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Friction Stir Welding of Dissimilar Materials Using Statistical Weld 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.

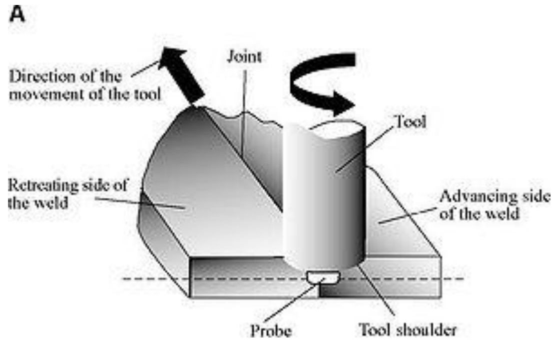
The aim of this paper is to investigate analytically friction stir welding of two dissimilar materials aluminum alloys 5083 and copper using different pin profiles, square, round, taper, thread and triangle. The analysis is done using different rotational speeds 700rpm, 1150rpm and 1350rpm. The plate 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 Catia and analysis is done in Ansys.

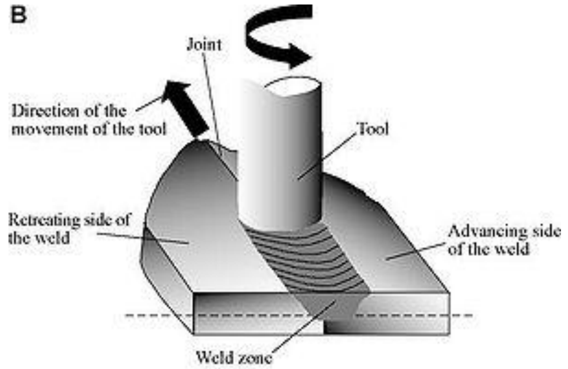
INTRODUCTION

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.

In FSW, a cylindrical-shouldered tool, with a profiled threaded/unthreaded probe (nib or pin) is rotated at a constant speed and fed at a constant traverse rate into the joint line between two pieces of sheet or plate material, which are butted together. The parts have to be clamped rigidly onto a backing bar in a manner that prevents the

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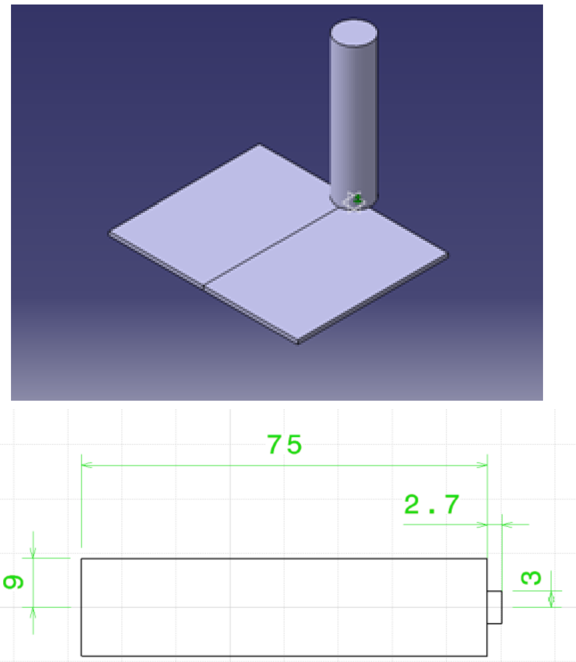
abutting joint faces from being forced apart. The length of the nib is slightly less than the weld depth required and the tool shoulder should be in intimate contact with the work surface. The nib is then moved against the work, or vice versa.

Frictional heat is generated between the wear-resistant welding tool shoulder and nib, and the material of the work pieces. This heat, along with the heat generated by the mechanical mixing process and the adiabatic heat within the material, cause the stirred materials to soften without reaching the melting point (hence cited a solid-state process), allowing the traversing of the tool along the weld line in a plasticised tubular shaft of metal. As the pin is moved in the direction of welding, the leading face of the pin, assisted by a special pin profile, forces plasticised material to the back of the pin while applying a substantial forging force to consolidate the weld metal. The welding of the material is facilitated by severe plastic deformation in the solid state, involving dynamic recrystallization of the base material.

