Study of Peak Temperature in Friction Stir Welded T- Joint for AA6061 using Altair Hyper Weld

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Abstract:- **In this present work a 3-dimensional non linear thermal numerical simulation is being conducted using Altair hyper weld friction stir welding module for the T joint of AA6061 work piece. In this work the maximum peak temperature is being calculated and plotted against the different varied parameters i.e. (tool pin dia., tool r.p.m., tool transverse speed) by the help of MATLAB simulator software. Friction stir welding simulation performed on Altair hyper weld had opened a new scope for the modeling and simulation of joining process. 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, T joint, peak temperature, thermal analysis, Altair hyper works.

INTRODUCTION:

The Friction Stir Welding (FSW) process is an innovative technique to join metals in the plasticity field, thus not reaching the melting temperature and consequently the liquid state as it happen in traditional welding processes. It was initially applied to aluminum alloys but now it is extended to other materials like copper, steel etc.

The advantages of FSW technique is that it is environment friendly, energy efficient, there is no necessity for gas shielding for welding aluminum. Mechanical properties as proven by fatigue, tensile tests are excellent. There is no fume, no porosity, no spatter and low shrinkage of the metal. Joining dissimilar and previously unweldable metals can be attempted by this unique process. FSW parameters are tool geometry, axial force, rotational speed, transverse speed, and tool tilt angle. Many study has been conducted on FSW of precipitation harden able and non- heat treatable aluminum alloys with respect to microstructure characterization [7], and the effect of welding parameters on mechanical properties [7]. Emphasis has been given to the effects of welding parameters on hardness fatigue strength residual stress and microstructure evolution [8]. 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. 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 **Belignault et al**. [9] discussed the development of a multi axial transducer capable of capturing the process footprints that can be used to measure the energy input to welding. **Hattingh et al.** [10] analyze the force footprints to systematically study the influence of tool geometry factors on FSW process parameters and on weld tensile strength and there by optimize the tool design to produce weld with 97% of the parent plate tensile strength in Al 5083-H321 alloy . **Arbegast** [11] experimentally demonstrated the changes in process forces due to clamping location, welding direction crossing over pre-existing FSW and changing the process parameters (rotational rate and transverse speed).The hot researcher area on FSW of heat treatable Al alloys has been focused on 2024 Al, 2195Al, 6061Al and 7075Al

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. The heat generation is often assumed to occur predominantly under the shoulder, due to its greater surface area, and to be equal to the power required to overcome the contact forces between the tool and the work piece. 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:

$$Q(total) = \frac{2}{3} P\mu\omega(R^3 shoulder - R^3 pin)\text{(Sliding)} \qquad ....1$$

$$Q(total) = \frac{2}{3} P\mu\omega(R^3 shoulder - R^3 pin)(\text{Sticking}) \quad .... 2$$

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

MODELING

The virtual experimental work is completed using Altair's Hyper weld Friction Stir Welding. The work material employed in the present study was Aluminium AA6061, measuring W1-177.8mm, W2-177.8mm, W3-101.6mm, H1-25.4mm, H2-76.2mm, L-508mm, Shoulder Diameter(DS)-20.32mm, Shoulder Height(HS)-76.2mm, Pin Diameter(PD)-variable, Pin Height(HP)-30.48mmThe T configuration model is shown in fig(1) and tool model is shown in fig(2).

