Analytical Investigations And Finite Element Analysis of Friction Stir Welding

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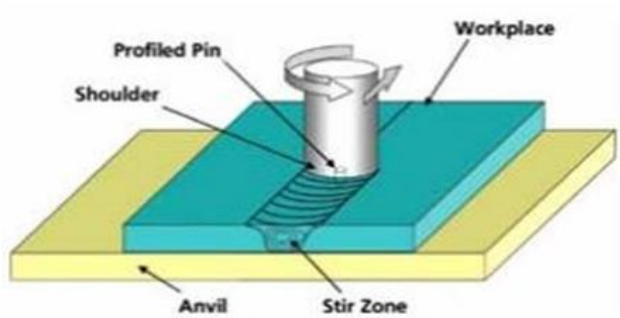
Abstract- *Friction Stir Welding (FSW), invented by Wayne Thomas at TWI (The Welding Institute) Ltd in 1991, overcomes many of the problems associated with traditional joining techniques. FSW is a solid-state process which produces welds of high quality in difficult-to-weld materials such as aluminum, and is fast becoming the process of choice for manufacturing lightweight transport structures such as boats, trains and aero-planes.Friction stir welding different cutting tool profiles are (round, taper and square) designed in CREO parametric software and analyzing in ANSYS software. Friction stir welding materials are 1) aluminum alloy and aluminum alloy 2) copper and copper 3) copper and aluminum alloy for work pieces and cutting tool material high carbon steel material, cutting tool spindle speeds are 800, 1000 & 1200rpm & welding speeds 30,40 &50 mm/s.*

Static analysis to determine the deformation stress and strain, modal analysis to determine the deformation with respect to frequencies at different materials and different speeds.

Keywords- Taguchi Analysis, Static Analysis, Modal Analysis ANSYS..

I. INTRODUCTION

Friction stir welding has loved international interest for the reason that its inception because of its advantages over conventional joining techniques. Essentially, FSW is a nearby thermo- mechanical metal running system with additional adiabatic heating from metallic deformation that changes the local properties without influencing homes within the remainder of the shape. As noted later, the pin and shoulder of the device may be changed in a number of approaches to influence fabric flow and micro-structural evolution. A rotating device with pin and shoulder is inserted within the fabric to be dealt with, and traversed along the road of hobby (Figure-1). The rotating device provides a continual warm working movement, plasticizing metal inside a slender region whilst transporting metal from the main face of the pin to its trailing area. The processed zone cools without solidification, as there may be no liquid and hence a disorder-free re-crystallized exceptional grain microstructure is shaped. ≥



ADVANTAGES AND DISADVANTAGES OF FSW:

The stable-kingdom nature of FSW without delay leads to numerous blessings over fusion welding methods given that any problems related to cooling from the liquid phase are without delay avoided. In trendy, FSW has been observed to provide a low awareness of defects and may be very tolerant to versions in parameters and substances

A quantity of capability benefits of FSW over traditional fusion-welding processes were

- .Can function in all positions (horizontal, vertical, etc.), as there may be no weld pool.
- Generally proper weld appearance and minimum thickness under/over-matching, as a result reducing the need for expensive machining after welding.
- Low environmental effect.

However, a few risks of the process had been recognized:

- Exit hollow left whilst device is withdrawn.
- Large down forces required with heavy-obligation clamping important to preserve the plates collectively.
- Less bendy than manual and arc processes (problems with thickness versions and non- linear welds).
- Often slower traverse fee than a few fusion welding strategies although this can be offset if fewer welding passes are required.

1) MATERIALS AND THICKNESSES:

For aluminum alloys, the following alloys are easily welded. Maximum thickness in a single pass is dependent on machine power, but values 50mm are achievable. TWI has welded 75mm 6xxx material in a single pass, and larger thicknesses are possible.

