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Analytical Investigation of Pipe of Tapered Thickness with an Internal Flow to Estimate Natural Frequency

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ABSTRACT

In this thesis, the effect of tapered thickness on the free transverse vibration of clamped – free pipe which have uniform circular cross section conveying water is determined analytically for two cases.The first involves the pipe which has a constant wall thickness at clamped end while the thickness at free end changes according to different thickness ratio. In the second case the thickness at free end is constant whereas the thickness at clamped end is changed at different thickness ratio. The pipe has a constant inner radius and length. The thickness ratios considered in this project are 0.2, 0.4, 0.6, 0.8 and 1.3D models of the pipe are done in Creo 2.0. CFD analysis, Static, Modal analysis is done in Ansys 14.5.

INTRODUCTION

A pipe is a tubular section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey substances which can flow — liquids and gases (fluids), slurries, powders and masses of small solids. It can also be used for structural applications; hollow pipe is far stiffer per unit weight than solid members.

FLOW IN PIPES

Fluid flow in circular and noncircular pipes is commonly encountered in practice. The hot and cold water that we use in our homes is pumped through pipes. Water in a city is distributed by extensive piping networks. Oil and natural gas are transported hundreds of miles by large pipelines. Blood is carried throughout our bodies by arteries and veins. The cooling water in an engine is transported by hoses to the pipes in the radiator where it is cooled as it flows. Thermal energy in a hydronic space heating system is transferred to the circulating water in the boiler, and then it is transported to the desired locations through pipes. Fluid flow is classified as external and internal, depending on whether the fluid is forced to flow over a surface or in a conduit. Internal and external flows exhibit very different characteristics. In this chapter we consider internal flow where the conduit is completely filled with the fluid, and flow is driven primarily by a pressure difference. This should not be confused with open-channel flow where the conduit is partially filled by the fluid and thus the flow is partially bounded by solid surfaces, as in an irrigation ditch, and flow is driven by gravity alone. We start this chapter with a general physical description of internal flow and the velocity boundary layer. We continue with a discussion of the

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dimensionless Reynolds number and its physical significance. We then discuss the characteristics of flow inside pipes and introduce the pressure drop correlations associated with it for both laminar and turbulent flows. Then we present the minor losses and determine the pressure drop and pumping power requirements for real-world piping systems. Finally, we present an overview of flow measurement devices.

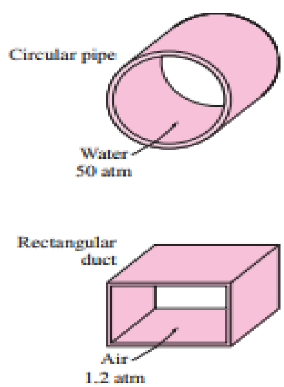

Fig: Circular Pipes Can Withstand Large Pressure Differences Between The Inside And The Outside Without Undergoing Any Significant Distortion, But Noncircular Pipes Cannot.

LITERATURE SURVEY

In the paper by Nawal H. Al Raheimy [1]This research study the effect of tapered thickness on the free transverse vibration of clamped – free pipe which have uniform circular cross section conveying water by using Raighly –Ritz method in the two case, the first involves the pipe have a constant wall thickness at clamped end equal to while the thickness at free end changes according to the ratio . In the second case the thickness at free end is constant whereas the thickness at clamped end changes at ratio . The pipe has a constant inner radius of and different values of length . This study shows in the 1st case the critical velocity of the fluid can be decreased at the increase in length of the pipe at the same values of but the value of critical velocity is increased with increasing t1, Riand the thickness ratio at the same length of the pipe. In addition at absence the flow of water the natural frequency of system is decreased with the increase in the and length of pipe, whereas Riand are decreased. In the 2nd case the dynamic behaviors of the system at the same that in the 1st case except that the natural frequency increase with increasing the thickness ratio . At any formation of the pipe for uniform section the natural frequency decreased when the velocity of water increased from zero to critical velocity. Results are compared with those available in literature and are found to be in excellent agreement.In the paper byJwege&Zahid[3]This research investigates the effect of end conditions on the vibration characteristics of a pipe conveying fluid with different cross sections such as (sudden enlargement and sudden contraction). Several end pipe supports (flexible, simply and rigid) were adopted to investigate the natural frequencies and their corresponding mode shapes. Also, the effect of some design parameters like pipe diameter, length, pipe material, and the effect of fluid velocity were investigated. From the results, it is concluded that the values of natural frequencies in rigid support case are higher than those in flexible and simply supports, because the overall stiffness of the system is higher. As well as, the natural frequency is affected by the diameter size for all kinds of selected supports, the decrease in the system pipe diameter to a half of this value will reduce values of the natural frequencies about 50 %, because increase the moment of inertia of the system. The study shows that the change of selected pipe length makes difference on the natural frequencies values for all kinds of supports.In the paper byWang &Bloom[4] we study both the static and dynamic instabilities of submerged and inclined concentric pipes conveying fluid. The governing equation for the inner tubular beam is derived under small deformation assumptions. We obtain the discretized dynamical equations using spatial finite-difference schemes. In the case of steady flow, both buckling and flutter instabilities are investigated. In the case of pulsatile flow, we compute the eigenvalues of the monodromy matrix derived from the discretized linear system with periodic coefficients, and deduce the dynamical stability information. In addition, for a special case, in which the concentric pipes have the same length, we compare the dynamic stability results with the corresponding solutions obtained with the Bolotin method.