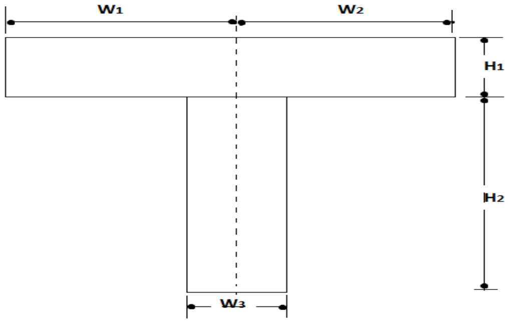


Fig1: Schematic diagram of T joint

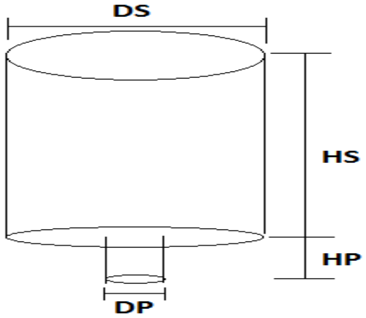


Fig2: Schematic diagram of Tool

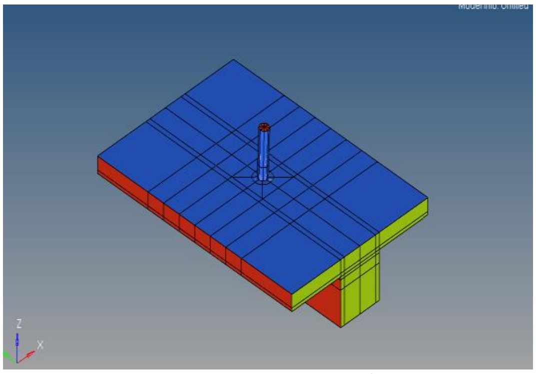


Fig3: Modeling and Meshing of T joint

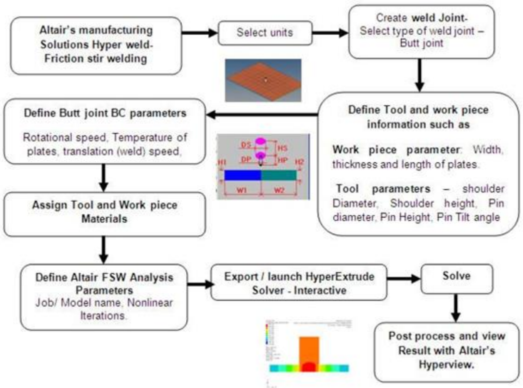


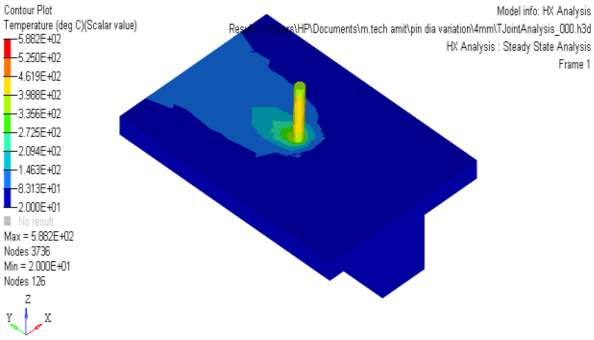
Fig4: Methodology to conduct the virtual experiment using Altair's Hyper Weld

