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Design and Analysis of Dissimilar Metals of Copper and Brass by Friction Stir Welding

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ABSTRACT

FSW design and analysis on dissimilar materials of Copper - Brass joints without any defects. It evaluated by mechanical behavior of the welded joints. In this process tool cylindrical shoulder produced frictional heat among tool shoulder and base materials.The main objective of this project is dissimilar copper and brass metals were friction stir welded at a constant welding speed. The plastic flow of metal induced by mechanical mixing in the stir zone during friction stir welding. In this project cutting tool taper is designed for doing Friction Stir Welding of two dissimilar materials Brass and Copper running at speeds of 710rpm, 900rpm and 1120 rpm. Modeling is done in Abaqus. To analyze the mechanical properties of weldment by optimizing welding method. The hardness is increased by observing various results increasing the speeds the strength is decreased and hardness is increased. i.e.710 RPM speed is suitable for this weld. The observed stir zone area properly joined in dissimilar metals without any defects.

KEYWORDS

Friction Stir Welding (FSW), Dissimilar Welding, Welding of Copper with Brass.

Introduction

FSW is generally identified as a new welding technology that can be used to weld dissimilar alloys and metals. The process of joining two similar materials/components with the application of heat and with or without application of pressure and with or without application of filler material is called welding.

Heat is generated by friction between the rotating tool and the workpiece material, which leads to a softened region near the FSW tool. The frictional heat sources of specimens become to softer under the melting temperature and travel beside the weld tracking line attains. The welding of the material is facilitated by severe plastic deformation in the solid state, involving dynamic recrystallization of the base material. Defect-free weld of the copper and brass attained by FSW made constant welding speed.

Selection of Material and Process Parameters

Brass and Copper

Copper is a soft, malleable, and ductile metal with very high thermal and electrical conductivity. It is used as a conductor of heat and electricity. Brass is an alloy of copper and zinc in proportions which can be varied to achieve varying mechanical and electrical properties.

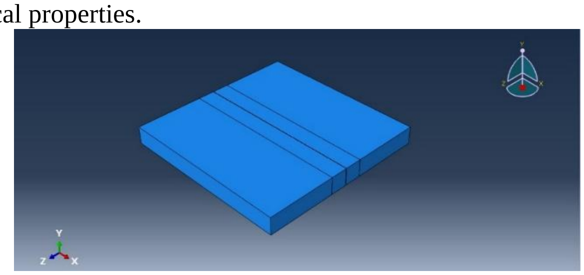

Fig.1.0

Hence, challenging to fabricate the fusion welding process to zinc attain the evaporation develops the main problem for the duration of the welding process. At the end of the welding stage, the porous formation attained the welded joints. Hence, copper and brass were failed its chemical and physical properties it generally retains. Therefore Cu and Br were carefully chosen for the FSWprocess and weld tool as well that shown in Fig.1.0 and Fig 1.1.

FSW Tool

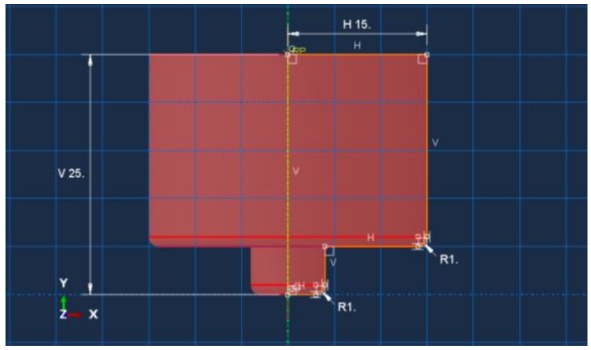

Fig.1.1

Chemical composition of Cu and Br materials.
Composition of copper and brass are given below.

Material	Zn	Sn	Fe	Al	Ni	Cu
Copper	0.05	0.1	-	0.03	0.02	Balance
Brass	38.55	0.30	0.19	-	0.02	Balance

Materials and Thickness

Friction stir welding can be used for joining many types of materials and material combinations, if tool materials and designs can be found which operate at the forging temperature of the work pieces.
For the high thermal and electrical conductivity of copper have long made it a difficult material to weld, particularly in thick sections. As FSW does not melt the workpiece and applies mechanically generated heating very locally, it was seen as a potentially useful process for welding copper.

