Thermal Analysis Estimation of Dissimilar Materials with Abaqus

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Abstract:

This project's objectives are to gain a better understanding of friction stir welding, investigate thermal stresses, and examine temperature distribution through finite element analysis using simulation using Abaqus, a software program used for mechanical component modelling and analysis. The characteristics and compatibility of various materials must be verified here by modelling and simulation approaches. Because of this, the combination of nickel and stainless steel produces better results in friction stir welding than the combination of copper and aluminium. Additionally, the average heat flux produced by the combination of nickel and stainless steel is lower than that of the combination of copper and aluminium. A solid-state welding technique called friction stir welding is carried out at a temperature where the metals recrystallize. This procedure creates welds by compressing workpieces that are spinning or moving in relation to one another. Heating from friction at the interface produces the heat needed to unite various specimens. the heat produced by friction between the pin and the shoulder of the wear-resistant welding tool. The benefits of friction stir welding stem from its special ability to weld without the need for consumables or shielding element approaches. The flawless, excellent weld is the result.

1. Introduction:

FRICTION STIR WELDING:

Friction stir welding (FSW) was invented at The Welding Institute (TWI) of UK in 1991 as a solid-state joining technique, and it was initially applied to aluminum alloys.

The basic concept of FSW is that a non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint. The tool serves two primary functions:

(a) heating of workpiece, and

(b) movement of material to produce the joint.

The heating is accomplished by friction between the tool and the workpiece and plastic deformation of workpiece. The localized 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 a result of this process a joint is produced in 'solid state'.

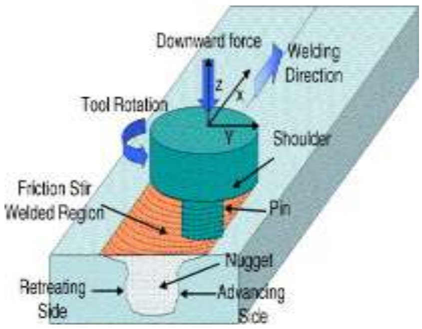


Fig1.1 **Schematic diagram of friction stir welding**

During FSW process, the material undergoes intense plastic deformation at elevated temperature, resulting in generation of fine and equiaxed recrystallized grains. Friction stir welds typically exhibit three main microstructural regions: a weld nugget, a thermo-mechanically affected zone (TMAZ) and a heat-affected zone (HAZ). Technically, the weld nugget and TMAZ are both "thermo-mechanically affected zones," but are considered separately for exhibiting distinct microstructural features. The weld nugget experiences dynamic recrystallisation while the TMAZ does not. The extent and microstructural composition of these zones are dependent on the material and processing conditions.

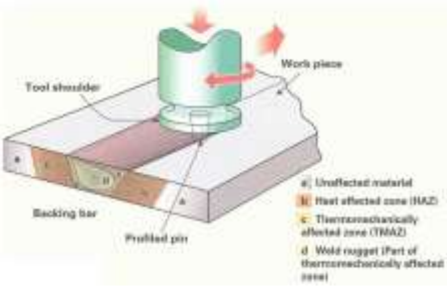


Fig1.2 **Friction stir welding**

FSW is mainly used in industry to join aluminium alloys of all grades, in cast, rolled or extruded condition. Aluminium alloy butt joints with a thickness from 0.3mm to 75mm have been successfully joined in a single pass (dependent on workpiece material, machine power and structural stiffness). Other materials have also been successfully joined, namely magnesium, titanium, copper, and steel alloys. Plastics and metal matrix composites (MMC) have been explored. Dissimilar combinations between these materials have also proven possible. The most commonly used material for the tool is HSS- High speed steel.