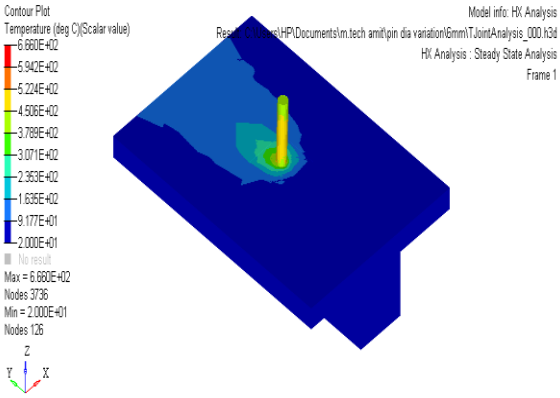
PROBLEM SPECIFICATION

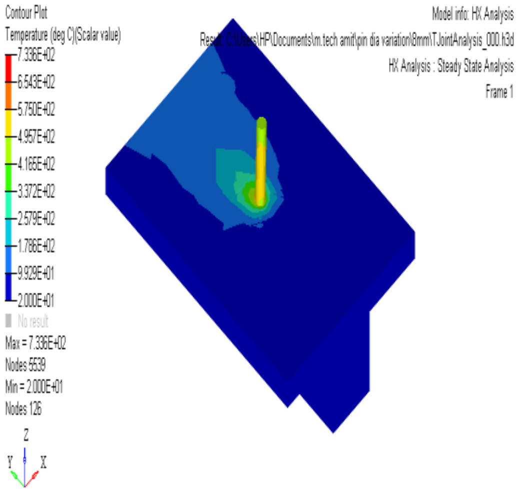
The friction stir weld – tool was made from H-13 hot-die steel material. The shoulder diameter, the pin diameter and the pin length is taken (D) 20.32mm, (d) variable and (l) 30.48mm, respectively. Process parameters such as Tool Rotational Speed , Welding Speed is varied from 600rpm-1800rpm in step of 200 , Welding Speed is varied from 3m/s-15m/s in step of 2 and Pin Diameter is varied from 2mm-14mm in step of 2 for the virtual experimental study of Friction Stir Welding.

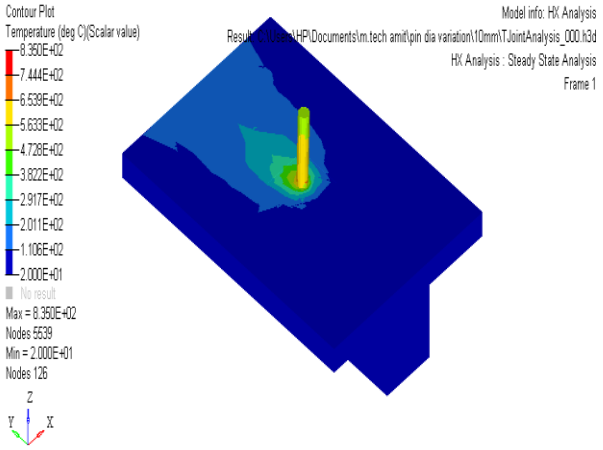
RESULTS AND DISCISSION

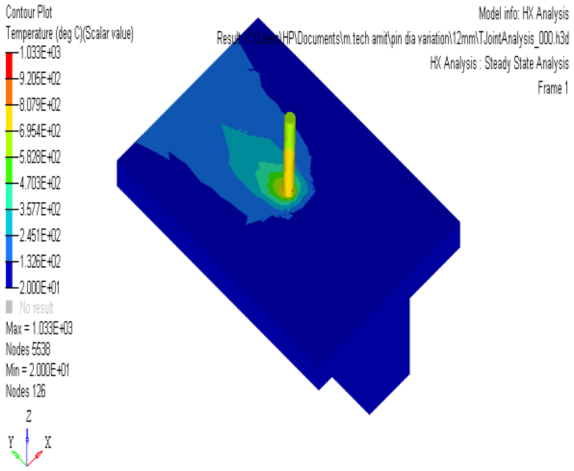
CONTOURS FOR MAXIMUM PEAK TEMPERATURE WITH VARYING TOOL PIN DIAMETER











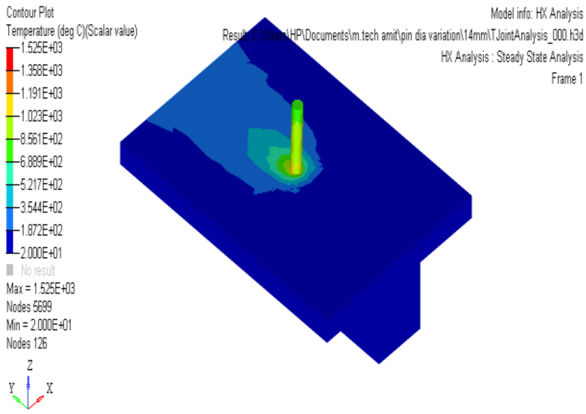


TABLE 1: Results for maximum temperature w.r.t variation in pin dia.