- 2000 series aluminum (Al-Cu)
- 5000 series aluminum (Al-Mg)
- 6000 series aluminum (Al-Mg-Si)
- 7000 series aluminum (Al-Zn)
- 8000 series aluminum (Al-Li)

2) APPLICATIONS OF FSW:

- SHIP BUILDING AND MARINE INDUSTRIES
- AEROSPACE INDUSTRY
- RAILWAY INDUSTRY
- LAND TRANSPORTATION
- THE MACHINE

II. MATERIALS USED

The objective of the present research is to develop a finite element analysis with improved capability to predict strength evolution in various materials and to determine the optimal weld parameters using FEA technique.

Materials	Tool speed (rpm)	Welding speed(mm/min)	Tool pin profiles
➢ Pure aluminum alloy ➢ Pure copper ➢ Aluminum and copper	800	30	Round
	1000	40	Square
	1200	50	Taper

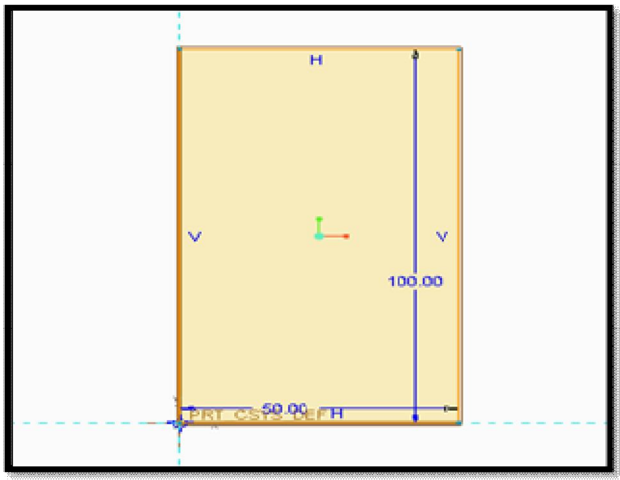
III. METHODOLOGY

- In this work frictional stir welded Pure Aluminium, copper and distinct materials (al and copper) are compared for mechanical homes. In this observe FSW specimens are organized at welding speed (30, 40 and 50 mm/min) ,tool profiles (taper, round an square)and The speeds are 800 rpm, a 1000 rpm and 1200 rpm.
- In this test plate length of aluminium and copper are equal and having 100 mm duration, 50 mm width and four mm thickness. H13 material is used to manufacture the tools. Tool has pin diameter of four millimetre size. Tool dimensions: Shoulder Diameter-20 mm, Pin Diameter 6mm
- The 3D modelling of FSW is designed in CREO.
- In static evaluation, to decide the stress, strain and deformation.

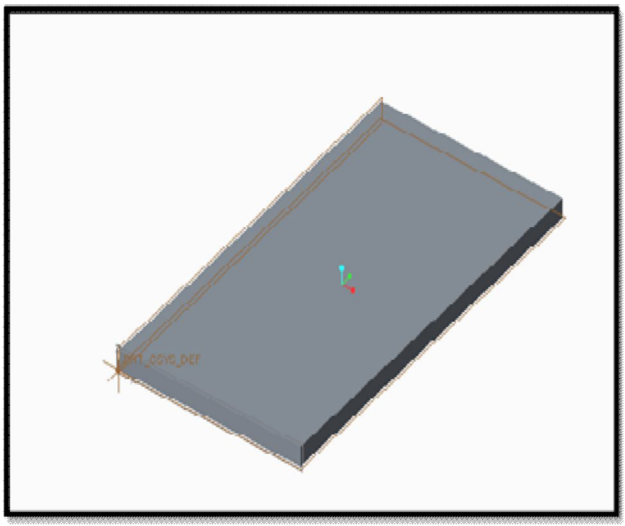
DIFFERENT MODULES IN PRO/ENGINEER:

- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL
- MANUFACTURING

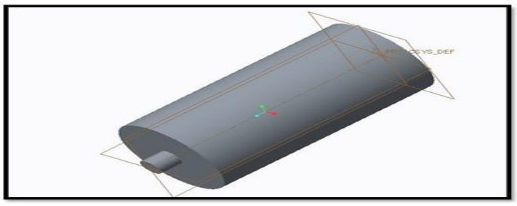
2D MODEL



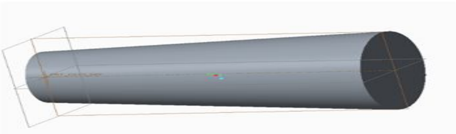
MODEL OF PLATE



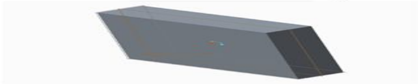
3D MODEL OF TOOL:



3D Model of Round Tool

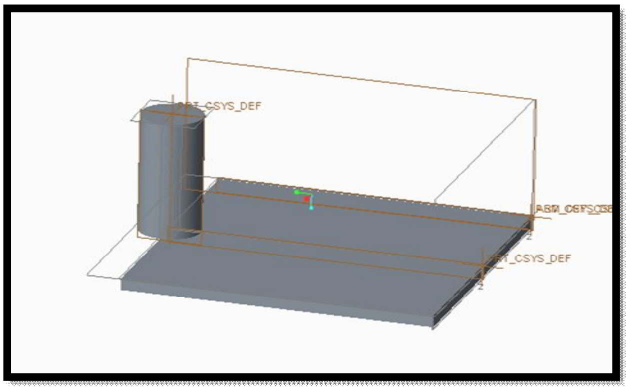


3D Model of Taper Tool



|3D Model of Square Tool

Assembly:



3) STEP –BY-STEP PROCEDURE OF ANALYSIS:

Every analysis involves four main steps

1.Preliminary decisions

- What type of analysis; static, modal, etc.?
- What to modal: part or assembly?
- Which elements: surface or solid bodies?

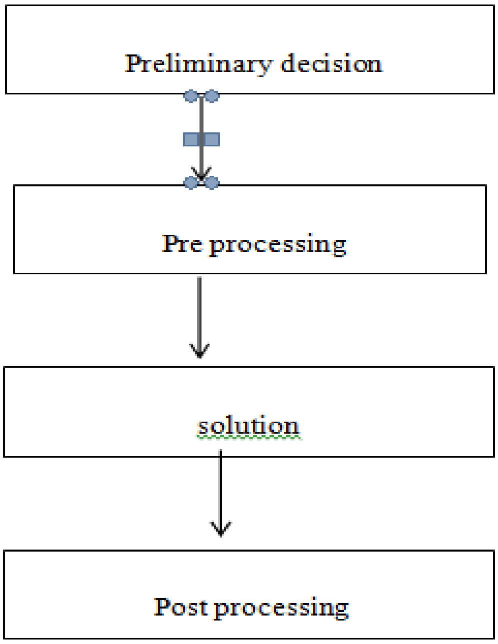
2.Pre processor

- Attach the modal geometry
- Define and assign material properties to part
- Mesh the geometry
- Apply the loads and supports
- Request result

3.Solve the modal

4.Post processor

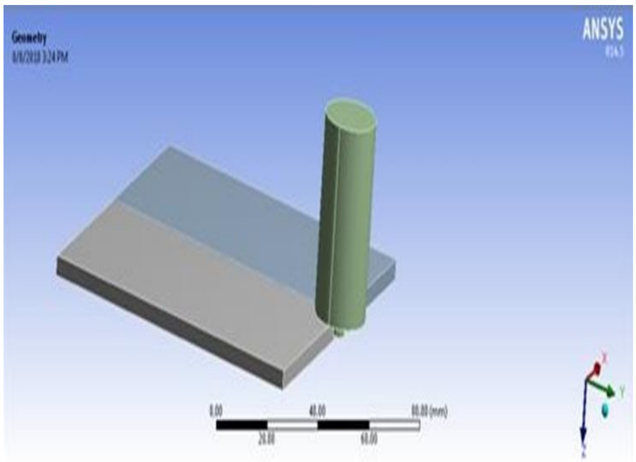
- Review results
- Check the validity of the solution



