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Finite Element Analysis to Determine Effect of Thickness Ratio on the Slip Damping of Jointed Aluminium Cantilever Beams

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ABSTRACT

The main aim of this thesis is to investigate the effect of thickness ratio on the damping ofcantilever beams jointed with rivets undergoing free vibration. The thickness ratios considered are 1, 1.5 and 2. The material used is Aluminum. Modeling is done in Creo. Static, Modal and harmonic analysis is performed in Ansys. Theoretical calculations are done to determine the damping ratio.

INTRODUCTION

Beam

A beam is a structural element that is capable of withstanding load primarily by resisting bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment.

Vibration and Damping

Most engineering structures experience unwanted vibration which results inpremature failure. It is observed that all free vibrations cannot keep on goingindefinitely and will die out ultimately. In other words, there is some resistance to themotion of the body. Damping characteristics represent the ability of the structure todissipate vibration energy so that the unwanted vibration is suppressed. However, thevibration energy loss from the system is dependent on the physical mechanisms thatcause the dissipation. These mechanisms are complicated processes that are not fullyperceived. The types of damping that are present in the structure will depend on themechanisms predominate in the given situation. For most vibrating systems, asignificant part of the energy is dissipated as heat to the environment in an irreversiblemanner.

LITERATURE SURVEY

In this paper by Rahul H. Hodgar, Dr. Y.R Kharde [1] Riveted joints are often used to fabricate assembled structures in machine tools, automotive, trusses and many such industries requiring high damping. The present work aims to study the mechanism of damping and its FEA evaluation for jointed cantilever beam with number of equispaced connecting rivets resulting in uniform pressure distribution at interfaces. Vibration attenuation in these structures can enhance the dynamic stability significantly. A little amount of work has been reported till date on the damping capacity of riveted structures. Using OROS Series (OR34 - 4 Channel) FFT analyzer experiments are performed on various specimens. The damping ratio is calculated from FFT spectrum obtained from FFT Analyzer. It is established that the damping capacity of structures jointed with connecting rivets can be improved substantially with an increase in number of rivets maintaining uniform intensity of pressure distribution at the interfaces.In This

Paper By R.C. Mohanty,Rajendra Kumar Mohanty [2] Damping In Built-Up Structures Is Produced By The Energy Dissipation Due To Micro-Slip Along The Frictional Interfaces. The Analysis Of The Problem Has Been Carried Out Using Finite Element Method (FEM). A Finite Element Model Of The Linear Elastic System Has Been Formulated Using The Euler-Bernoulli Beam Theory To Investigate The Damping Phenomena In Riveted Connections. The Discrete Element System Having Two Degrees Of Freedom Per Node V X Has Been Used For The Analysis. The Solution Considers One-Dimensional Beam Elements With∂∂Representing V And Each One Consisting Of Two Nodes Having Two Degrees Of Freedom, I.E. Transverse Displacement And Rotation At Each Node. The Generalized Stiffness And Mass Matrices For This Element Has Been Derived. Extensive Experiments Have Been Conducted For The Validation Of The Analysis. From This Study, It Is Established That The Damping Capacity Increases And The Natural Frequency Decreases Due To The Joint Effects.

3D MODELS OF BEAM WITH DIFFERENT THICKNESS RATIOS OF DAMPING MATERIAL

The reference journal for the modeling is International Journal of Innovative Research in Science, Engineering and Technology “Study on Improvement of Damping in Jointed Cantilever Beams Using FEM " R.C. Mohanty , Rajendra Kumar Mohanty specified as [2] in References chapter.