3D MODELS OF PIPE WITH DIFFERENT THICKNESS RATIOS

The reference for the modelling is taken from the journal paper "Nawal H. AlRaheimy, Theoretical Study on Pipe of Tapered Thickness with an Internal Flow to Estimate Natural Frequency International Journal of Mechanical Engineering and Technology, 7(2), 2016, pp. 105–120" specified as [1] in References chapter.

Case 1:- Thickness Ratio--- $t_2/t_1 = 0.2$

Fig: - Assembly of pipe and fluid with $t_2/t_1 = 0.2$

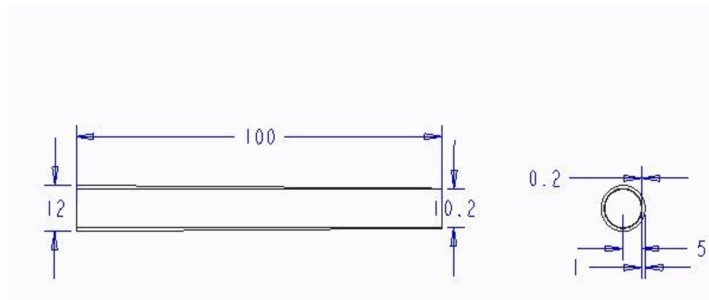

Fig: - 2d Drafting for pipe with $t_2/t_1 = 0.2$

CFD ANALYSIS ONPIPE OF TAPERED THICKNESS

The boundary conditions for the analysis is taken from the journal paper "Nawal H. AlRaheimy, Theoretical Study on Pipe of Tapered Thickness with an Internal Flow to Estimate Natural Frequency International Journal of Mechanical Engineering and Technology, 7(2), 2016, pp. 105–120" specified as [1] in References chapter.

CASE 1- THICKNESS RATIO --- $t_2/t_1 = 0.2$

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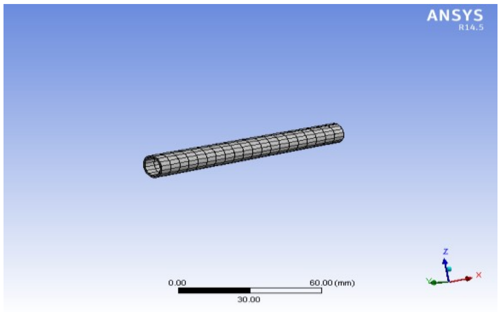

Fig: - Meshed of pipe with $t_2/t_1 = 0.2$

Select faces → right click → create named section → enter name → air inlet & outlet