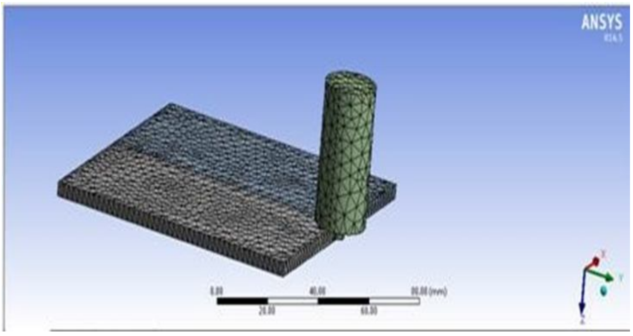
The Workbench surroundings allows you to clear up lots extra complicated analysis such as

- Multi element assemblies
- 3-D strong factors, shell elements, and shell stable assemblies
- Nonlinear touch without or with friction
- Small displacement and large displacement static analysis
- Modal, harmonic, and Eigen price buckling analysis
- Steady country thermal evaluation together with temperature based fabric properties and thermal contact.

IMPORT MODEL



MESH MODEL

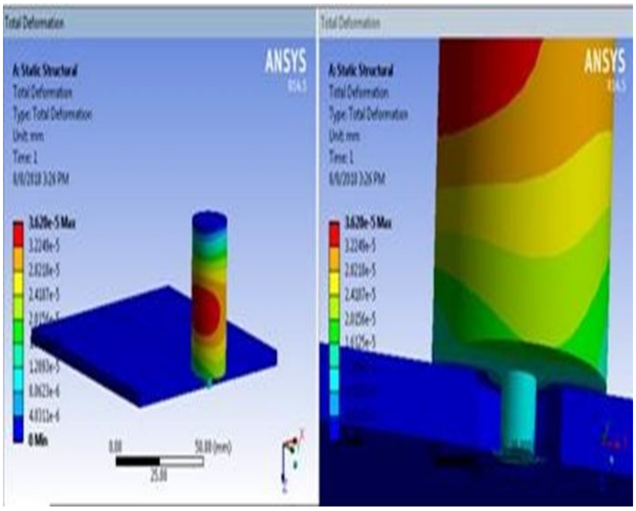


BOUNDARY CONDITION

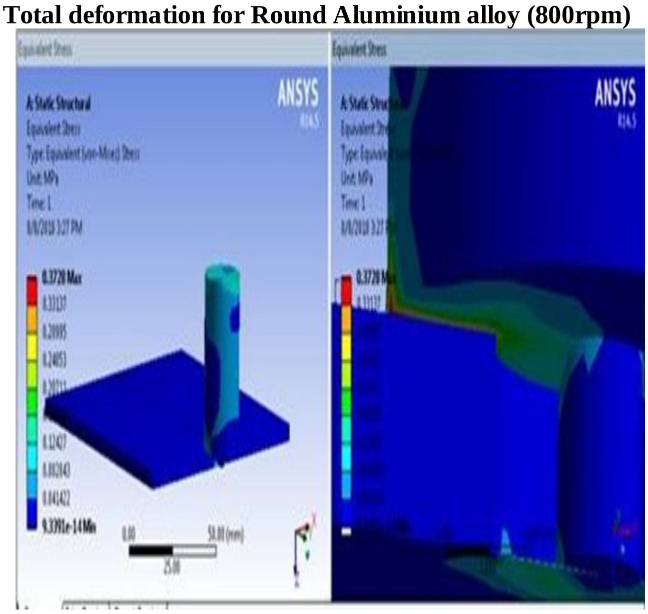
IV. RESULTS AND DISCUSSION

MATERIAL-PURE ALUMINUM ALLOY

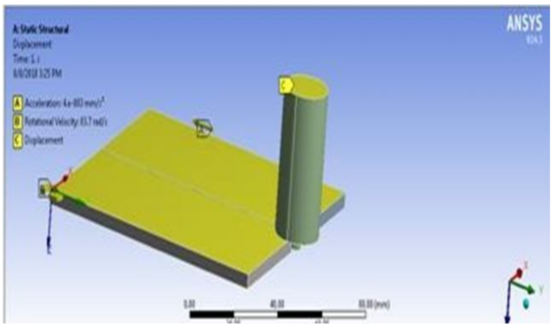
TOOL PIN PROFILE ROUND CONDITION- 1 AT TOOL SPEED -800RPM