PIN DIAMETER (mm)	MAXIMUM TEMPERATURE (KELVIN)
2	489
4	588
6	666
8	733
10	835
12	1033
14	1525

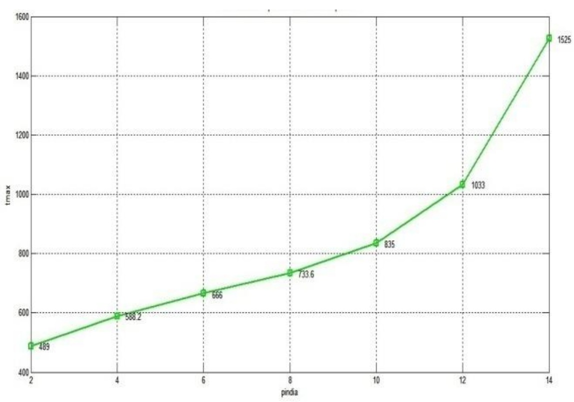
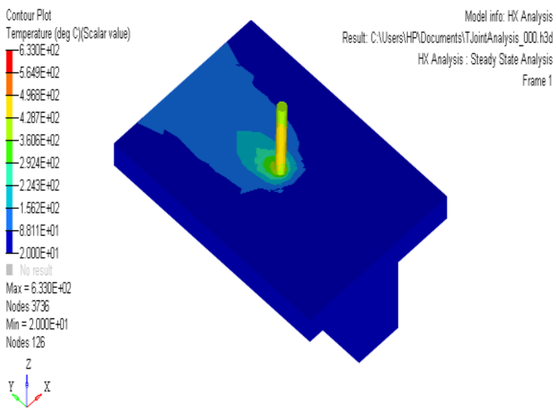
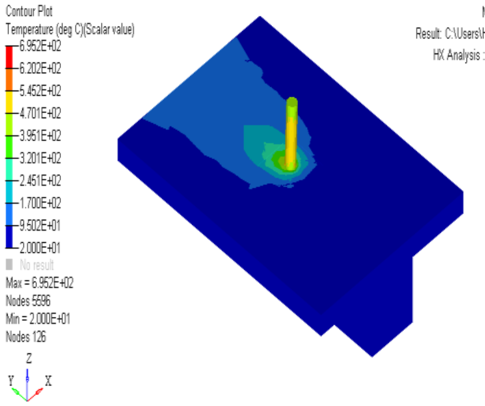
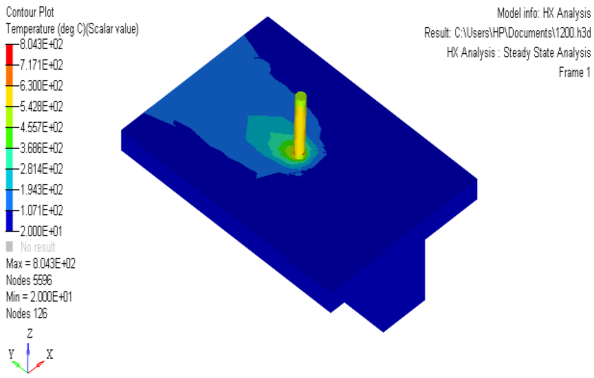


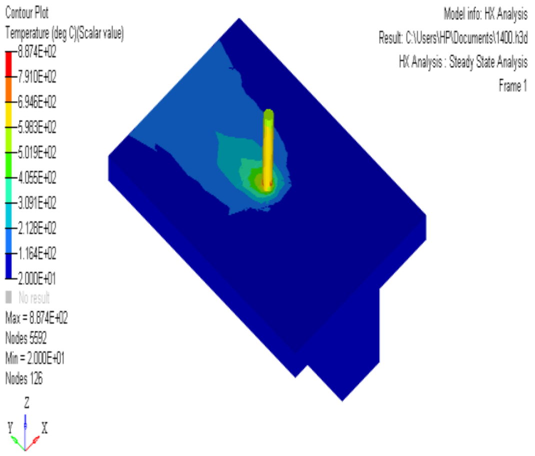
Fig 5: Variation of Peak Temperature with varying pin dia.