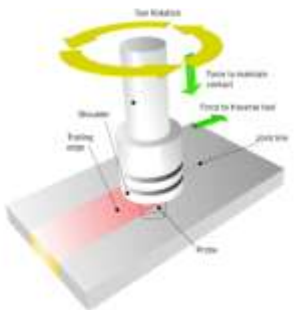


Fig1.3 **Principle of Friction Stir Welding**

FSW is considered to be the most significant development in metal joining in a decade and is a "green" technology due to its energy efficiency, environment friendliness, and versatility. As compared to the conventional welding methods, FSW consumes considerably less energy. No cover gas or flux is used, thereby making the process environmentally friendly. The joining does not involve any use of filler metal and therefore any aluminium alloy can be joined without concern for the compatibility of composition, which is an issue in fusion welding. Stresses that arise both during and after welding are known as welding stresses. The latter are referred to as residual tensions from welding. As a result, welding strains represent a particular kind of thermal stress. The main source of thermal strains during welding is an uneven temperature field. The development of these stresses is determined by thermal strains, material behavior, and internal and external constraints.. As in FSW results in intense plastic deformation around rotating tool and friction between tool and work pieces. Both these factors contribute to the temperature increase and stresses takes place within and around the stirred zone. Since the temperature distribution and stresses within and around the stirred zone directly influences the microstructure of the welds, such as grain size, grain boundary character, coarsening and dissolution of precipitates, and resultant mechanical properties of the welds, it is important to obtain information about temperature distribution during FSW. However, temperature measurements within the stirred zone are very difficult due to the intense plastic deformation produced by the rotation and translation of tool. Therefore, the stresses analysis, maximum and minimum temperatures within the stirred zone during FSW have been either estimated from the microstructure of the weld. Acerra. F et al (2010): Attempted to weld the combination of two dissimilar aluminum alloy in T-configuration of AA7075-AA2024. It was to be investigated that higher the shoulder diameter of tool higher the heat to be generated by the FSW process on the weld zone. It was done to fulfil the forging requirement. Sometimes coating blank elements was obtained causes major defect was analyzed. Buffa et al (2006b): Studied the model simulation in which he investigated how the tool geometry affects the weld zone. He tried with conical as well as cylindrical geometry of the tool and advancing speed of FSW on rigid viscos-plastic three-dimensional finite element model of 7075 aluminum alloy. In this model he studied how material flow takes place over the weld to be done as well as microstructural behavior like grain size variation. This result was used further to find the optimum tool geometry as well as speed to be advance. Khadar and Shibahara (2008): Studied and presented what are the effect of process parameters like welding speed and the location of the base metal in the microstructure obtained also the mechanical properties like tensile strength and hardness distribution of the joints made by Friction stir welding process of 7075-T6 and 2024-T3 Al alloy. The defect which is called as kissing bond defect is appears on weld zone when the speed of weld is increased. Onion ring pattern obtained by different equiaxial grain sizes and nonhomogeneous distribution of alloying element was obtained. Lim et al. (2004) and Cavaliere et al. (2006, 2008): Applied FSW on aluminum 6xxx alloy to evaluate the effect of rotational and translational speeds on tensile behavior of weld and reported that ductility of weld is adversely affected by tool rotation. In 2006, Schmidt applied this technique for butt joining of aluminum alloy 2024-T3 and inserted thin copper strip as a marker material; estimated average velocity of flow materials through shear layer.

2. Chemical Compositions:

Table2.1 **Chemical composition for aluminium alloy 6063 and 6063A**

Constituent element	Minimum(% by weight)	Maximum(% by weight)
Aluminium(Al)	97.5%	99.35%
Magnesium(Mg)	0.45%	0.90%
Silicon(Si)	0.20%	0.60%
Iron(Fe)	0	0.35%
Chromium(Cr)	0	0.10%
Copper(Cu)	0	0.10%
Manganese(Mn)	0	0.10%
Titanium(Ti)	0	0.10%
Zinc(Zn)	0	0.10%
Others	0	0.15% total (0.05%each)