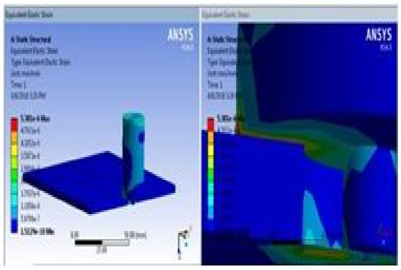


Total deformation for Round Aluminium alloy (800rpm)



Stress for Round Aluminum alloy (800rpm)

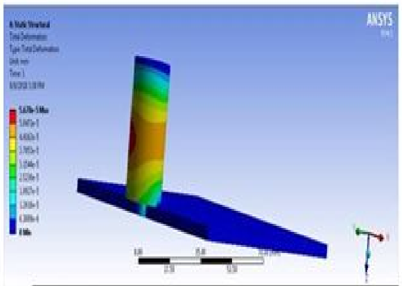




Strain for Round Aluminium alloy (800rpm)

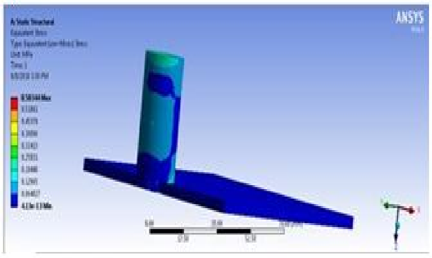
Represents the Total stain for a round aluminium alloy pin profile at cutting spindle speed is 800rpm.

CONDITION 2: AT TOOL SPEED -1000 RPM:



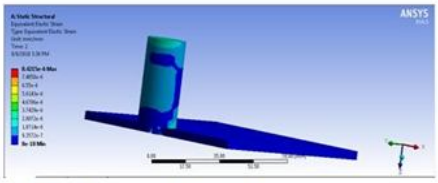
Total deformation for Round Aluminium alloy (1000rpm)

Represents the Total deformation for a round aluminium alloy pin profile at cutting spindle speed is 1000rpm.



Stress for Round Aluminium alloy (1000rpm)

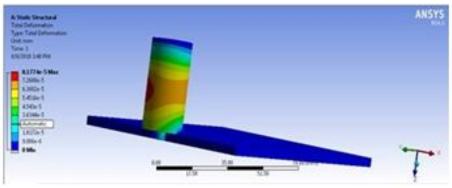
Represents the stress for a round aluminium alloy pin profile at cutting spindle speed is 1000rpm.



Strain for Round Aluminium alloy (1000rpm)

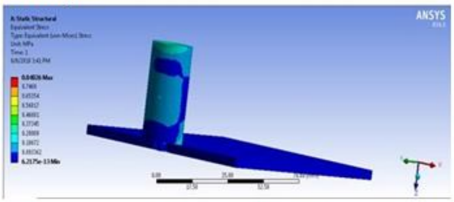
represents the strain for a round aluminium alloy pin profile at cutting spindle speed is 1000rpm.

CONDITION 3: AT TOOL SPEED -1200 RPM:



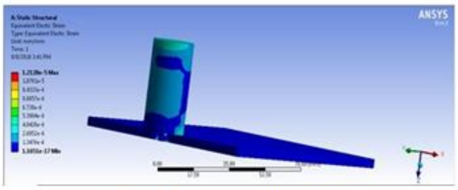
Total deformation for Round Aluminium alloy (1200rpm)

Represents the Total deformation for a round aluminium alloy pin profile at cutting spindle speed is 1200rpm.