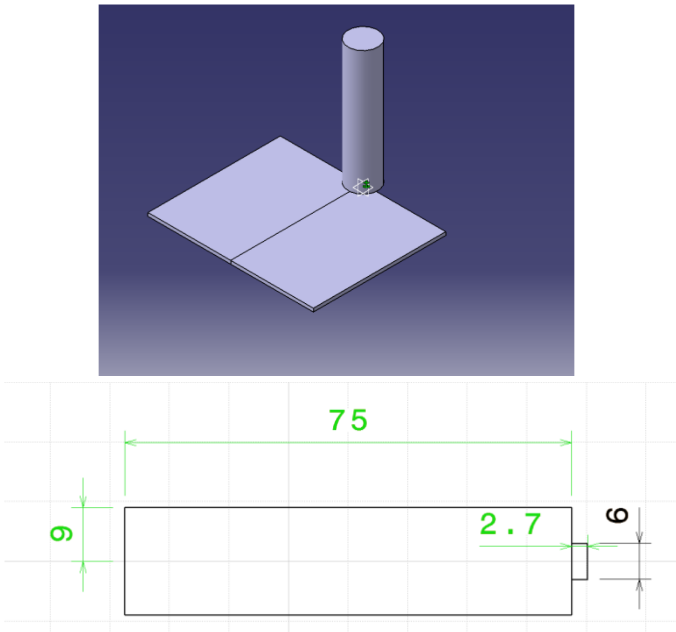
3D MODELING OF CUTTING TOOL AND WORKPIECE