3.METHODOLOGY

Design and Modelling

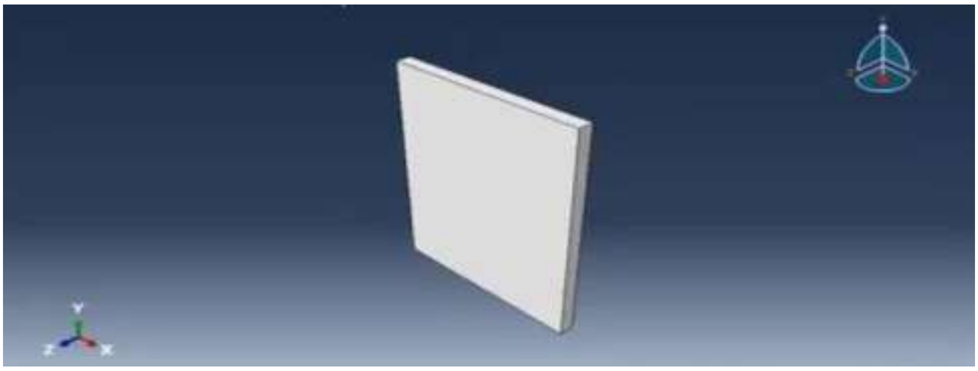


Fig5.3 3Dimensional Plate2 Model

CREATING A TOOL

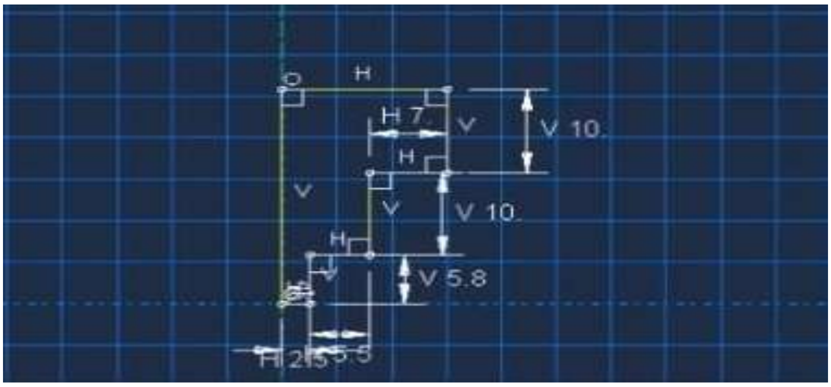


Fig5.4 **Tool Design (All dimensions are in mm)**

4. <u>ANALYSIS</u>

Temperature distribution and Heat flux distribution in Al-Cu FSW at different tool speeds