- Copper and its alloys (up to 50 mm in one pass)
- Lead
- Titanium and its alloys
- Magnesium alloysZinc
- Plastics
- Stainless steel (austenitic, martensitic and duplex)

Different Modules in Abaqus

- PART DESIGN
- ASSEMBLY
- DRAWING
- ANALYSIS

The above all sketches are performed under ABAQUS Software. It is a software application used for both the modeling and analysis of mechanical components and assemblies.

Abaqus allows for dissimilar meshes between the heat transfer analysis model and the thermal-stress analysis model.

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Temperature values will be interpolated based on element interpolators evaluated at nodes of the thermal-stress model.

Sketch

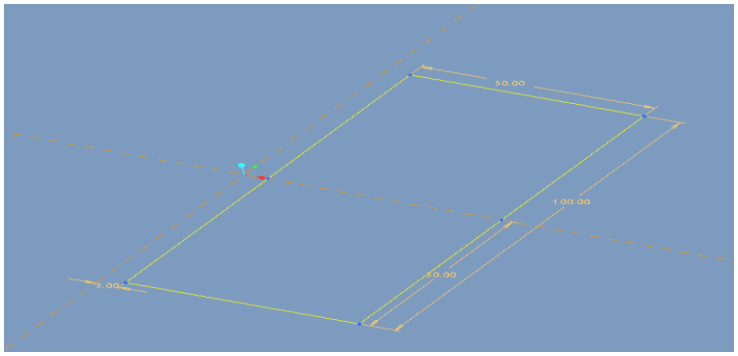

Fig.1.2

The above picture Fig.1.2 depicts the 2D measurement of a copper and brass in a scale of 100 x 50 x 10

Extrude Part

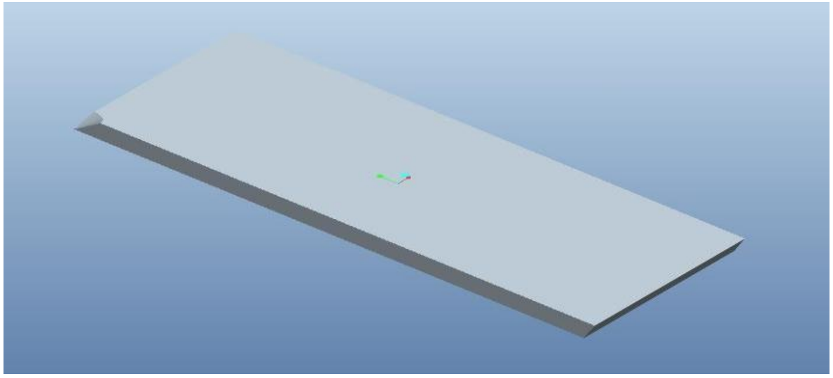

Fig.1.3. Copper plate

The fig.1.3 depicts the extruded component of copper plate using ABAQUS software in a required dimensions.

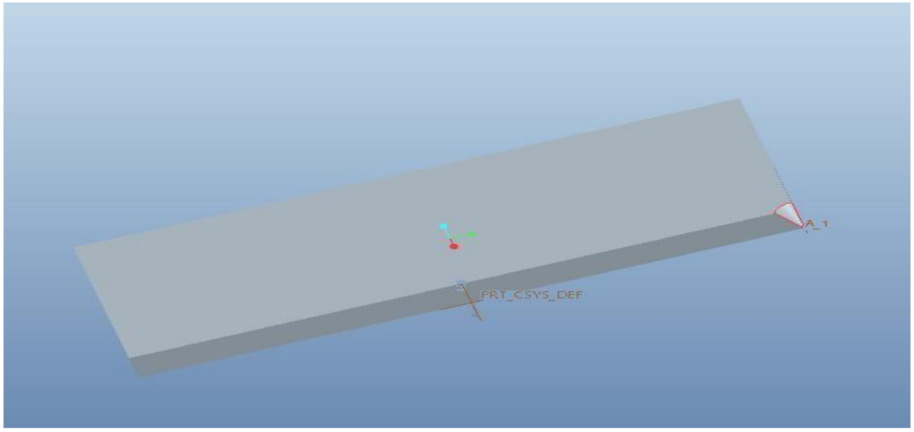

Fig.1.4. Brass Plate

The fig.1.4 depicts the extruded component of Brass plate using ABAQUS software in a required dimensions.

