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Friction Stir Welding of Dissimilar Materials Statistical Analysis of the Welding Data


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ABSTRACT:

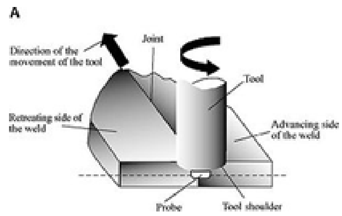
Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) and is used when the original metal characteristics must remain unchanged as much as possible. It mechanically intermixes the two pieces of metal at the place of the join, then softens them so the metal can be fused using mechanical pressure, much like joining clay, dough, or plasticine. It is primarily used on aluminum, and most often on large pieces that cannot be easily heat-treated after welding to recover temper characteristics.The aim of this paper is to investigate analytically friction stir welding of two materials aluminum alloys 6005-T1 and 6053-T6using different pin profiles, square, round, taper, thread and triangle. The analysis is done using different rotational speeds 700rpm, 1150rpm and 1350rpm. The plate sizes are 50mmX80mmX2mm. The tool material is H13 steel. The tool shoulder dia is 24mm, tool pin dia is 5mm, pin length is 1.7mm.

Modeling is done in Pro/Engineer and analysis is done in Ansys.

INTRODUCTION TO FRICTION STIR WELDING:

Friction-stir welding (FSW) is a solid-state joining process (meaning the metal is not melted during the process) and is used for applications where the original metal characteristics must remain unchanged as far as possible. This process is primarily used on aluminum, and most often on large pieces which cannot be easily heat treated post weld to recover temper characteristics.

PRINCIPLE OF OPERATION



Schematic diagram of the FSW process: (A) Two discrete metal workpieces butted together, along with the tool (with a probe).

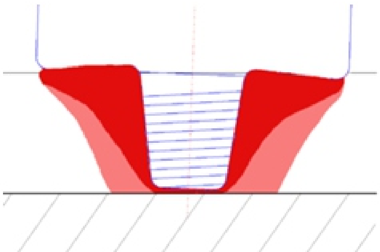
(B) The progress of the tool through the joint, also showing the weld zone and the region affected by the tool shoulder.

IMPORTANT WELDING PARAMETERS TOOL ROTATION AND TRAVERSE SPEEDS:

There are two tool speeds to be considered in friction-stir welding; how fast the tool rotates and how quickly it traverses the interface. These two parameters have considerable importance and must be chosen with care to ensure a successful and efficient welding cycle. The relationship between the welding speeds and the heat input during welding is complex but, in general, it can be said that increasing the rotation speed or decreasing the traverse speed will result in a hotter weld. In order to produce a successful weld it is necessary that the material surrounding the tool is hot enough to enable the extensive plastic flow required and minimise the forces acting on the tool. If the material is too cool then voids or other flaws may be present in the stir zone and in extreme cases the tool may break.At the other end of the scale excessively high heat input may be detrimental to the final properties of the weld.

Theoretically, this could even result in defects due to the liquation of low-melting-point phases (similar to liquation cracking in fusion welds). These competing demands lead onto the concept of a 'processing window': the range of processing parameters that will produce a good quality weld. Within this window the resulting weld will have a sufficiently high heat input to ensure adequate material plasticity but not so high that the weld properties are excessively reduced.

TOOL TILT AND PLUNGE DEPTH:

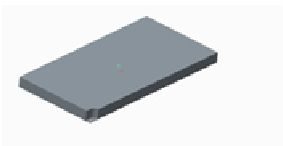


A drawing showing the plunge depth and tilt of the tool. The tool is moving to the left.

DIFFERENT MODULES IN PRO/ENGINEER:

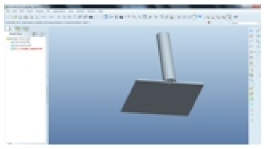
- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL
- MANUFACTURING

MODELS OF CUTTING TOOLS
ROUND TOOL
PLATE

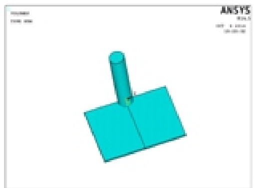


ROUND TOOL

ROUND TOOL ASSM



STRUCTURAL ANALYSIS OF TOOL AND WORKPIECE ASSEMBLY
SPEED - 700 rpm
ROUND TOOL
Import IGES model



Material properties
Aluminum 6005-T1

Element Type: solid 20 nodes 95
Material Properties: Density-0.0000027 kg/mm3
Young's modulus- 69000 mpa
Possions ratio- 0.33
Specific heat -890j/kg c
Thermal conductivity - 0.18 w/mmk

Aluminum 6053-T6

Element Type: solid 20 nodes 95
Material Properties: Density-0.00000269 kg/mm3
Young's modulus- 69000 mpa
Possions ratio- 0.33
Specific heat -890j/kg c
Thermal conductivity - 0.163 w/mmk

H13 steel

Element Type: Solid 20 node 95
Material Properties: Density-0.0000078 kg/mm3
Young's modulus- 210000 mpa
Possions ratio- 0.3
Specific heat -460j/kg c
Thermal conductivity - 0.0247 w/mmk