MODEL OF CUTTING TOOL

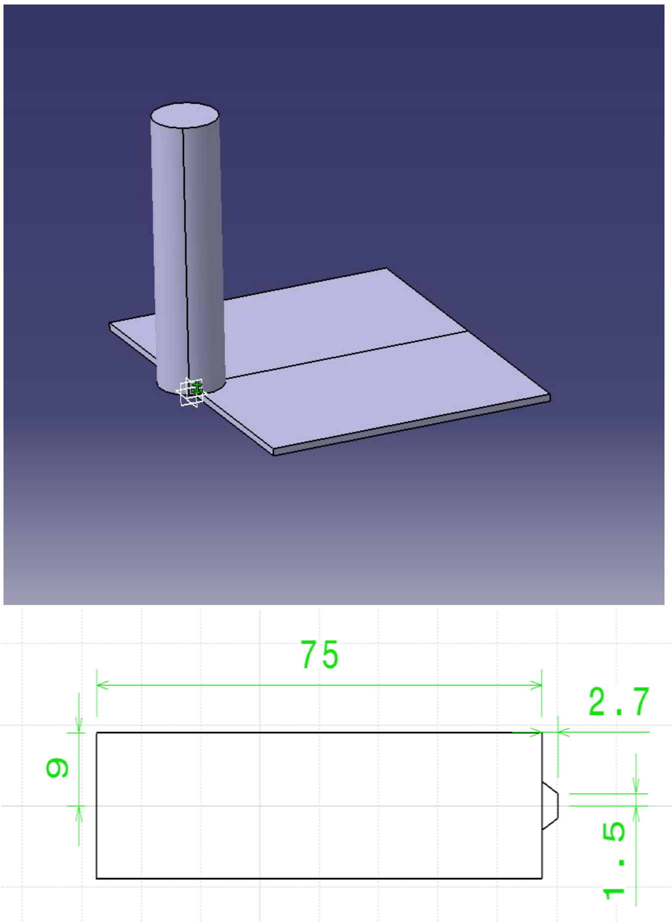
Round tool



Square tool



Tapered tool



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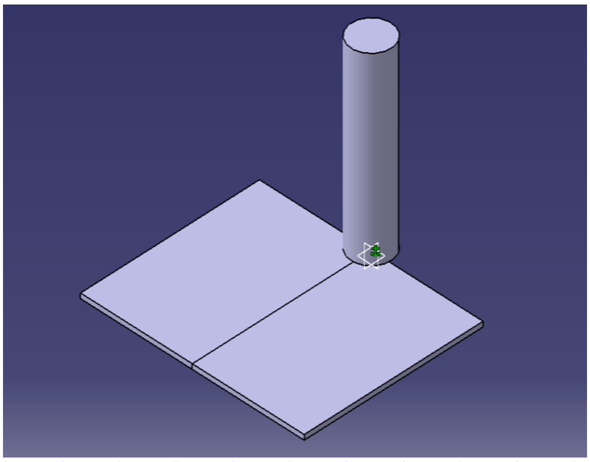
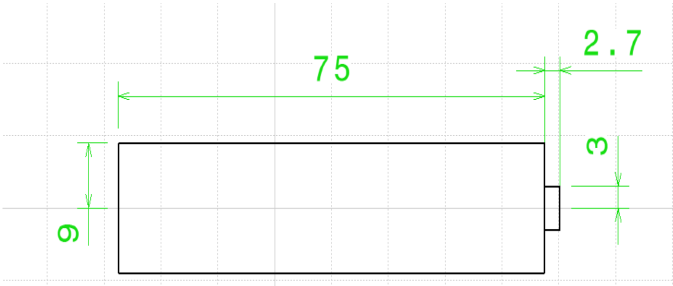
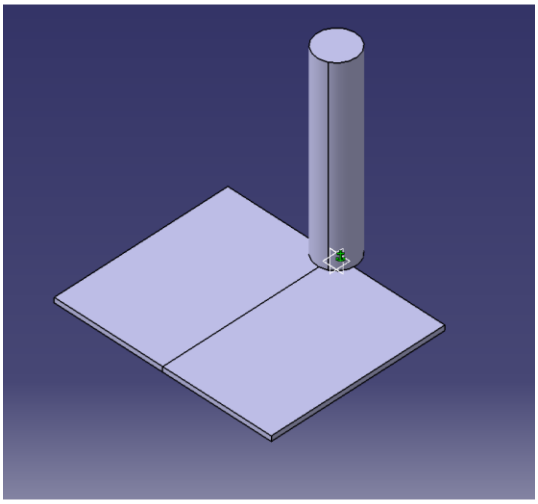
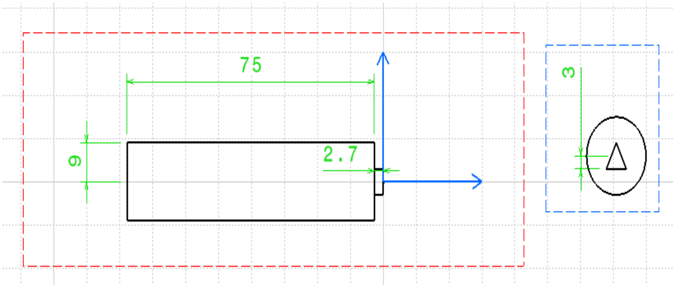
Thread tool