Taper tool

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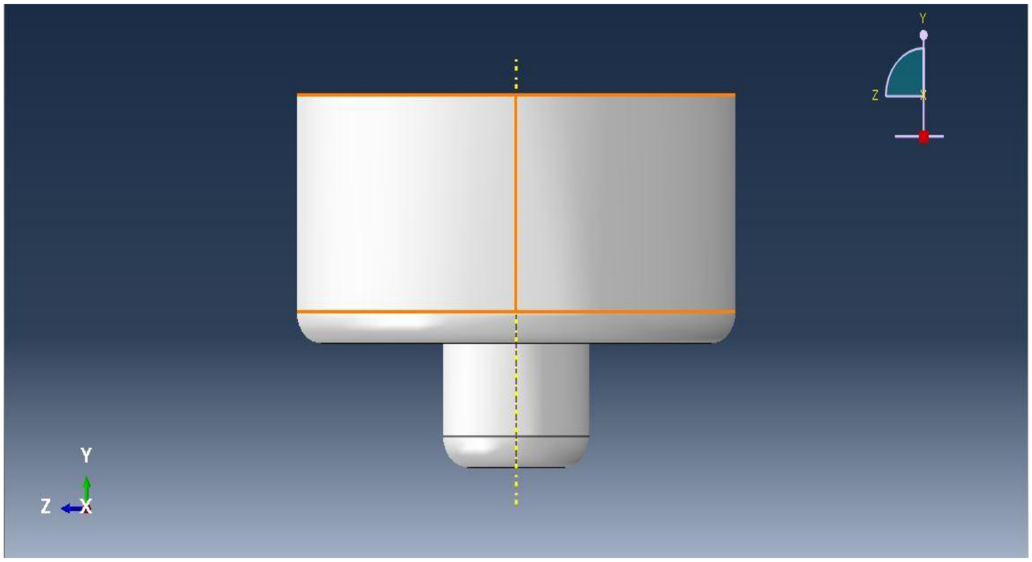