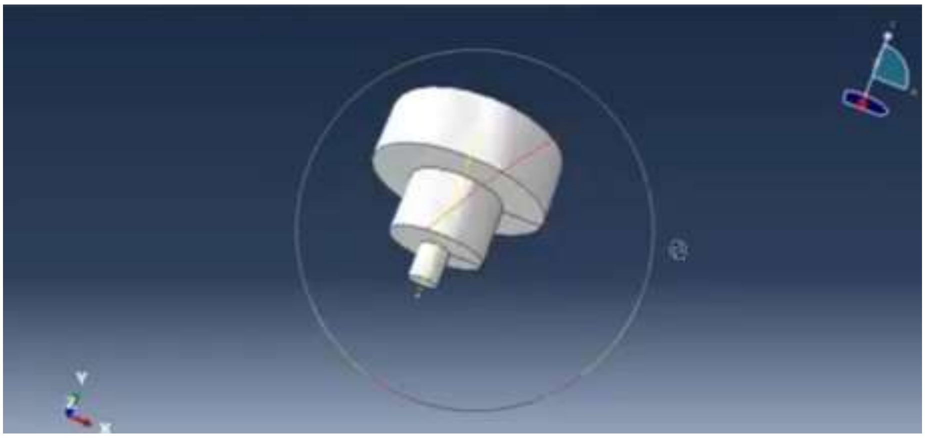


Fig5.5 **3Dimensional Tool Model**

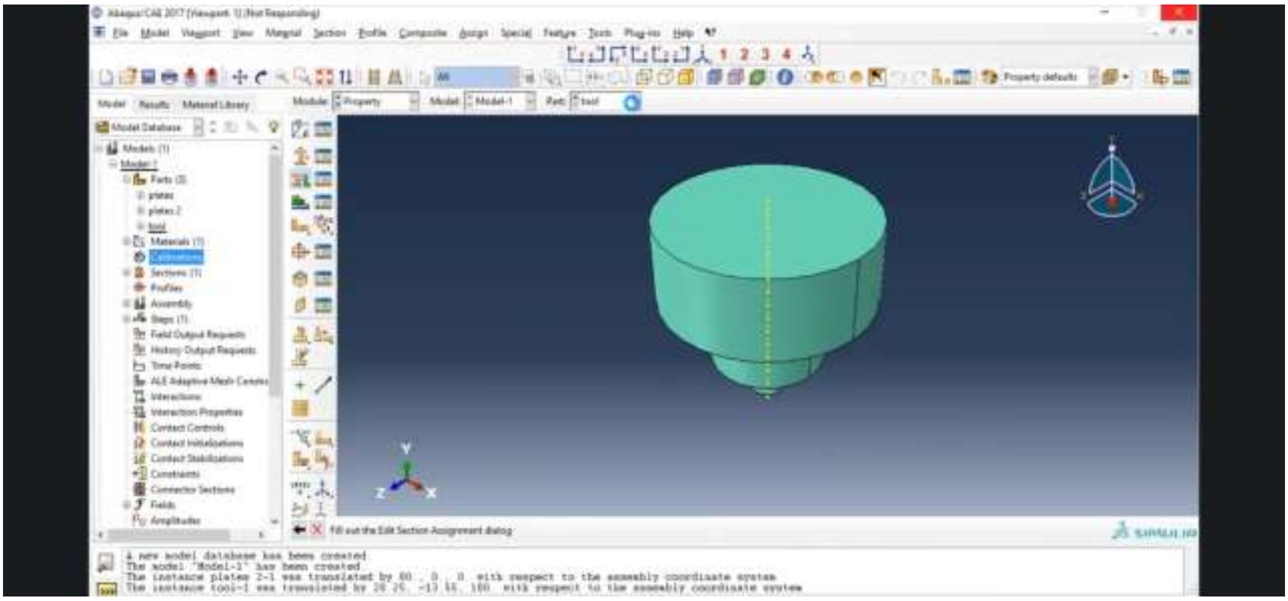
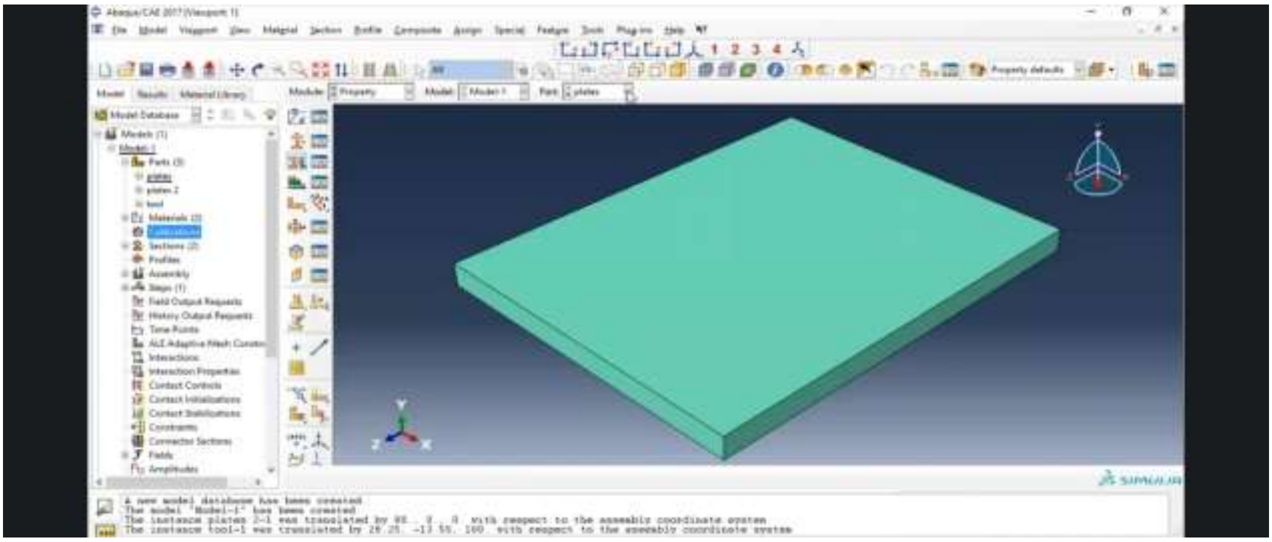