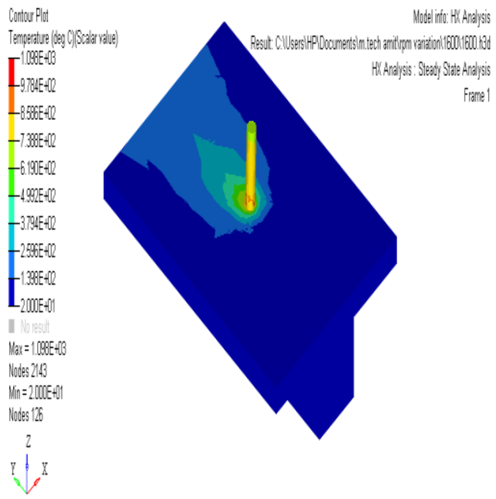
CONTOURS FOR MAXIMUM PEAK TEMPERATURE WITH VARYING TOOL R.P.M.











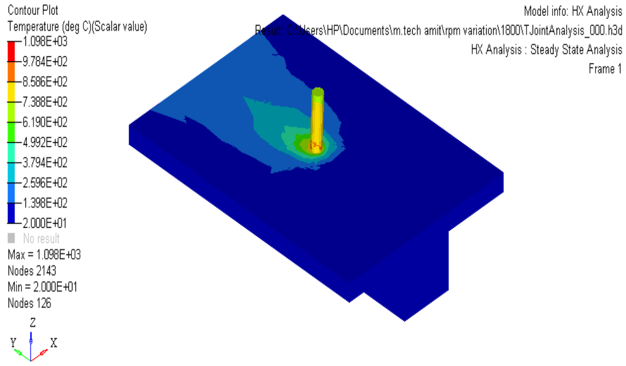


TABLE 2: Results for maximum temperature w.r.t. variation in r.p.m.

RPM	MAXIMUM TEMPERATURE (KELVIN)
600	633.0
800	695.2
1000	743.3
1200	804.3
1400	887.4
1600	1098
1800	1098

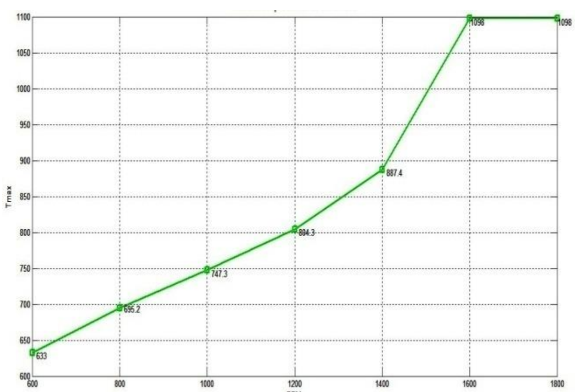
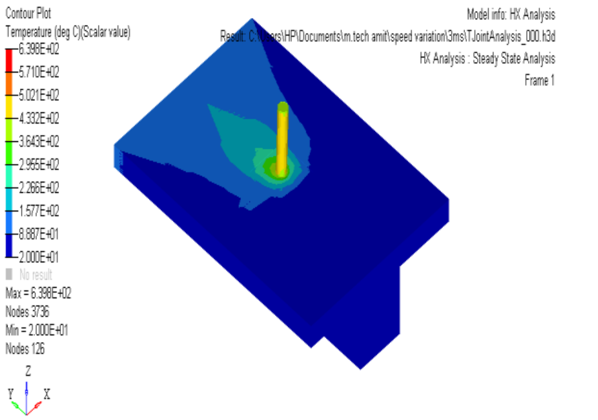
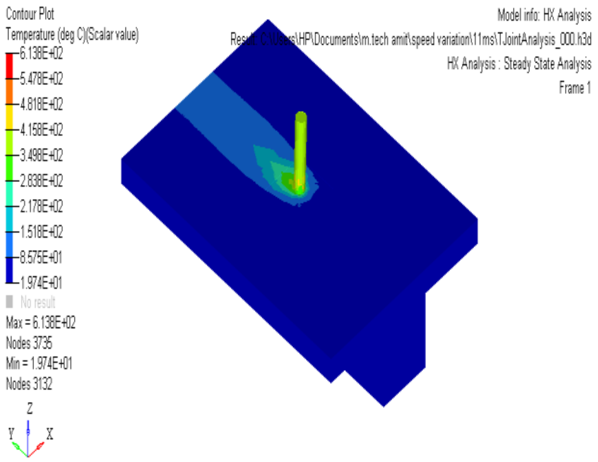
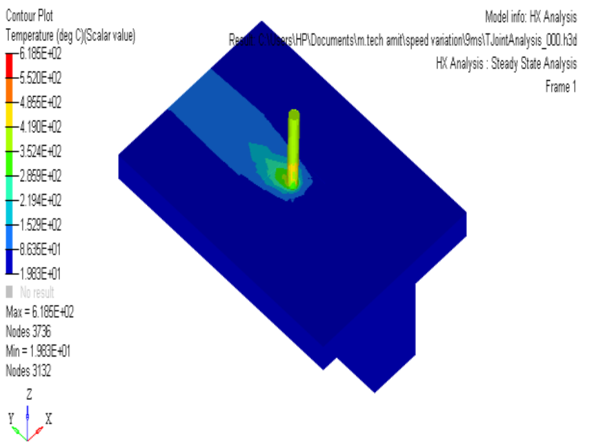