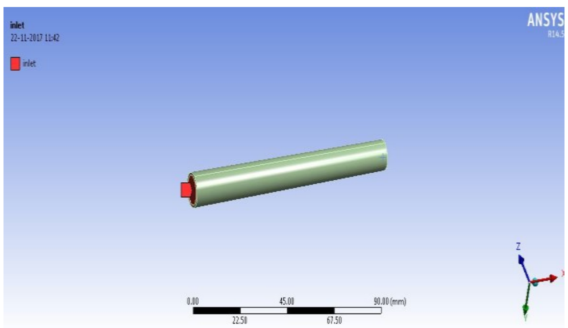

Fig: - Inlet of pipe with $t_2/t_1 = 0.2$

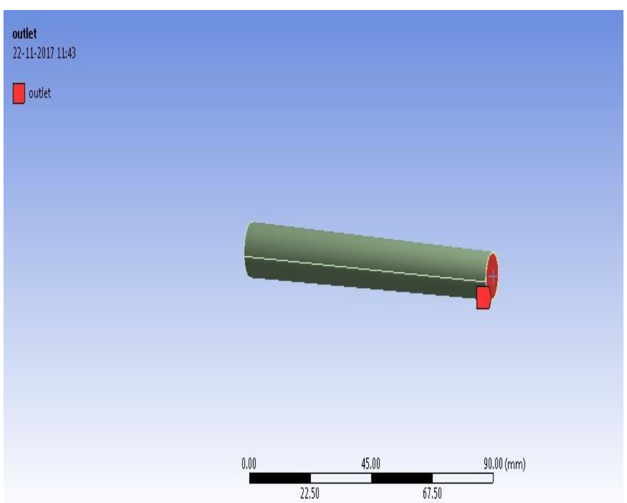

Fig: - Outlet of pipe with $t_2/t_1 = 0.2$

Energy equation is kept on, Standard k-e is taken as viscous model and water – liquid is taken as fluid.

Update project>setup>edit>model>select>energy equation (on)>ok
Inlet velocity is taken as 2m/s