Meshed model

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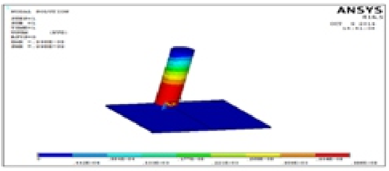
Loads – Inertia – Angular velocity – 73.3rad/s
Solution
Solution – Solve – Current LS – ok
Post Processor

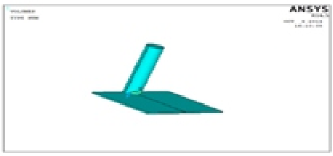
SPEED - 1150 rpm

Loads – Inertia – Angular velocity – 120.42rad/s

Displacement



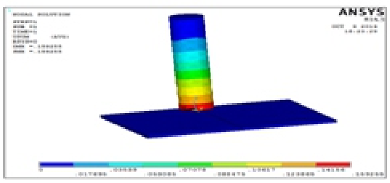
SQUARE TOOL
SPEED – 700rpm
Importing IGES model



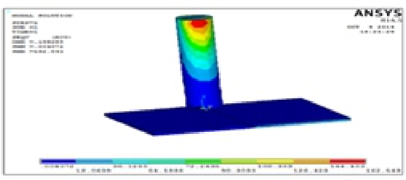
THREAD TOOL
SPEED - 700 RPM

Solution
Solution – Solve – Current LS – ok
Post Processor

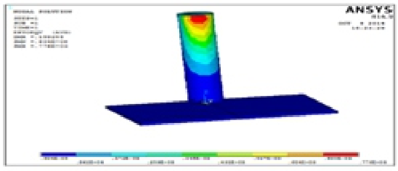
General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Displacement Vector Sum



General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress



General Post Processor – Plot Results – Contour Plot – Nodal Solution – Strain – Von Mises Strain



Material properties
Aluminium6005-T1

Element Type: solid 20 nodes 90
Material Properties: Density-0.0000027 kg/mm3
Young's modulus- 69000 mpa
Possions ratio- 0.33
Specific heat -890j/kg c
Thermal conductivity - 0.18 w/mmk

Aluminum 6053-T6

Element Type: solid 20 nodes 90
Material Properties: Density-0.00000269 kg/mm3
Young's modulus- 69000 mpa
Possions ratio- 0.33
specific heat -890j/kg c
Thermalconductivity - 0.163 w/mmk

H13 steel

Element Type: solid 20 nodes 90
Material Properties: Density-0.0000078 kg/mm3
Young's modulus- 210000 mpa
Possions ratio- 0.3
Specific heat -460j/kg c
Thermal conductivity - 0.0247 w/mmk

Meshed model

Apply Loads
Loads – Define Loads – Apply – Thermal – Temperature
Temperature – 924k
Loads – define Loads – Apply – Thermal – Heat flow – On nodes
Loads – define Loads – Apply – Thermal – Convection – on areas
Bulk Temperature – 313k
Film Coefficient –0. 000025W/mmK
Solution
Solution – Solve – Current LS - ok
Post Processor

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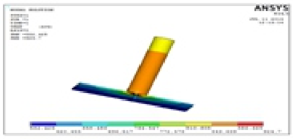
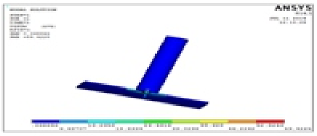
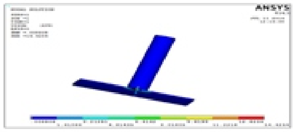
General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Nodal Temperature Vector sum



General Post Processor – Plot Results – Contour Plot - Nodal Solution – Thermal Gradient Vector sum



General Post Processor – Plot Results – Contour Plot - Nodal Solution – Thermal flux vector sum



RESULTS SUMMERY
STRUCTURAL ANALYSIS
Round tool

	Displacement (mm)	Stress (N/mm^2)	Strain
At 700 rpm	0.147E-03	143.464	0.226E-03
At 1150 rpm	0.398E-03	387.068	0.610E-03
At 1350 rpm	0.548E-03	533.64	0.514E-03

THERMAL ANALYSIS RESULTS
Round tool

Nodal temperature (K)	Thermal gradient (K/mm)	Thermal flux (W/mm^2)
924.7	59.427	14.4254

CONCLUSION:

In this thesis, 5 types of cutting tools Round, Round taper, Square, Triangle and Thread for performing Friction Stir Welding is designed and analyzed for the mechanical properties. Modeling is done in Pro/Engineer.FEA Structural analysis is done using all the tools for welding of aluminum alloy 6005-T1 and 6053-T6rotating at speeds of 700rpm, 1150rpm and 1350rpm. By observing the analysis results, triangle tool has less stresses than other tools but practically using triangle tool is difficult since the welding area of the tool is less, so more speed is required. The square tool has also has less stresses but the disadvantage is that its welding is more, more material will be taken off which needs more holder diameter. The round tool is better by analysis and practically also. So for using Friction Stir Welding, round cutting tool is more effective than other cutting tools.

Thermal analysis is also done on the round tool to verify the temperature distribution and heat transfer rate.

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