Thickness ratio 1

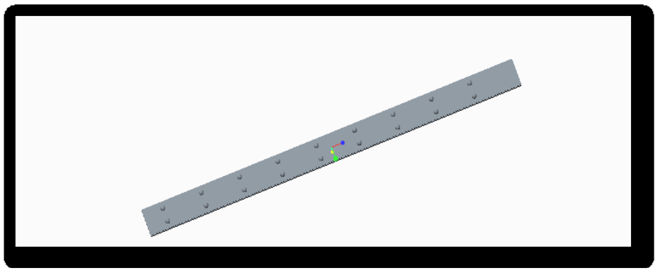

Fig: 3D model of beam with thickness ratio 1

ANALYSIS OF CANTILEVER BEAM

MATERIAL - ALUMINUM ALLOY

THICKNESS RATIO - 1

STATIC ANALYSIS, MODAL ANALYSIS, HARMONIC RESPONSE ANALYSIS

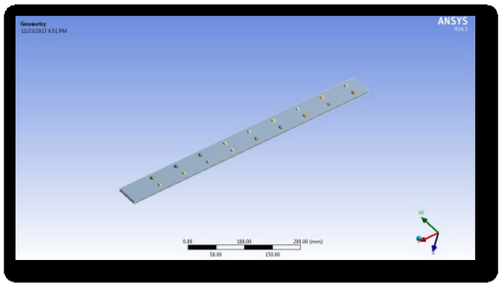

Fig: Imported geometry of beam with thickness ratio 1

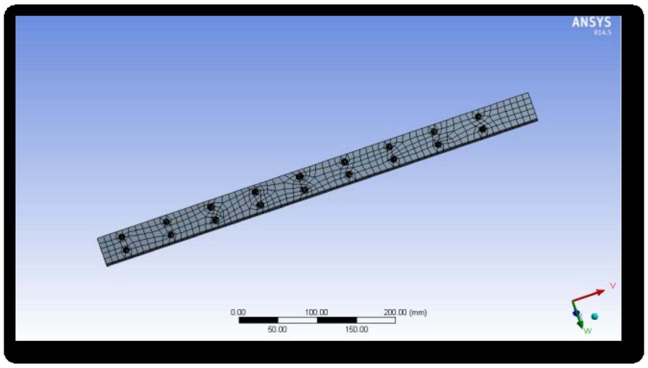

Fig: Meshed model of beam with thickness ratio 1

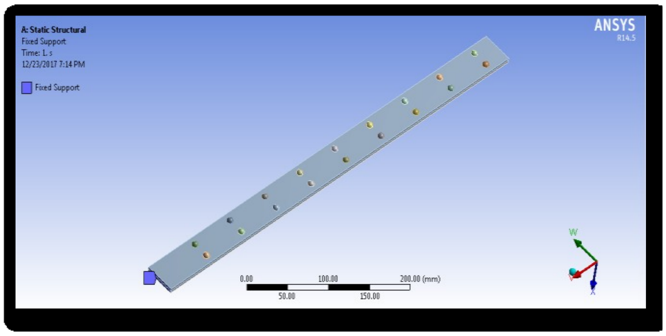

Fig: Fixed support is applied at one end of the beam

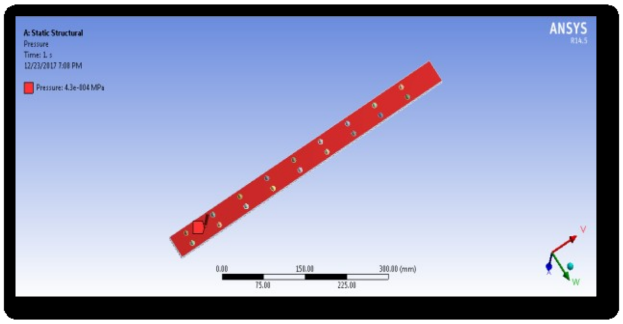

Fig: Pressure is applied on top of the beam

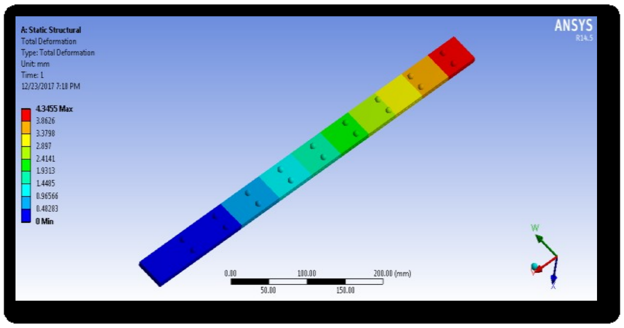

Fig: Total deformation of beam with thickness ratio 1