Fig.1.5. Round tool

Taper Tool Assembly

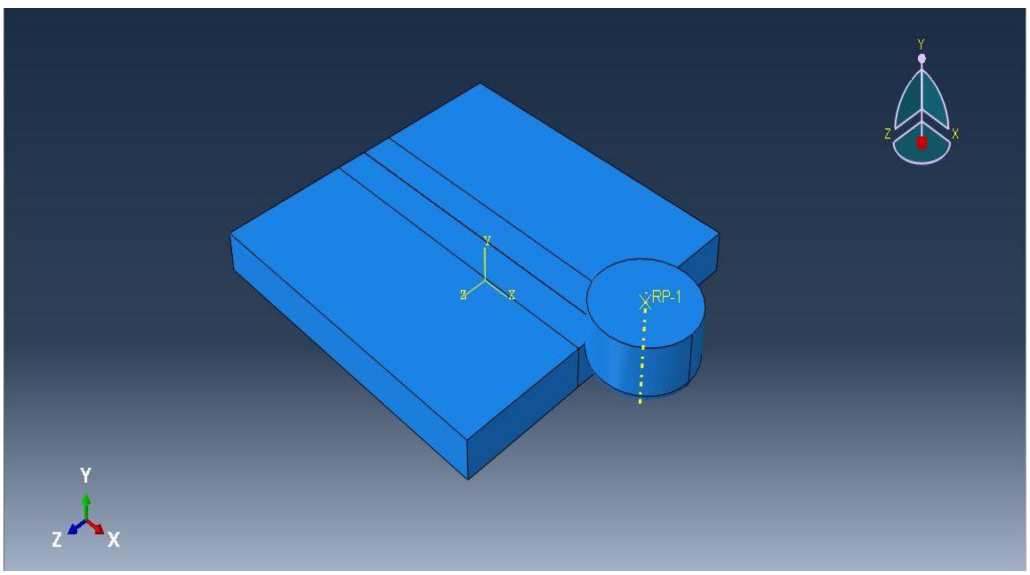

Fig.1.6. Round tool assembly

The fig.1.6 depicts the assembly component of all extruded parts (Copper plate, Brass plate, Weld tool) using ABAQUS software in a required specification.

Thermal Analysis

ABAQUS is capable of both steady state and transient analysis of any solid with thermal boundary conditions. Steady-state thermal analyses calculate the effects of steady thermal loads on a system or component. Users often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished. ABAQUS can be used to determinetemperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following:

- Convection
- Radiation
- Heat flow rates
- Heat fluxes (heat flow per unit area)
- Heat generation rates (heat flow per unit volume)
- Constant temperature boundaries

A steady-state thermal analysis may be either linear, with constant material properties; or nonlinear, with material properties that depend on temperature. The thermal properties of most material vary with temperature. This temperature dependency being appreciable, the analysis becomes nonlinear. Radiation boundary conditions also make the analysis nonlinear. Transient calculations are time dependent and ABAQUS can both solve distributions as well as create video for time incremental displays of models.

Meshing

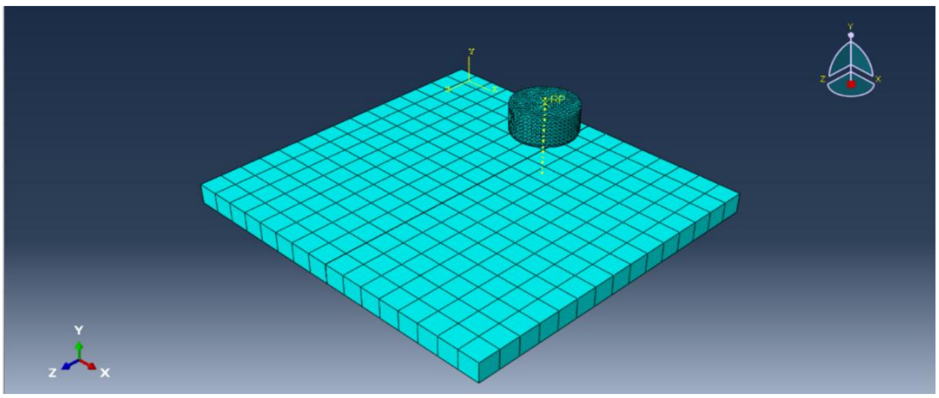

Fig.1.7. Mesh components

The above Fig.1.7 shownmesh is created to conform exactly to the geometry of a region and **Meshing** is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain.