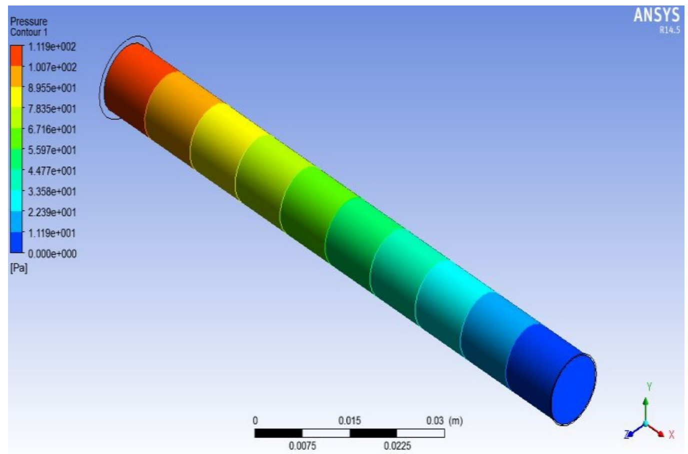

Fig: - Pressure of pipe with $t_2/t_1 = 0.2$

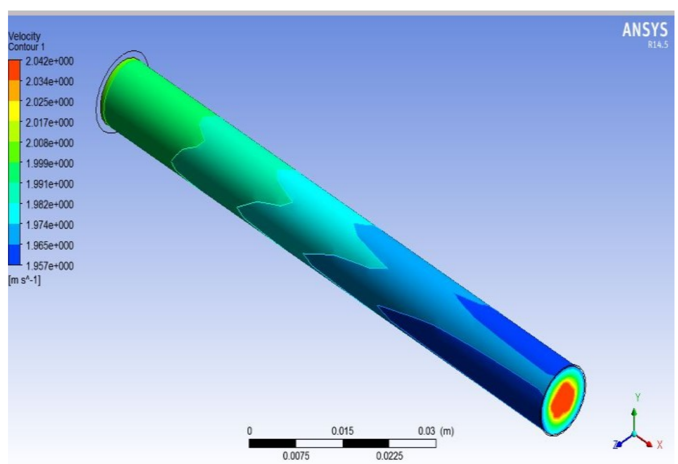

Fig: - Velocity of pipe with $t_2/t_1 = 0.2$

Graphs

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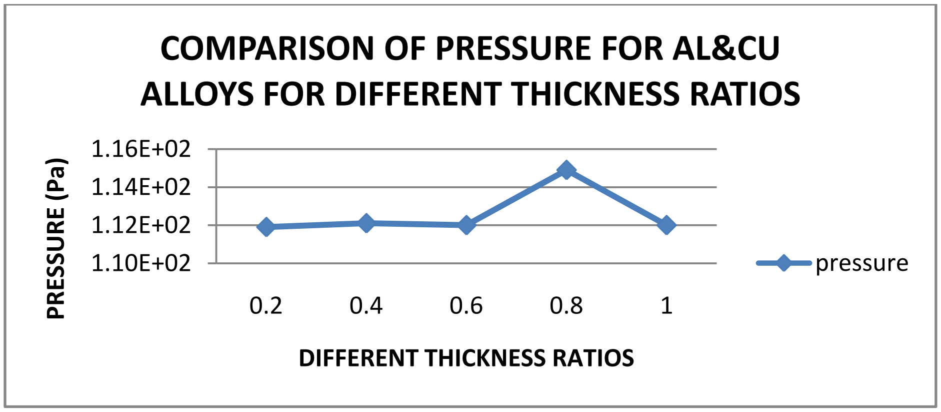
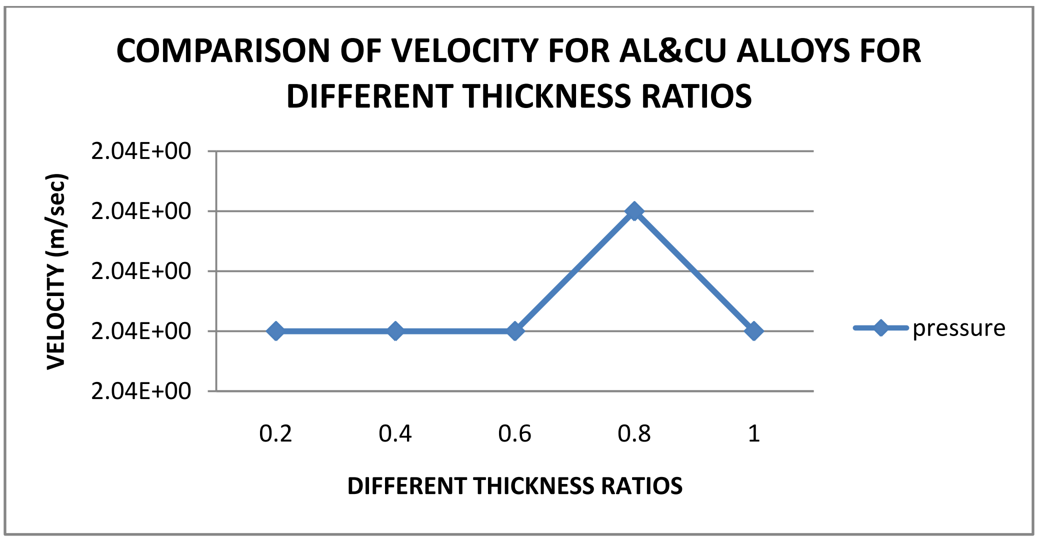


By observing above graph, the pressure is increasing by increasing the thickness ratio to 0.8 but is reducing for thickness ratio 1. The pressure is reducing by about 2.5% for thickness ratio 1 when compared with that of thickness ratio 0.8.



By observing above graph, the velocity is almost equal for all pipes.

STATIC– MODAL ANALYSIS OF PIPE

Static and Modal analyses are performed on all the pipes by changing the boundary conditions (i.e) changing the fixed support, once specifying at the smaller end of pipe and other at the larger end of pipe. The pressure applied is taken from the results of CFD analysis.

THICKNESS RATIO $t_2/t_1 = 0.2$

FIXED AT SMALLER END

MATERIAL - COPPER ALLOY

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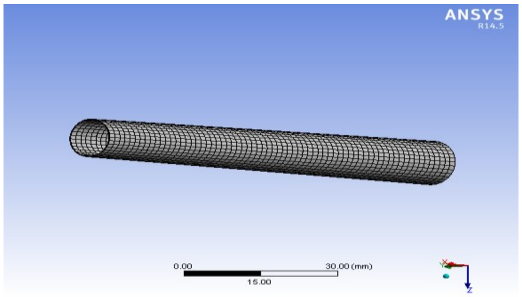