Triangular tool



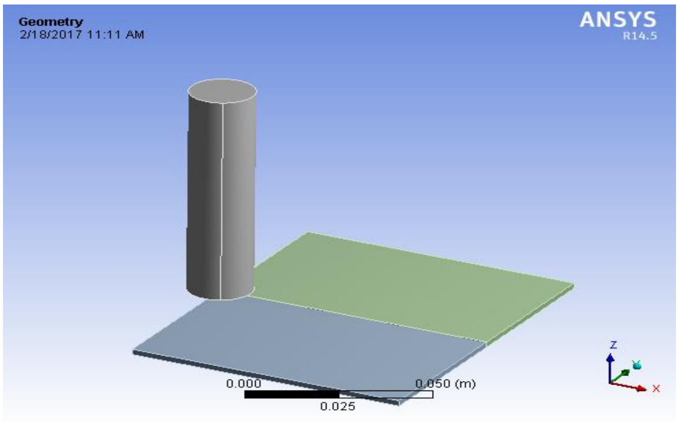


STRUCTURAL ANALYSIS OF TOOL AND WORKPIECE ASSEMBLY

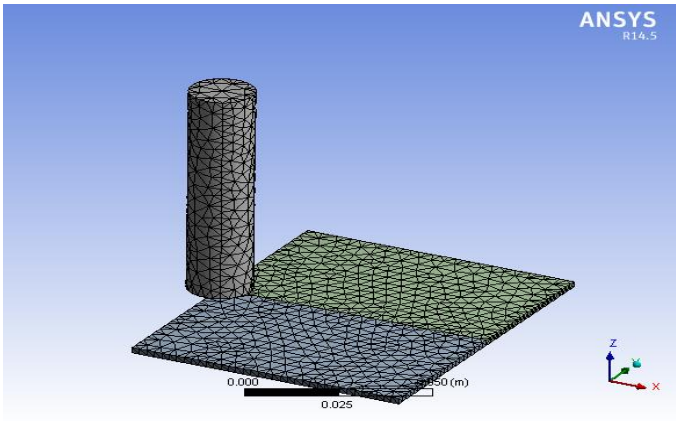
SPEED - 700 rpm

ROUND TOOL

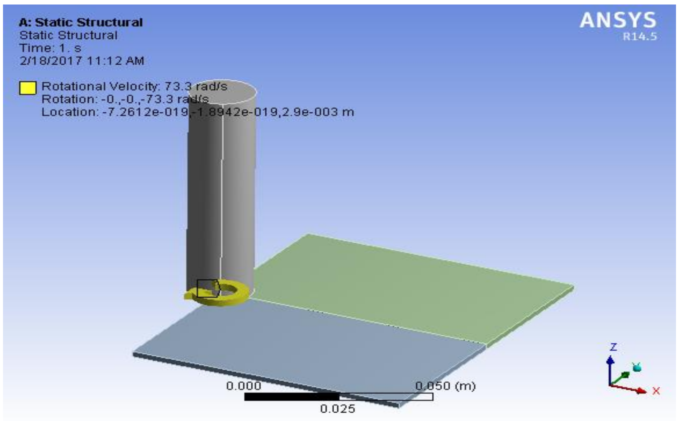
Geometry



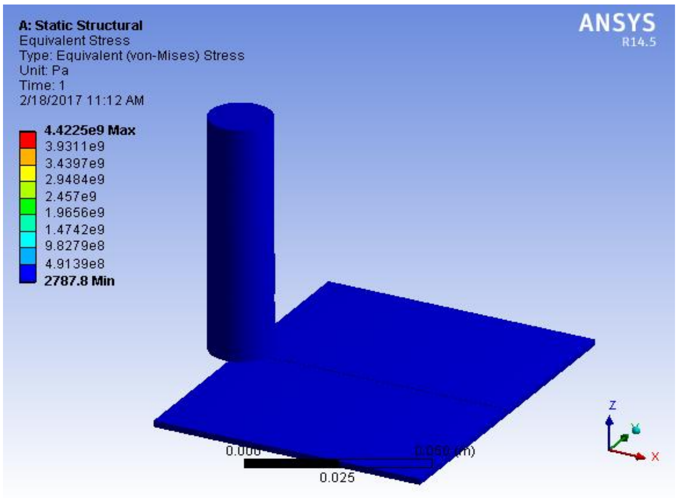