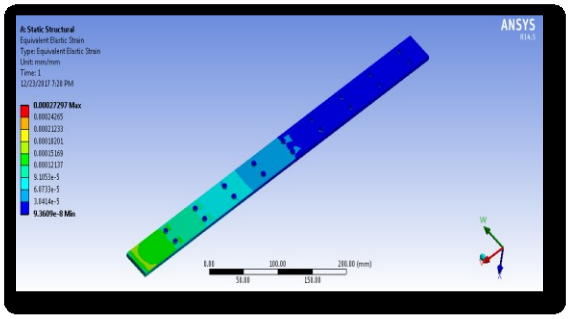

Fig: Strain of beam with thickness ratio 1

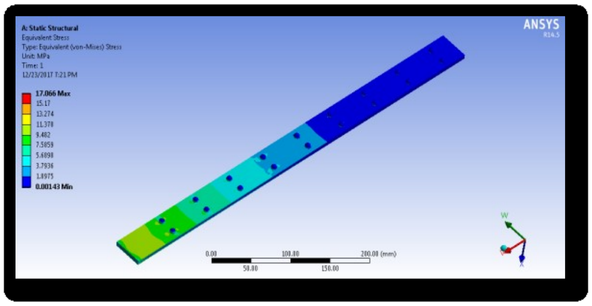

Fig: Stress of beam with thickness ratio 1

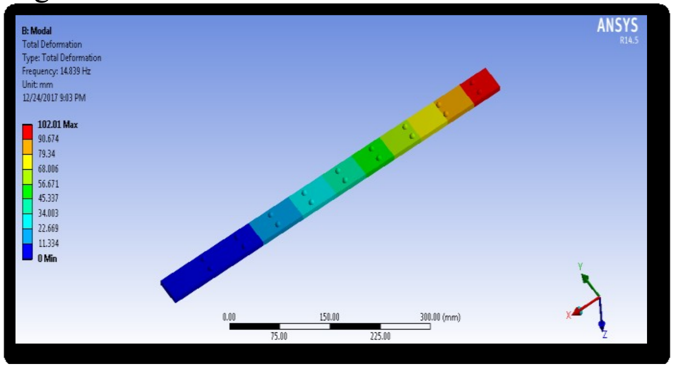

Fig: mode 1 of beam with thickness ratio 1

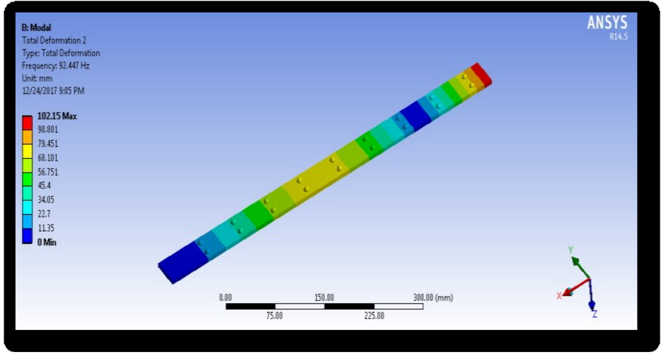

Fig: mode 2of beam with thickness ratio 1

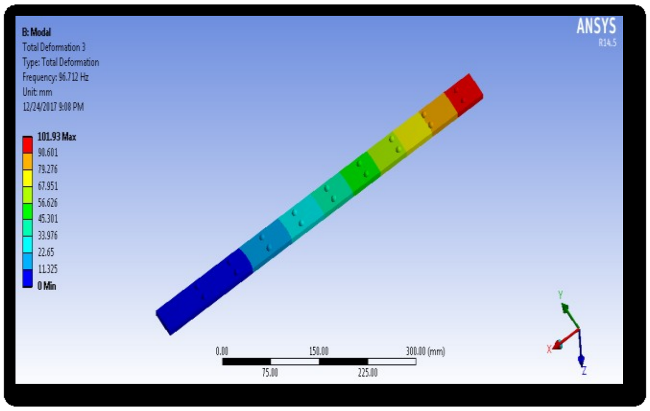

Fig: mode 3of beam with thickness ratio 1

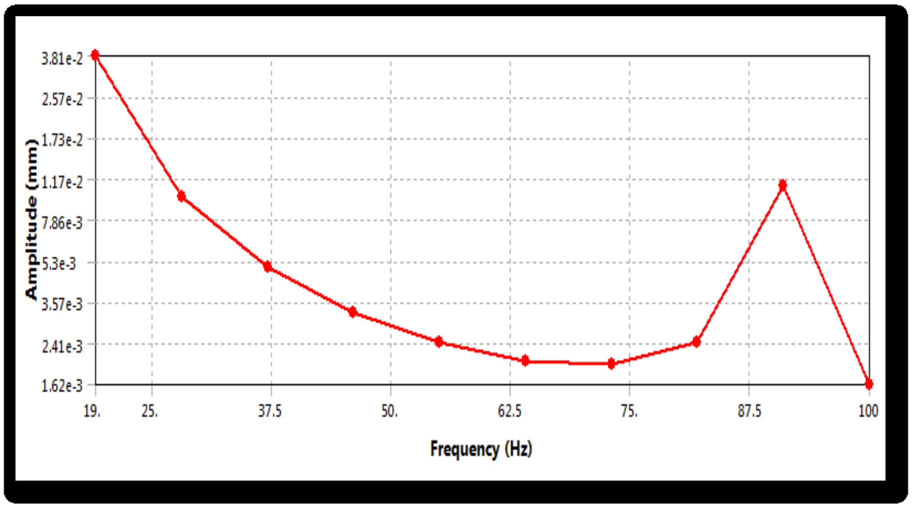

Fig: Frequency Response1

RESULTS TABLE

STATIC STRUCTURAL ANALYSIS RESULTS

	THICKNESS RATIO 1	THICKNESS RATIO 1.5	THICKNESS RATIO 2
TOTAL DEFORMATION (mm)	4.3455	2.2426	1.3007
STRAIN	0.00027297	0.00016385	0.00011417
STRESS (MPa)	17.066	11.437	6.2941