Stress for Round Aluminium alloy (1200rpm)

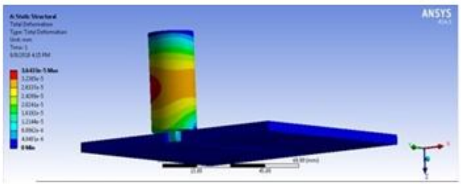
represents the stress for a round aluminium alloy pin profile at cutting spindle speed is 1200rpm.



Strain for Round Aluminium alloy(1200rpm)

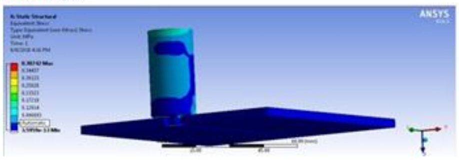
represents the strain for a round aluminium alloy pin profile at cutting spindle speed is 1200rpm.
TOOL PIN PROFILE: SQUARE TOOL:

CONDITION 1: AT TOOL SPEED -800 RPM:



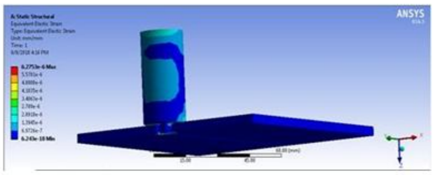
Total deformation for Square Aluminium alloy (800rpm)

Represents the Total deformation for a square aluminium alloy pin profile at cutting spindle speed is 800rpm.



Stress for Square Aluminium alloy (800rpm)

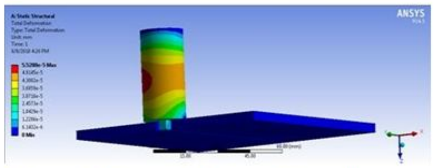
represents the stress for square aluminium alloy pin profile at cutting spindle speed is 800rpm.



Strain for Square Aluminium alloy (800rpm)

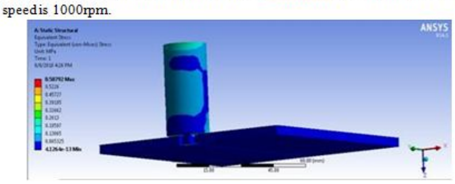
represents the strain for a square aluminium alloy pin profile at cutting spindle speed is 800rpm.

CONDITION 2: AT TOOL SPEED -1000 RPM:



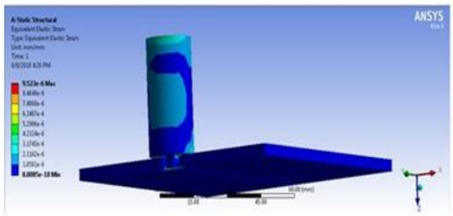
Total deformation for Square Aluminium alloy (1000rpm)

Represents the Total deformation for a square aluminium alloy pin profile at cutting spindle speed is 1000rpm.



Stress for Square Aluminium alloy (1000rpm)

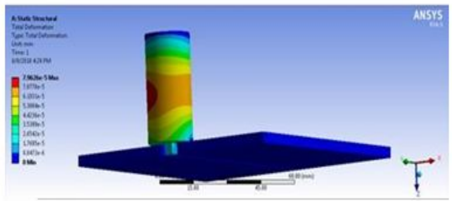
represents the stress for a square aluminium alloy pin profile at cutting spindle speed is 1000rpm.



Strain for Square Aluminium alloy (1000rpm)

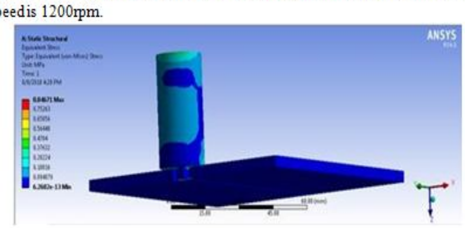
represents the strain for a square aluminium alloy pin profile at cutting spindle speed is 1000rpm.