Meshed file



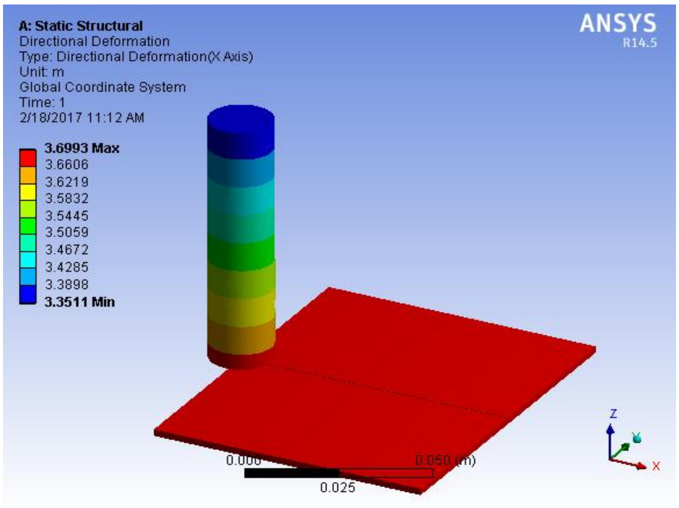
Input data



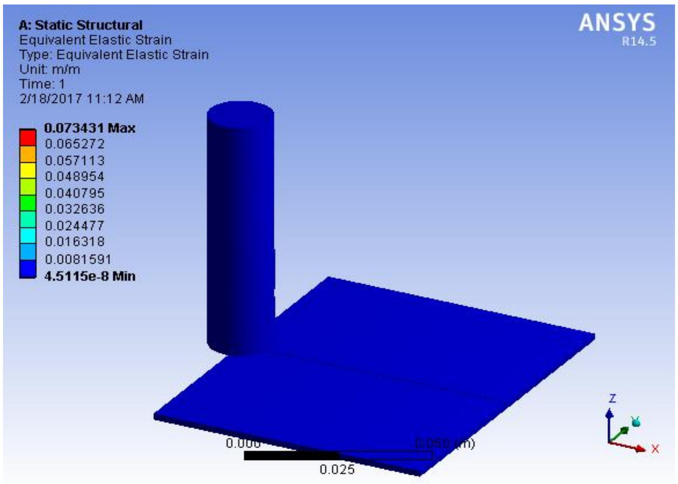
Stress



Directional deformation



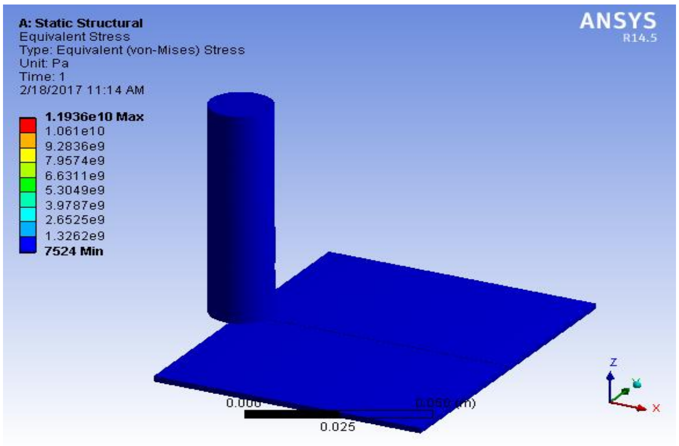
Strain



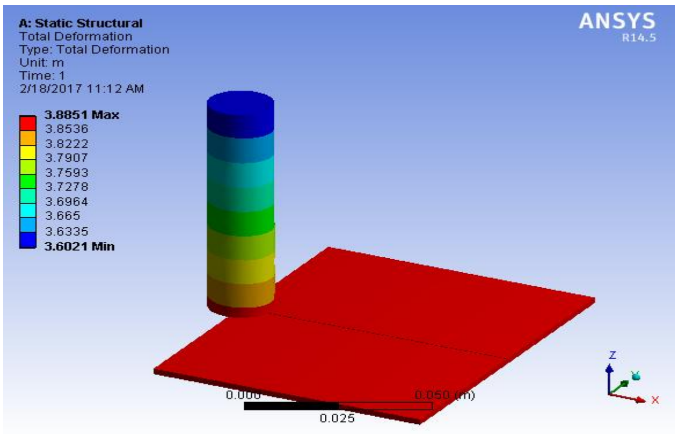