Fig: - Meshed of pipe with $t_2/t_1 = 0.2$

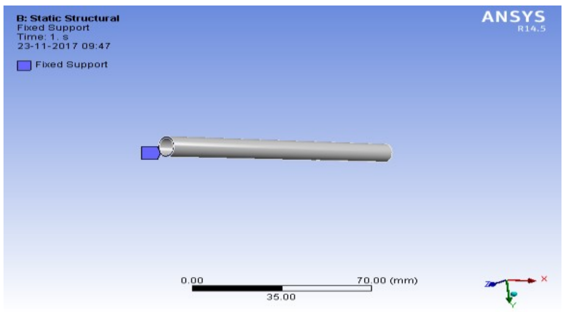

Fig: - Fixed supportis applied at smaller end of pipe with $t_2/t_1 = 0.2$

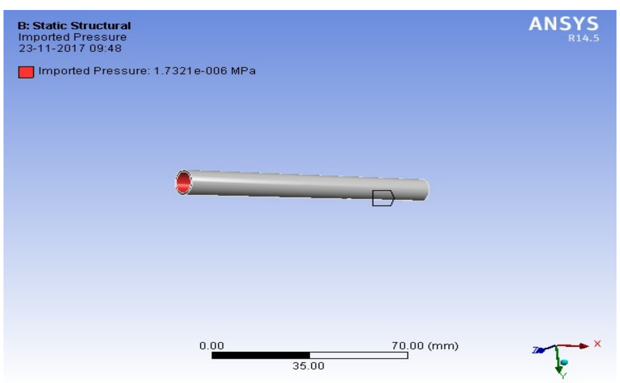

Fig: - Imported pressure applied inside the pipe

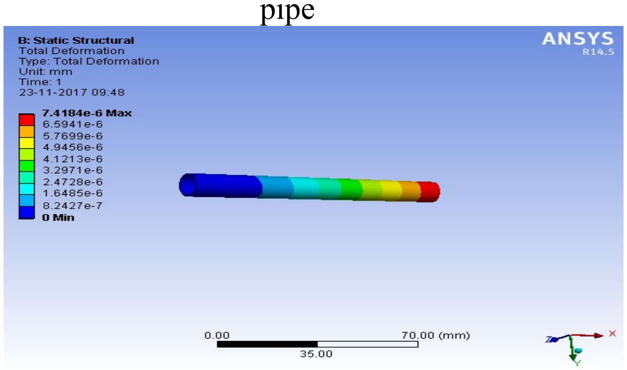

Fig: - Total deformation of pipe using Copper alloy material with $t_2/t_1 = 0.2$

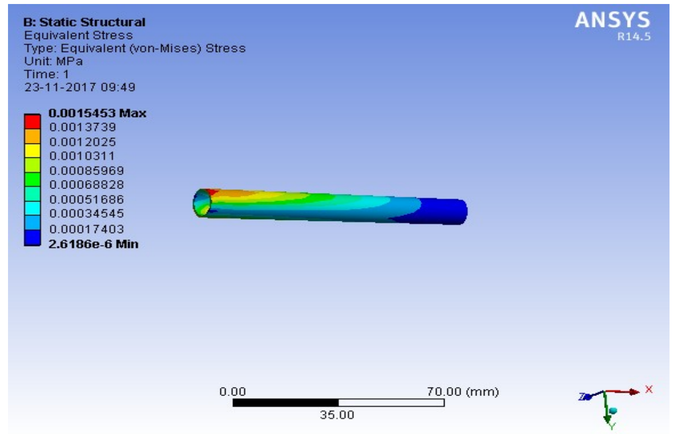

Fig: - Equivalent stress of pipe using Copper alloy material with $t_2/t_1 = 0.2$

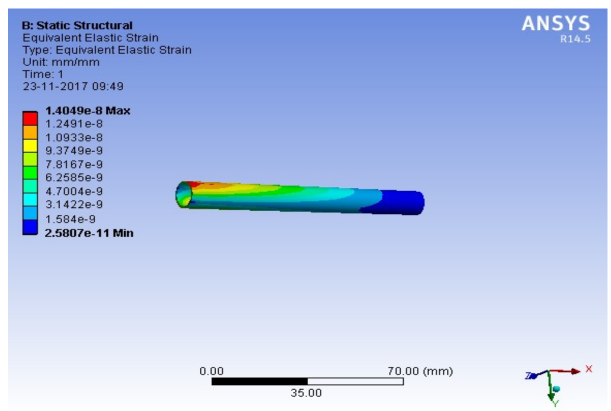

Fig: - Equivalent strain of pipe using Copper alloy material with $t_2/t_1 = 0.2$

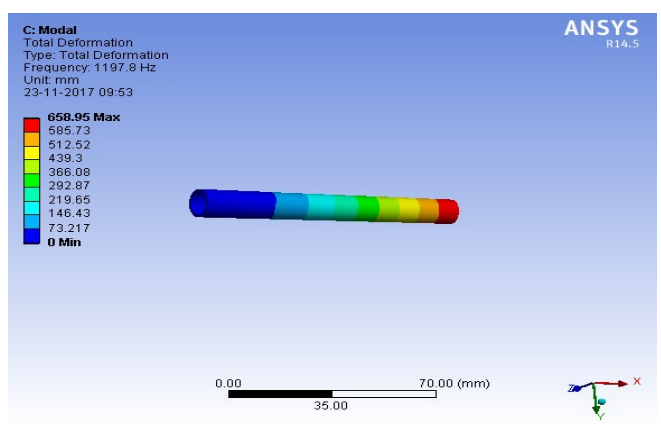

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Fig: - Mode-1 of pipe using Copper alloy material with $t_2/t_1 = 0.2$