CONDITION 3: AT TOOL SPEED -1200 RPM



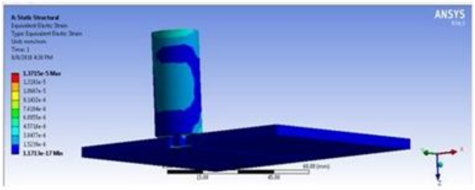
Total deformation for Square Aluminium alloy (1200rpm)

Represents the Total deformation for a square aluminium alloy pin profile at cutting spindle speed is 1200rpm.



Stress for Square Aluminium alloy (1200rpm)

represents the strain for a square aluminium alloy pin profile at cutting spindle speed is 1200rpm.

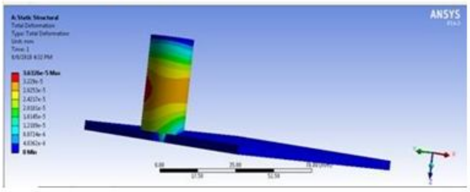


Stress for Square Aluminium alloy (1200rpm)

represents the stress for a square aluminium alloy pin profile at cutting spindle speed is 1200rpm.

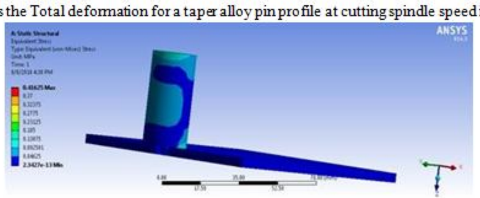
TOOL PIN PROFILE: TAPER

CONDITION 1: AT TOOL SPEED -800 RPM:



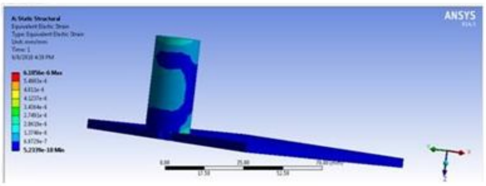
Total deformation for Taper Aluminium alloy (800rpm)

Represents the Total deformation for a taper alloy pin profile at cutting spindle speed is 800rpm.



Stress for Taper Aluminium alloy (800rpm)

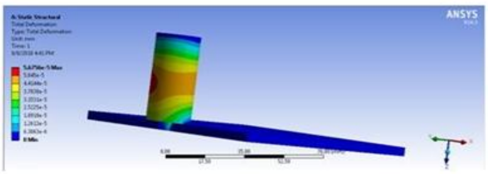
represents the stress for a taper aluminium alloy pin profile at cutting spindle speed is 800rpm.



Strain for Taper Aluminium alloy (800rpm)

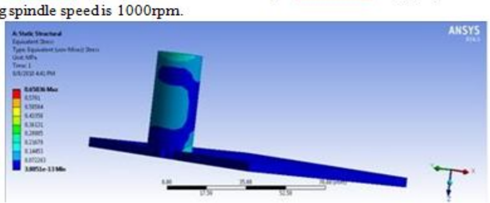
represents the strain for a taper aluminium alloy pin profile at cutting spindle speed is 800rpm.

CONDITION 2: AT TOOL SPEED -1000 RPM:



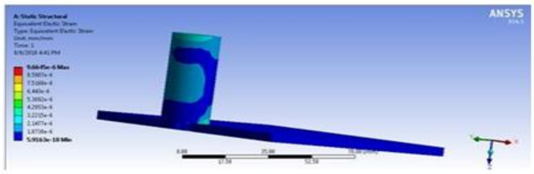
Total deformation for Taper Aluminium alloy (1000rpm)

represents the Total deformation for a taper aluminium alloy pin profile at cutting spindle speed is 1000rpm.



Stress for Taper Aluminium alloy (1000rpm)

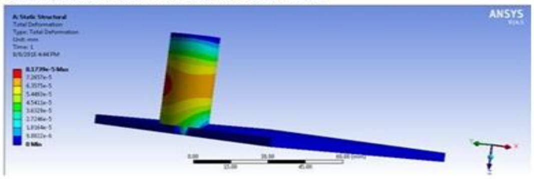
represents the stress for a taper aluminium alloy pin profile at cutting spindle d is 1000rpm.