SPEED -1150 rpm

ROUND TOOL

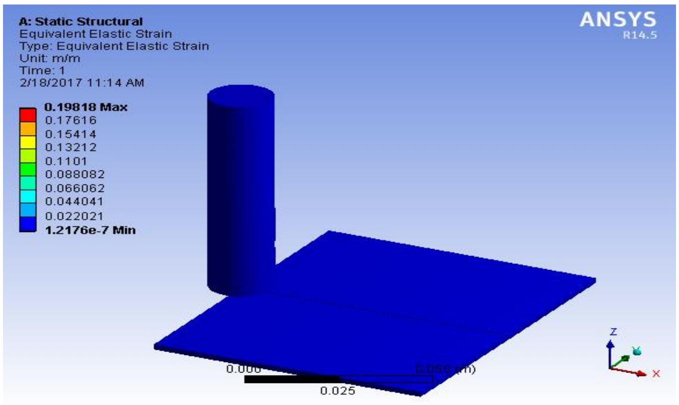
Stress



Total deformation



Strain



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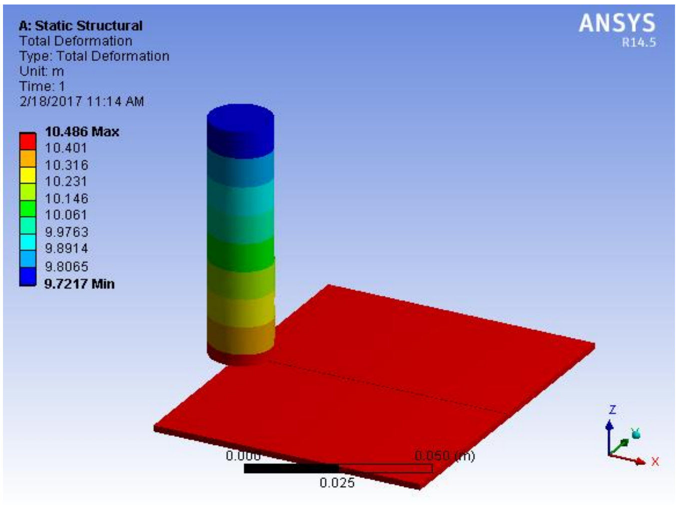
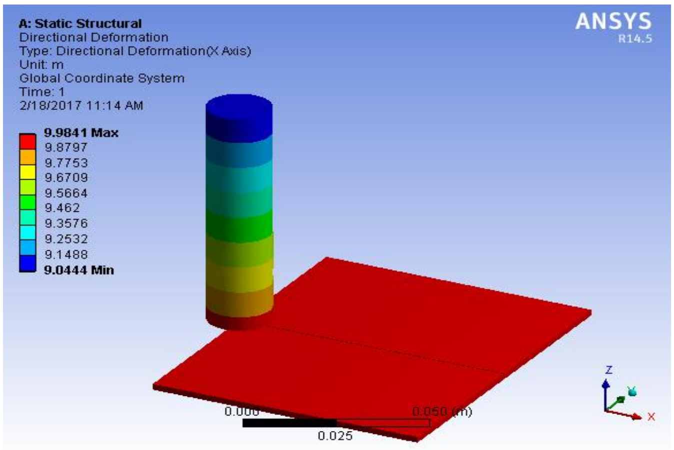
Total deformation