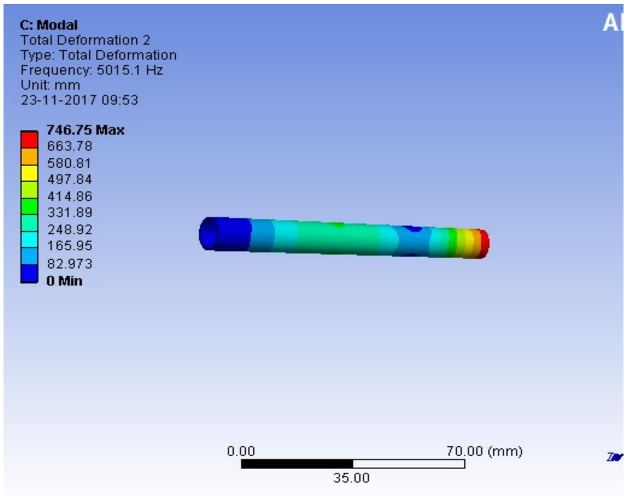


Fig: - Mode-2 of pipe using Copper alloy material with $t_2/t_1 = 0.2$

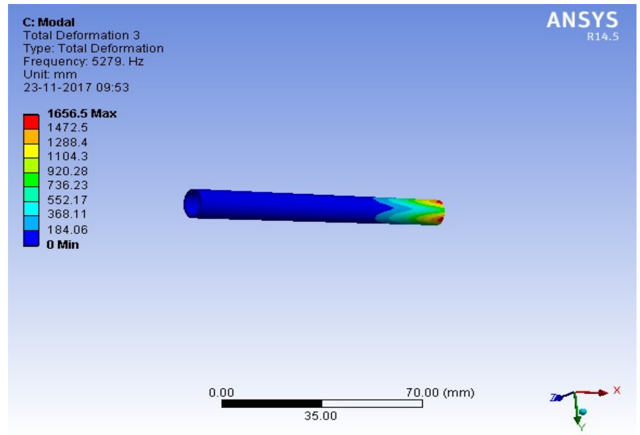
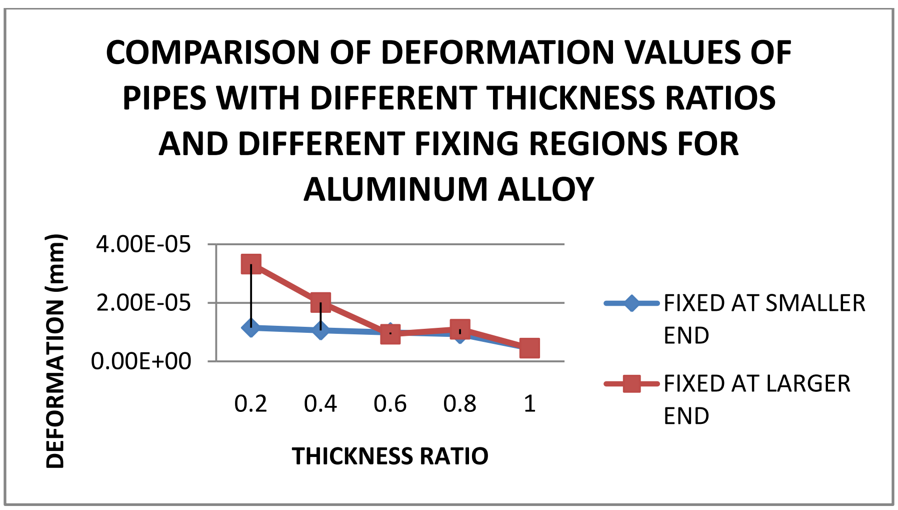