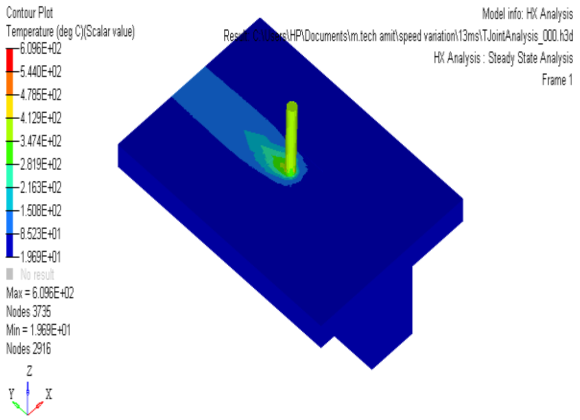
Fig 6: Variation of Peak Temperature with tool rotational speed

CONTOURS FOR MAXIMUM PEAK TEMPERATURE WITH VARYING TOOL TRANSVERSE SPEED









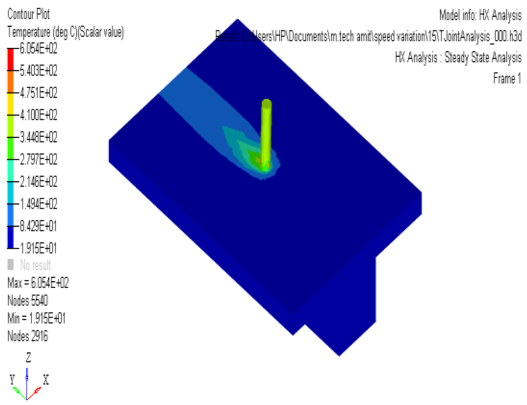


TABLE 3: Results for maximum temperature w.r.t. variation in tool travel

TOOL TRAVEL (m/s)	MAXIMUM TEMPERATURE (KELVIN)
3	639.8
5	630.0
7	623.8
9	618.5
11	613.8
13	609.6
15	605.4

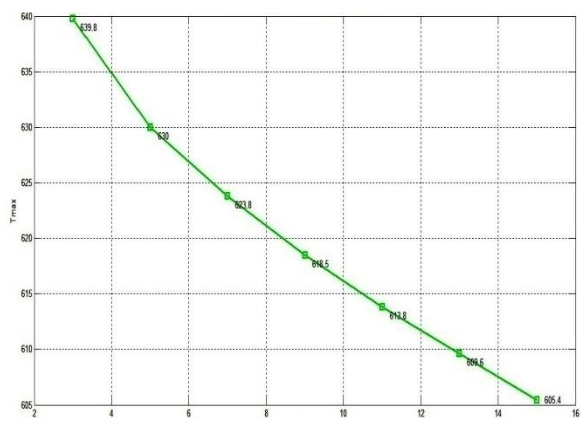


Fig 7: Variation of Peak Temperature with tool travel speed In HAZ of Friction Stir Welding

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 pin diameter, while the temperature decreases with increase in welding speed. The result also indicates that the temperature at advanced side is higher than retract side.

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