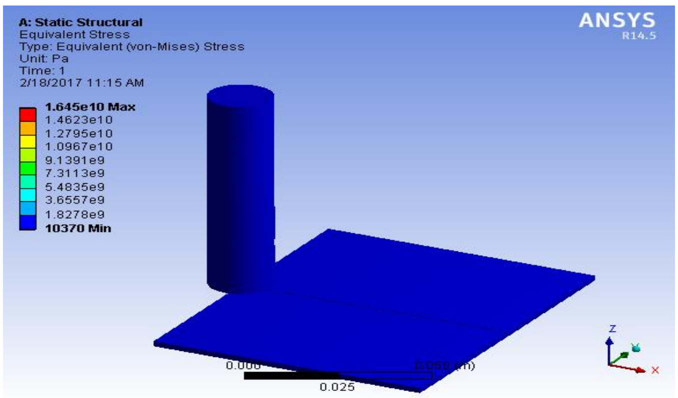
Directional deformation



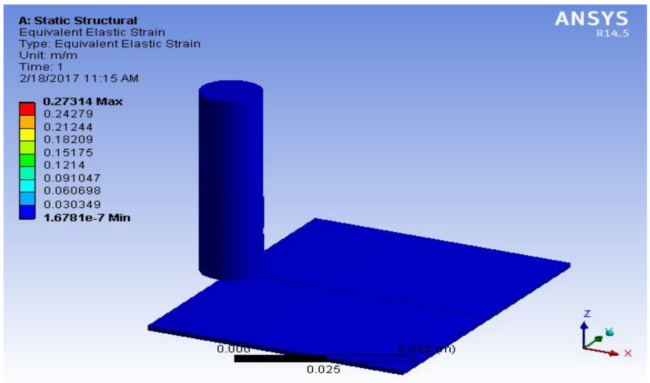
SPEED -1350 rpm

ROUND TOOL

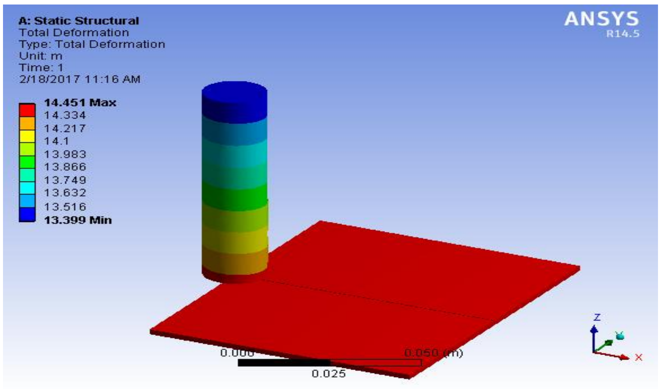
Stress



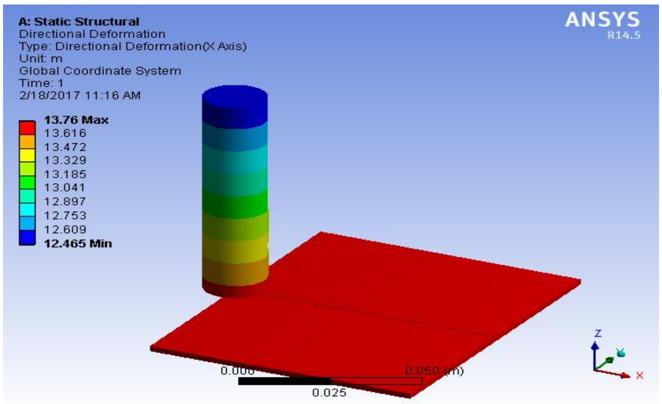
Strain



Total deformation



Directional deformation



RESULT TABLES

STRUCTURAL ANALYSIS

Round tool

	Deformation (m)	Stress (Pa)	Strain
At 700 rpm	3.8851	4.422e9	0.073431
At 1150 rpm	10.486	1.193e10	0.19818
At 1350 rpm	14.451	1.645e10	0.27314

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Square tool

	Deformation (m)	Stress (Pa)	Strain
At 700 rpm	5.8302	1.0827e8	0.0010161
At 1150 rpm	15.735	2.922e8	0.0027423
At 1350 rpm	21.687	4.027e8	0.0037794

Taper tool

	Deformation (m)	Stress (Pa)	Strain
At 700 rpm	3.8017	1.907e9	0.022722
At 1150 rpm	10.261	5.148e9	0.061324
At 1350 rpm	14.141	7.095e9	0.084518