Fig5.6 **Tool model after adding material.**

ADDING THE MATERIAL TO THE PLATE:

Fig5.7 **Plate model after adding material**



Similarly, following the same procedure for adding the copper, nickel and stainless-steel materials for the plates

ASSEMBLING THE TWO PLATES

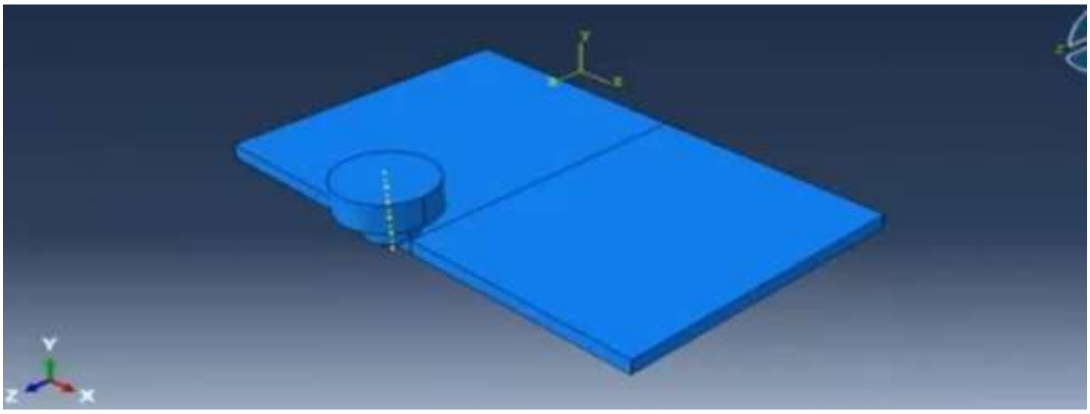
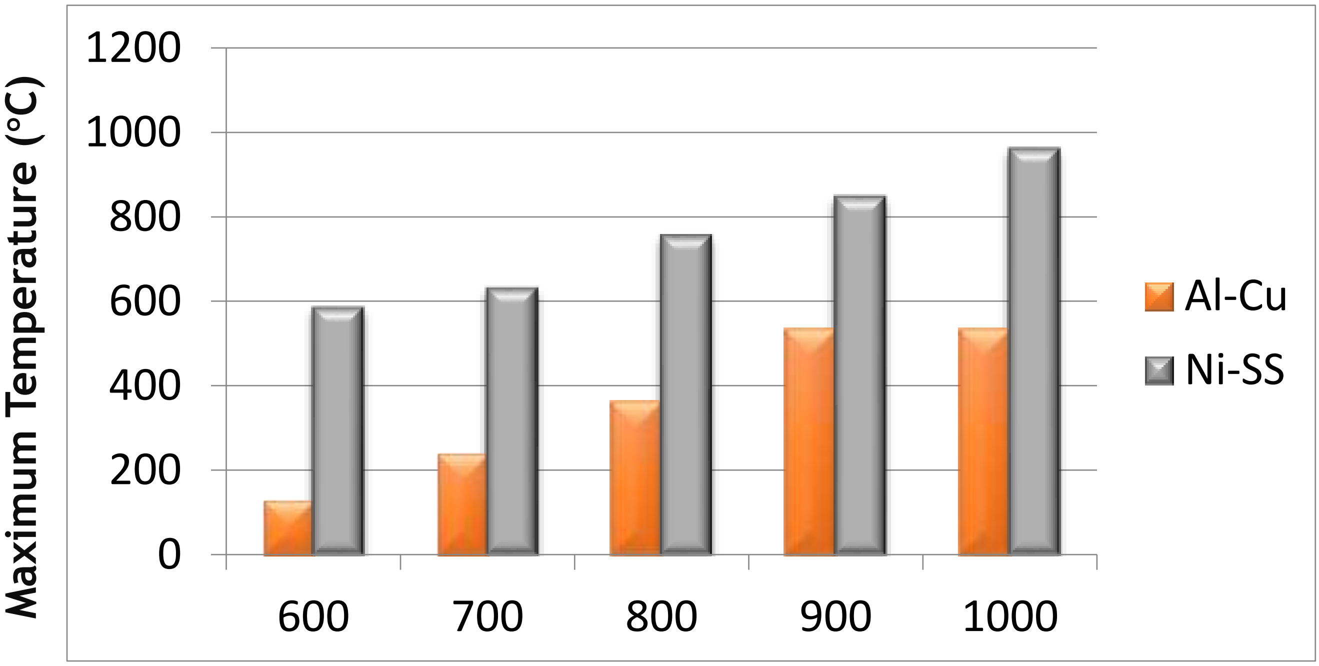