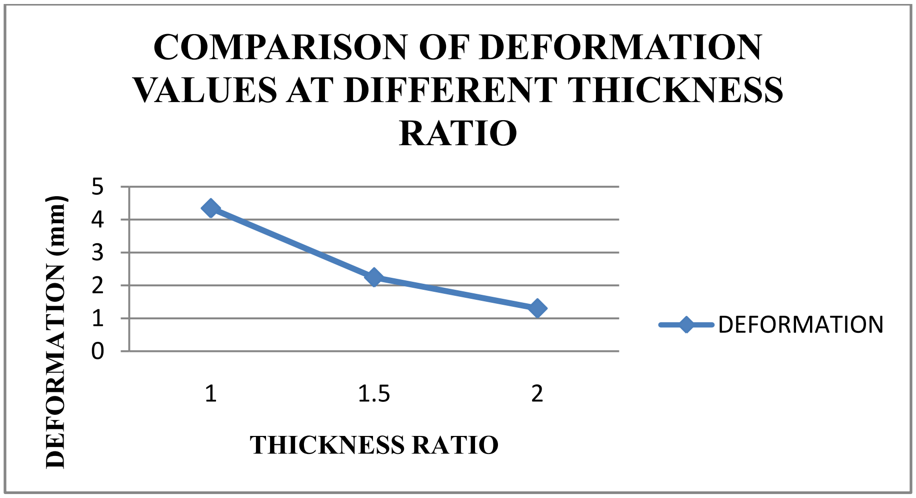

Fig: Comparison of Deformation Values at Different Thickness Ratio

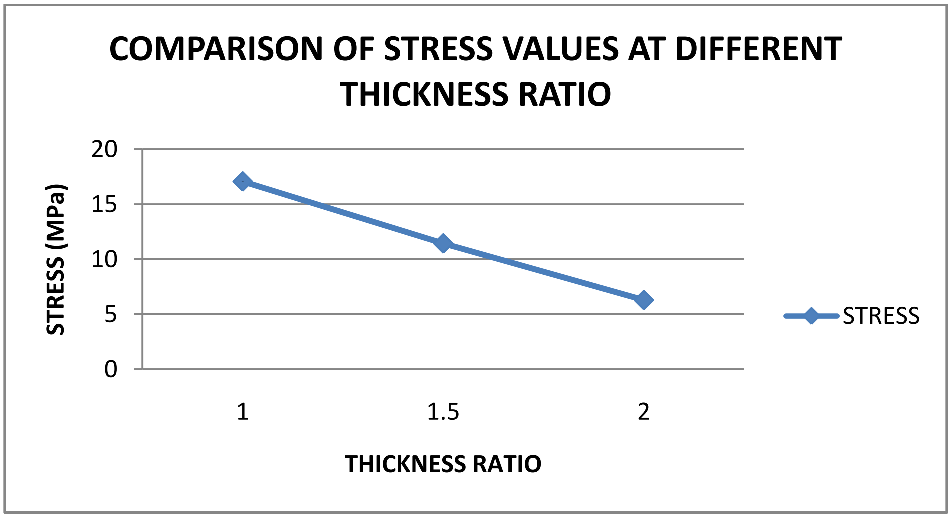

Fig: Comparison of Stress Values at Different Thickness Ratio

MODAL ANALYSIS RESULTS

	FREQUENCY (Hz) MODE 1	DEFORMATION (mm) MODE 1	FREQUENCY (Hz) MODE 2	DEFORMATION (mm) MODE 2	FREQUENCY (Hz) MODE 3	DEFORMATION (mm) MODE 3
THICKNESS RATIO 1	14.839	102.01	92.447	102.15	96.712	101.93
THICKNESS RATIO 1.5	18.523	91.463	96.903	91.375	115.46	91.569
THICKNESS RATIO 2	22.265	83.829	97.266	83.696	138.79	84.083

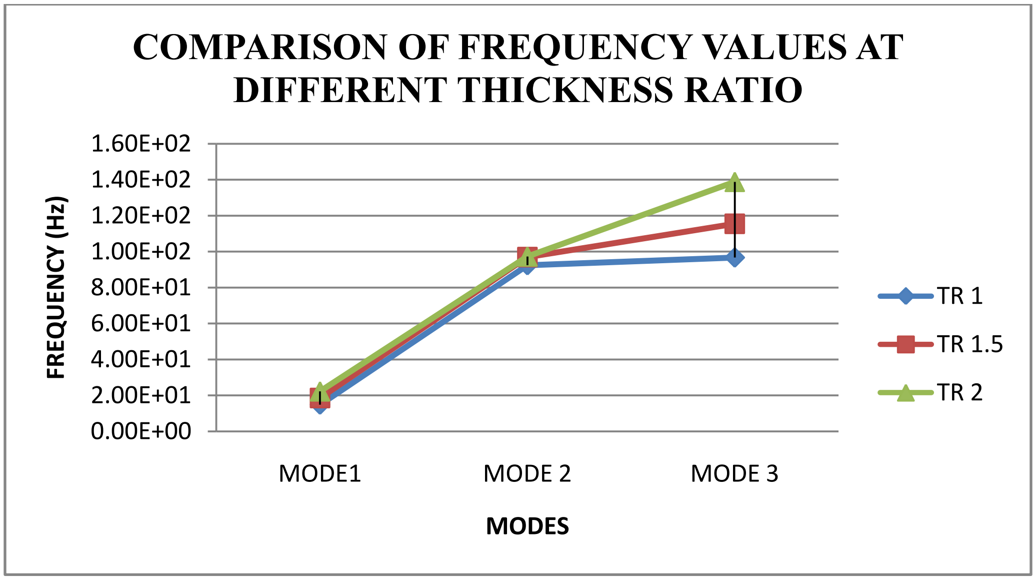

Fig: Comparison of Frequency Values at Different Thickness Ratio

THEORETICAL CALCULATIONS TO DETERMINE DAMPING RATIO

F_n, W_n = Natural frequency

δ= logarithmic decrement

ζ = damping ratio

ρ=density of material

E = Young's modulus of cantilever beam

I = moment of inertia

m = mass of the object

b= width of the object

h=thickness of the object

Frequency

$$F_n = \frac{w_n}{2\pi} = \frac{3.52}{2\pi l^2}\sqrt{\frac{EI}{m}}$$

$$m = bh\rho$$

Damping ratio

$$\delta = \varsigma w_n \tau_d$$

$$\varsigma = \frac{\delta}{w_n \tau_d}$$

CONCLUSION

In this thesis, the effect of thickness ratio on the damping ofcantilever beams jointed with rivets undergoing free vibration. The thickness ratios considered are 1, 1.5 and 2. The material used is Aluminum. Modeling is done in Pro/Engineer. Static, Modal and harmonic analyses is performed in Ansys. By observing the static analysis results, the deformation and stress values are decreasing by increasing the thickness ratio.By observing the modal analysis results, the frequencies are increasing by increasing the thickness ratio, so vibrations will be increasing in the beam.By observing the harmonic analysis results, as the frequency increases, the amplitude is decreasing (i.e) the maximum displacement of the beam is decreasing and also by increasing the thickness ratio, the amplitude is decreasing.Theoretical calculations are done to determine the damping ratio.The damping ratio is less than 1 for all thickness ratios, so the system is under-damped. In this situation, the system will oscillate at the natural damped frequency.

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