Simulation of Thermal Analysis

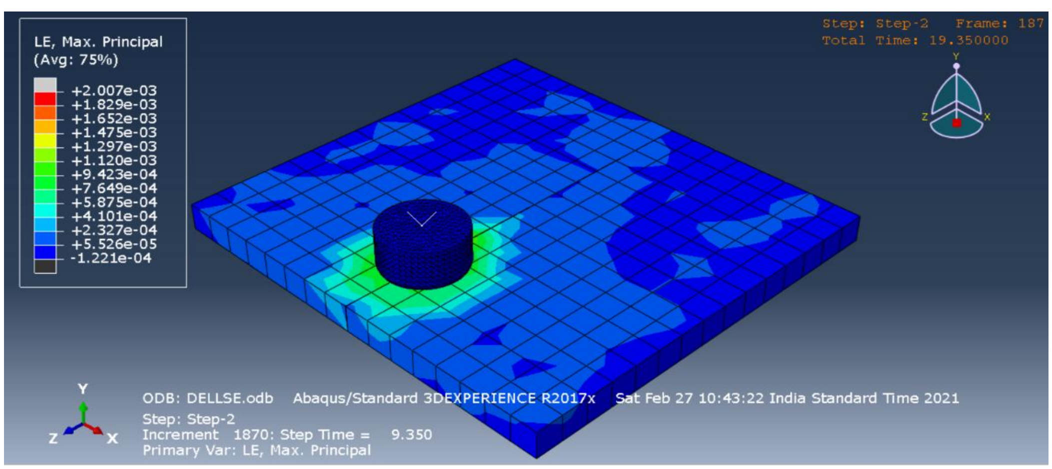

Fig.1.8. Thermal analysis in a simulation way

The above fig.1.8 shows the thermal analysis with a moving of tool in a certain manner that depicts the how heat is distributed in a weld plate with a certain conditions. At the time we can conclude whether the weld is done without

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any defect or not. In this picture weld is performed without any internal error or defect.

Thetemperaturedistribution,resultedfrom FSWprocess,throughouttheworkpieces. Thetemperaturearoundtheprobeishigherthanthesurroundingarea.Thiscanberelatedtotheeffectof generatedheatdue tobothfrictionandsevereplasticdeformation. Because oflocalizedheating,the temperature aroundtheprobe is highest anditdecreasesasthedistancefromthepinincreases.

TemperaturehistoriesmeasuredbyAbaqusfordifferentnodes,atsitesresemblingexperimentalmeasurements,are presented. I llustratesthethermalhistoriesrecordedby thefourthermocouplesinsertedaccordingtothelayout of thermocouplesTC1andTC3werelocatedontheadvancingsideoftheworkpiece,whereasTC2andTC4were insertedontheretreatingside.

Results & Discussions

CASES	Speed - 710rpm	Speed - 900rpm	Speed - 1120rpm
Total deformation (mm)	0.00056675	0.00059871	0.00086277
Stress (Mpa)	24.32	24.329	24.342
Strain	0.00020142	0.00019801	0.0001937

By observing above table at 710 RPM the total deformation is low comparedto various speeds(900,1120), and the stress analysis at 710 RPM is low, but in thestrain analysis at 710 RPM is high.

Stress Strain, Deformation Graphs

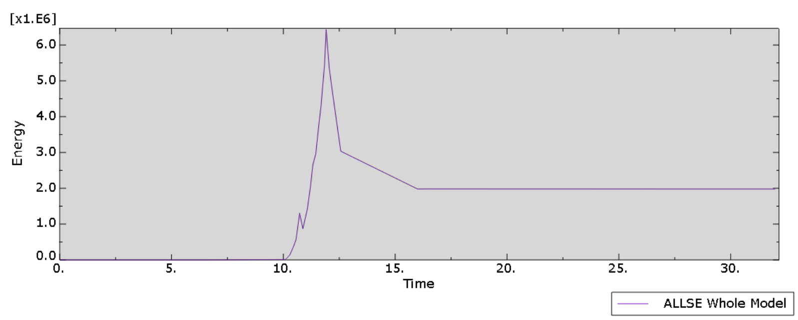

Fig.1.9

The above Fig.1.9 graph represent that the comparison of deformation in thermal analysis, by observing that graph we understand that increasing the speed leads to increase the deformation of weld.

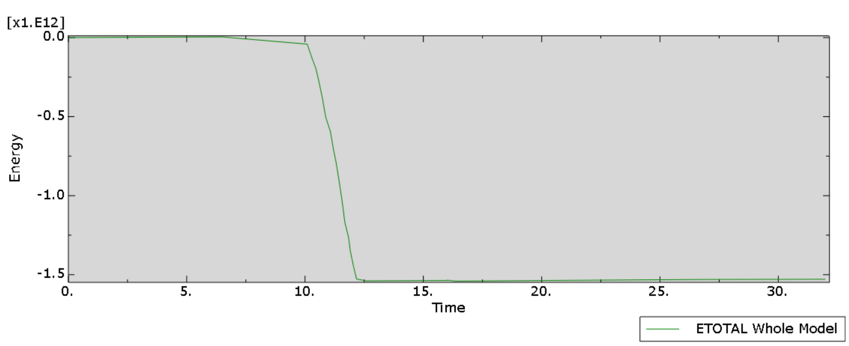

Fig.2.0

The above Fig.2.0 graph represent that the comparison of stress in thermal analysis by observing that graph we understand that increasing the speed leads to increase the stress of weld