Fig: - Mode-3 of pipe using Copper alloy material with $t_2/t_1 = 0.2$

Graphs



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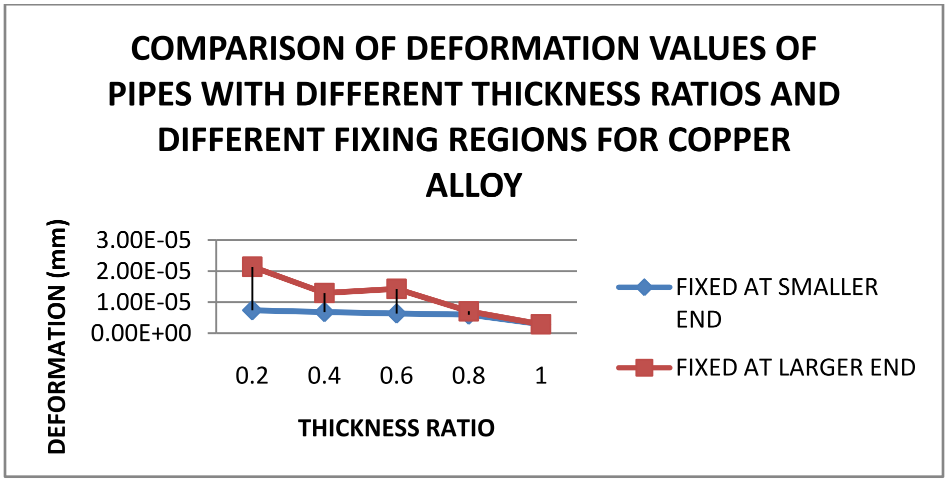
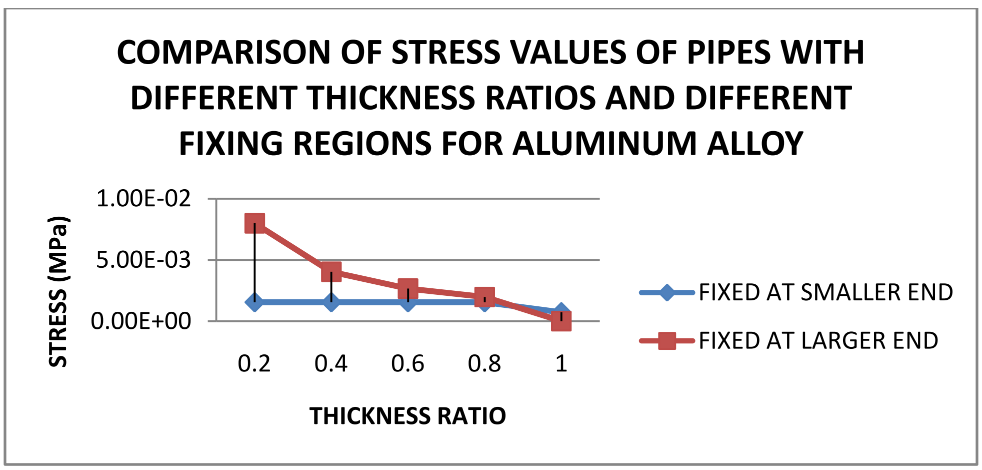
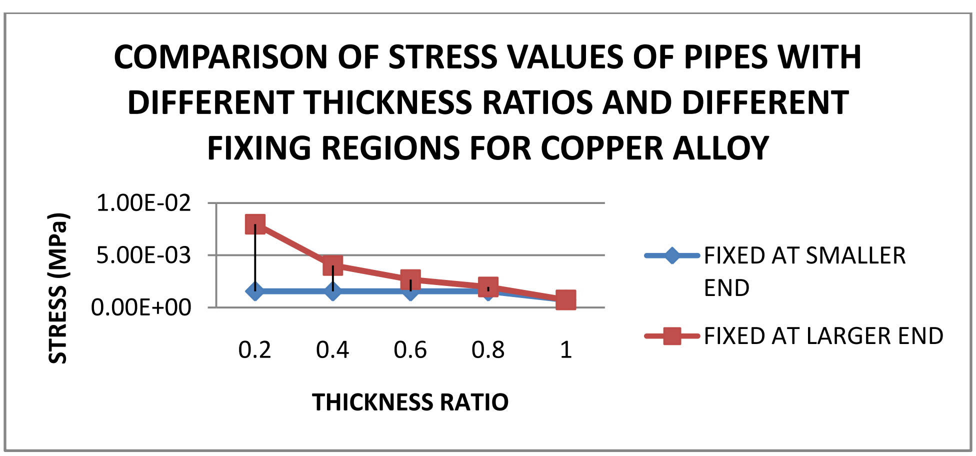


By observing above graphs, the deformation is reducing by increasing the thickness ratio. The deformations are more when fixed at the larger end. The deformation values are decreasing for pipe with fixing at smaller end by 65.4% for thickness ratio 0.2, by 47.3% for thickness ratio 0.4, by 55.5% for thickness ratio 0.6 and by 15.37% for thickness ratio 0.8 when compared with that of pipe with fixing at larger end.