Strain for Taper Aluminium alloy (1000rpm)

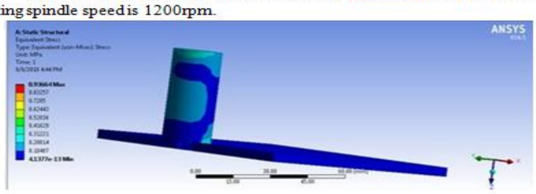
represents the strain for a taper aluminium alloy pin profile at cutting spindle speed is 1000rpm.

CONDITION 3- AT TOOL SPEED -1200 RPM:



Total deformation for Taper Aluminium alloy (1200rpm)

Represents the Total deformation for a taper aluminium alloy pin profile at cutting spindle speed is 1200rpm.



: Stress for Taper Aluminium alloy (1200rpm)

represents the stress for a taper aluminium alloy pin profile at cutting spindle d is 1000rpm.

RESULTS

MATERIAL- ALUMINUM ALLOY:

TOOL PI PROFILE	TOOL SPEED(RPM)	DEFORMATION (mm)	STRESS(N/mm^2)	STRAIN
ROUND	800	3.26e-5	0.3728	5.381e-6
	1000	5.678e-5	0.58344	8.421e-6
	1200	8.177e-5	0.84026	1.212e-5
SQUARE	800	3.643e-5	0.38742	6.2753e-6
	1000	5.528e-5	0.58792	9.523e-6
	1200	7.962-5	0.84671	1.3715e-5
TAPER	800	3.632e-5	0.41625	6.1856e-6
	1000	5.675e-5	0.65036	9.664e-6
	1200	8.173e-5	0.93664	1.3919e-5

MATERIAL- COPPER

TOOL PI PROFILE	TOOL SPEED(RPM)	DEFORMATION (mm)	STRESS(N/mm^2)	STRAIN
ROUND	800	7.051e-5	1.1198	1.0436e-5
	1000	0.00011018	1.7495	1.6306e-5
	1200	0.00015868	2.5197	2.3483e-5
SQUARE	800	6.8119e-5	1.1154	1.1641e-5
	1000	0.00010727	1.7565	1.833e-5
	1200	0.00015449	2.5296	2.602e-5
TAPPER	800	**7.047e-5**	1.2443	1.1925e-5
	1000	**0.00011024**	1.9464	1.8653e-5
	1200	**0.0015859**	2.7999	2.6833e-5

MATERIAL- DISSIMILAR MATERIAL (ALUMINUM AND COPPER)

TOOL PIN PROFILE	TOOL SPEED(RPM)	DEFORMATION (mm)	STRESS(N/mm^2)	STRAIN
ROUND	800	3.6303e-5	1.0661	6.286e-6
	1000	5.672e-5	1.6657	9.888e-6
	1200	8.1688e-5	2.3989	1.424e-5
SQUARE	800	3.5886e-5	0.84334	7.3303e-6
	1000	5.6038e-5	1.3177	1.1453e-5
	1200	8.0707e-5	1.8977	1.6494e-5
TAPER	800	3.6525e-5	1.2168	6.2976e-6
	1000	5.7067e-5	1.9012	9.8395e-6
	1200	8.2187e-5	2.7381	1.4171e-5

V. CONCLUSION

Friction stir welding different cutting tool profiles are (round, taper and square) designing in CREO parametric software and analyzing in ANSYS software. friction stir welding materials are aluminum alloy and aluminum alloy 2) copper and copper 3) copper and aluminum alloy for work pieces and cutting tool material high carbon steel material , cutting tool speeds are 800, 1000 & 1200rpm By observing the static analysis results the stress values are less for square type pin profile and at work piece material aluminum alloy-aluminum alloy, cutting tool material high carbon steel. the stress value is 0.87Mpa, the stress values are increase by increasing the speed. By observing the analytical results and by taguchi, the following conclusions can be made:

To minimize the cutting speed, the optimal parameters are cutting tool spindle speed – 800rpm, pin profile -square and weld speed 30 mm/s.

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