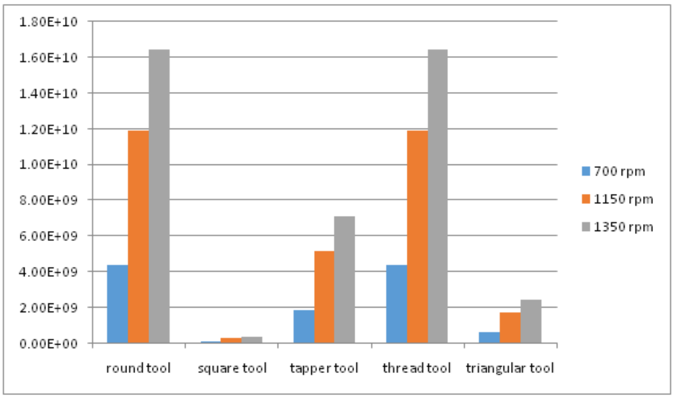
Thread tool

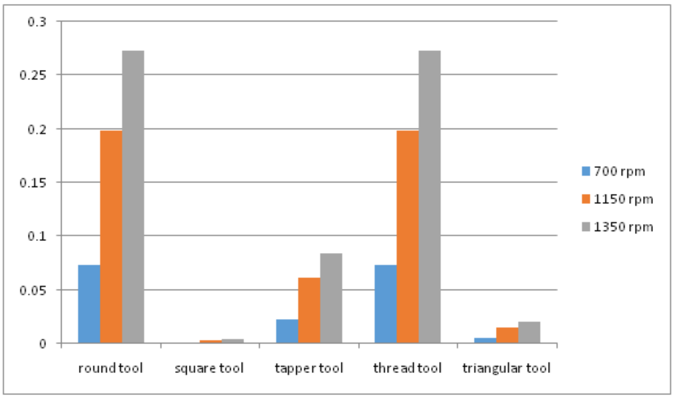
	Deformation (m)	Stress (Pa)	Strain
At 700 rpm	3.8851	4.4225e9	0.073431
At 1150 rpm	10.486	1.193e10	0.19818
At 1350 rpm	14.451	1.645e10	0.27314

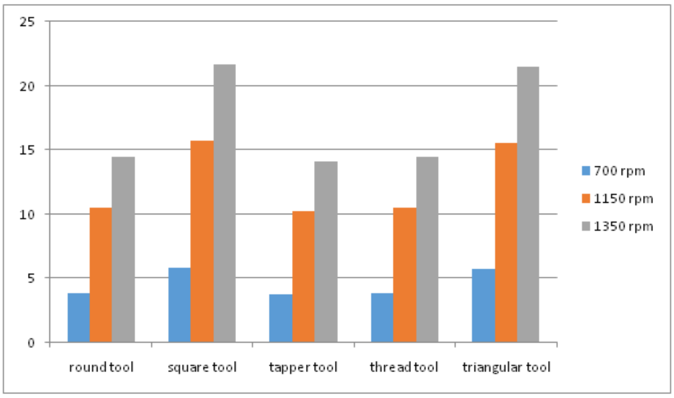
Triangle tool

	Deformation (m)	Stress (Pa)	Strain
At 700 rpm	5.766	6.536e8	0.0054196
At 1150 rpm	15.562	1.7642e9	0.014627
At 1350 rpm	21.448	2.431e9	0.020159

GRAPHS







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 6061 and copper rotating at speeds of 700rpm, 1150rpm and 1350rpm.

By observing the analysis results, square tool has less stresses than other tools but practically using square tool is difficult since the welding area of the tool is more and more material will be taken off which needs more holder diameter, so more speed is required. The triangle tool has also has less stresses but the disadvantage is that its welding is less; because tool is difficult since the welding area of the tool is less. The round tool is better by analysis as it si easily manufactured and the welding will be done as per the best area without the wastage of material and preferable for all speeds..

So for using Friction Stir Welding, round cutting tool is more effective than other cutting tools.

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