Fig5.8 **Assemble of Plates**

ASSEMBLY OF TWO PLATES WITH TOOL

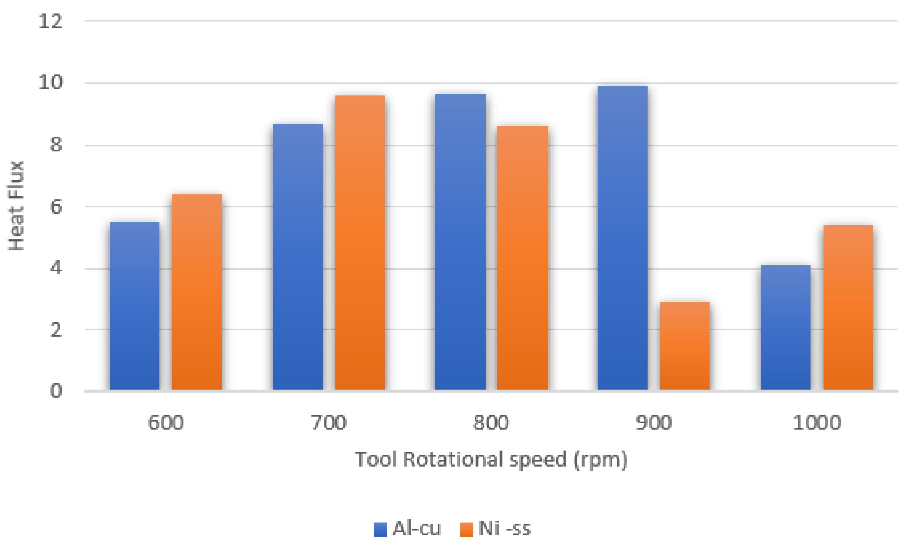
Fig 5.9 Assemble of Tool and Plates

Temperature Distribution at different tool rotational speeds



Tool rotational speed (rpm)

Heat Flux at different tool rotational speeds



4. CONCLUSION

The present work evaluated the optimization of process parameters using ABAQUS software for machining parameters such as Tool Rotational Speed. Here, the analysis was done by comparing with the combination of materials such as Aluminium-Copper and Nickel-Stainless steel and with the tool piece material which is Tungsten (High Speed Steel). When we had joined Al-Cu the maximum temperature distribution is low, while for Ni-Stainless steel the maximum temperature is high. We studied the temperature distribution during the friction stir welding of dissimilar material at different speeds and also the average heat flux generated in Nickel and Stainless-steel material is less than the combination of Aluminium and copper material

5. REFERENCES

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