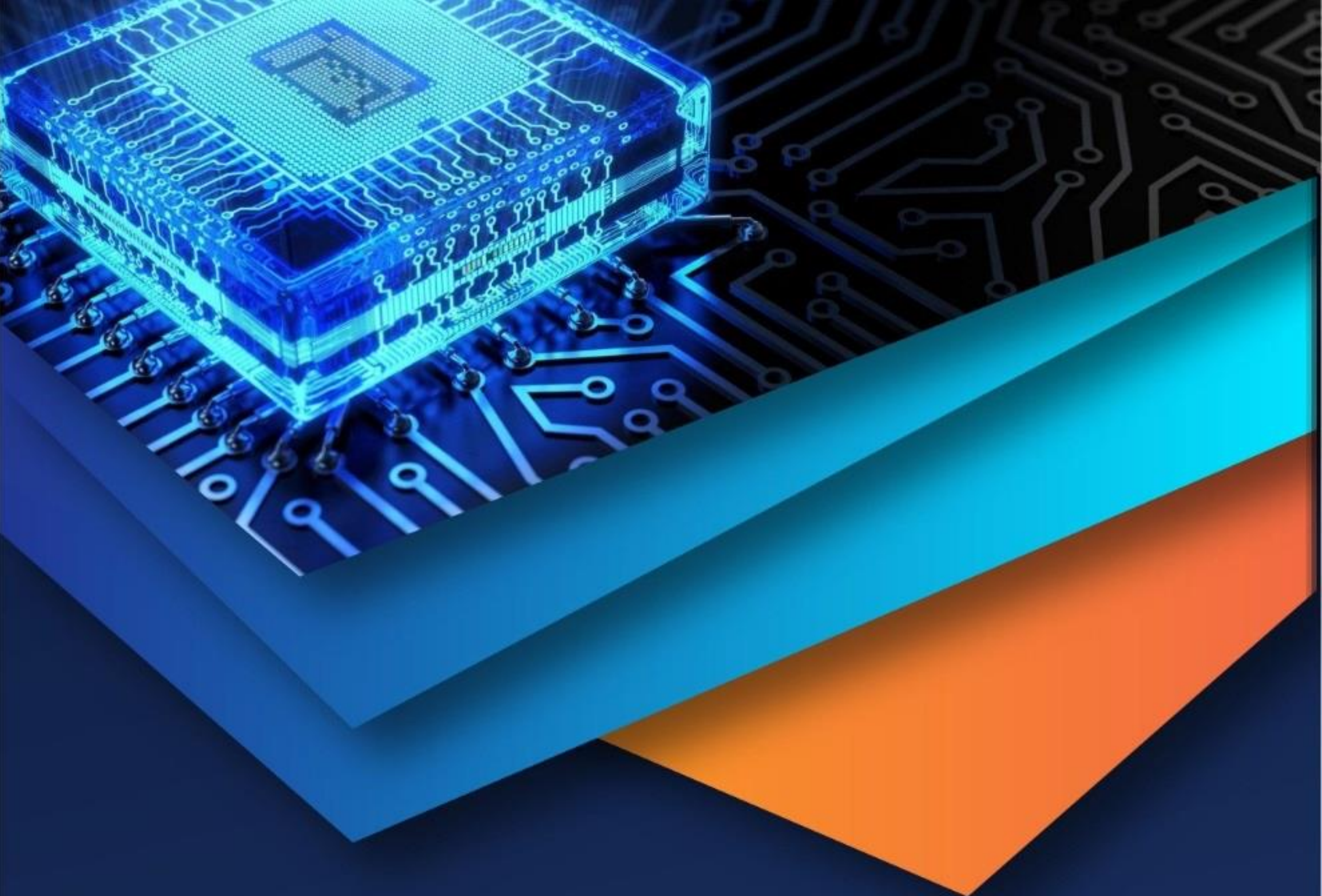

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