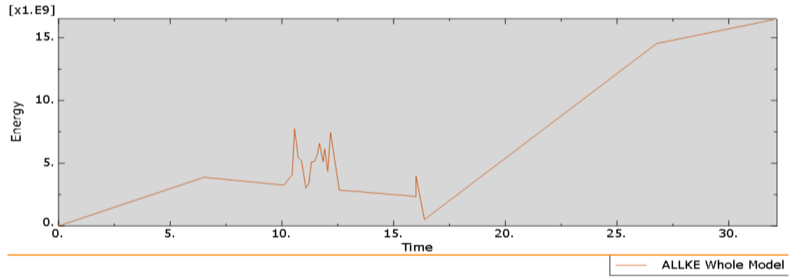

Fig.2.1

Conclusion

The defect of welding was not found in the welded zone based on optimized FSW processing parameters. In this project cutting tool taper is designed for doing Friction Stir Welding of two dissimilar materials Brass and Copper running at speeds of 710rpm, 900rpm and 1120 rpm. Modeling is done in Abaqus.Thermal analysis is performed on the taper tool to verify the temperature distribution, thermal flux, gradient and stresses.

By observing the results, stresses produced are increasing by increasing the speeds and the heat transfer rates are increasing by increasing the speeds.By observing the tensile test results, ultimate tensile strength is decreasing by increase of the speeds. The hardness is increasing with increase of speed.So it can be concluded that by increasing the speeds the strength is decreased and hardness is increased by observing various results increasing the speeds the strength is decreased and hardness is increased. i.e.710 RPM speed is suitable for this weld.

References

[1] A reference by https://en.m.wikipedia.org/Friction_stir_welding
[2] Recent advances in Friction stir welding by International journal for mechanical engineering.
[3] P. Xue, G.M. Xie, B.L. Xiao, Z.Y. Ma, L. Geng, Effect of Heat input conditions on microstructure and mechanical properties of Friction stirs welded Pure copper, *Scr. Mater.* (2010).
[4] S.T. Selvamani, K. Umanath, K. Palanikumar, Heat Transfer Analysis during Friction Stir Welding of Al6061-T6 Alloy, pp. 1453–1460.
[5] Jawdat A. Al-Jarrah, Talal Abu SallamehSwalha, Masould Ibrahim Mansour, Maen Al-Rashdan, Deya A. Al-Qashsi, Welding equality and mechanical properties of aluminium alloys joints prepared by friction stir welding, *Mater. Des.* (2014) 929–936.
[6] G.M. Xie, Z.Y. Ma, L. Geng, Development of a fine-grained microstructure and the properties of a nugget zone in Friction stir welded pure copper, *Scr. Mater.* (2007) 73–76.
[7] CemalMeran, The joint properties of brass plates by friction stir welding, *Mater. Des.* 27 (2006) 719–726.
[8] P. Xue, B.L. Xiao, D.R. Ni, Z.Y. Ma, Enhanced mechanical properties of friction stir welded dissimilar Al-Cu joint by intermetallic compounds, *Mater. Sci. Eng. A* (2010) 5723–5727.
[9] C. Devanathan, A. SureshBabu, Friction stir welding of metal matrix composite using coated tool, *Procedia Mater. Sci.* 6 (2014) 1470–1475.
[10] Pasquale Cavaliere, Friction stir welding of Al alloys: analysis of processing parameters affecting mechanical behaviour, *Procedia CIRP* (2013) 139–144.
[11] H. Su, C.S. Wu, A. Pittner, M. Rethmeier, Thermal energy generation and distribution in friction stir welding of aluminium alloys, *Energy* (2014) 720– 731.