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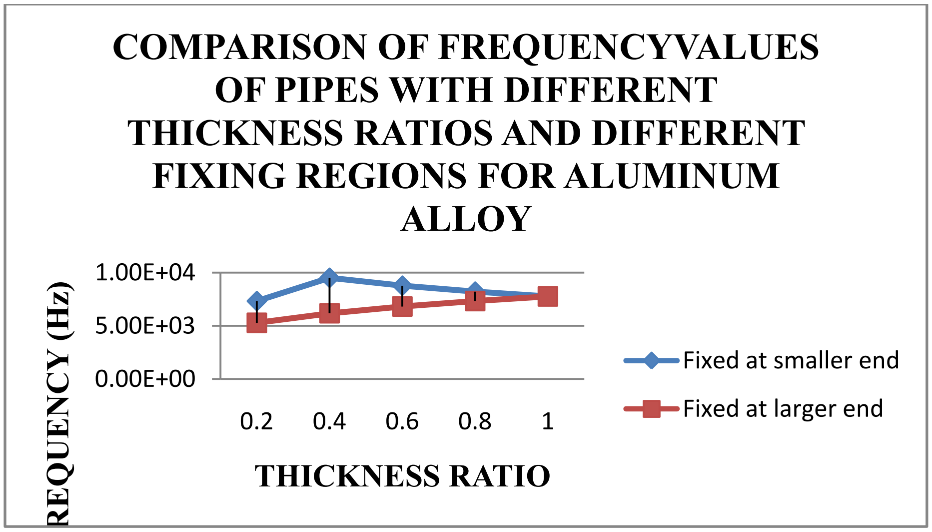
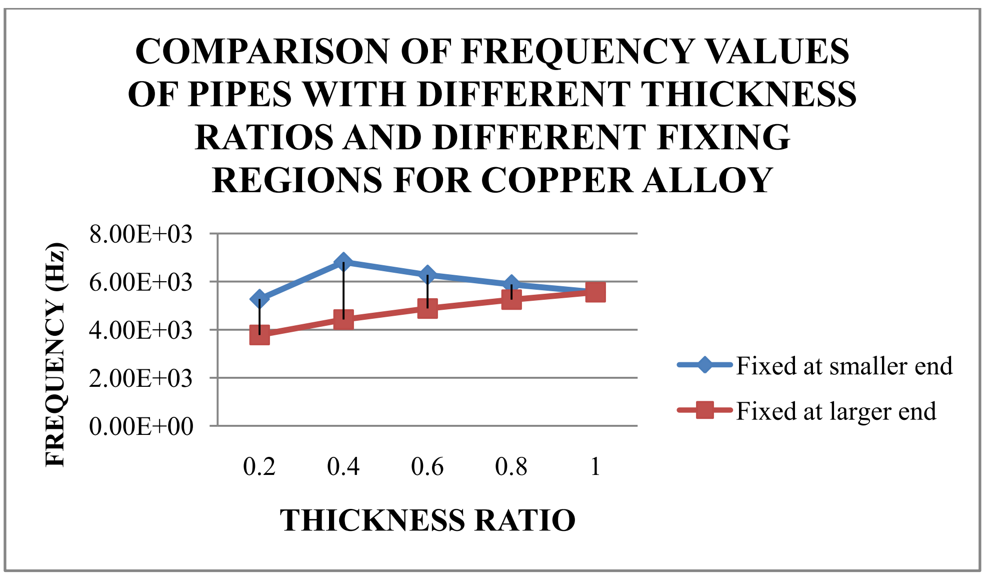
By observing above graphs, the stress is reducing by increasing the thickness ratio. The stresses are more when fixed at the larger end. The stress values are decreasing for pipe with fixing at smaller end by 80.59% for thickness ratio 0.2, by 61.5% for thickness ratio 0.4, by 41.8% for thickness ratio 0.6 and by 21.5% for thickness ratio 0.8when compared with that of pipe with fixing at larger end.

MODAL ANALYSIS

Graphs





By observing above graphs, the frequency is increasing by increasing the thickness ratio. The frequencies are more when fixed at the smaller end. The frequency values are increasing for pipe with fixing at smaller end by 28% for thickness ratio 0.2, by 35.1% for thickness ratio 0.4, by 44.3% for thickness ratio 0.6 and by 10.74% for thickness ratio 0.8 when compared with that of pipe with fixing at larger end.

CONCLUSION

By observing CFD analysis results, the pressure is increasing by increasing the thickness ratio to 0.8 but is reducing for thickness ratio 1. The pressure is reducing by about 2.5% for thickness ratio 1 when compared with that of thickness ratio 0.8.By observing Static analysis results, the deformation is reducing by increasing the thickness ratio. The deformations are more when fixed at the larger end. The deformation values are decreasing for pipe with fixing at smaller end by 65.4% for thickness ratio 0.2, by 47.3% for thickness ratio 0.4, by 55.5% for thickness ratio 0.6 and by 15.37% for thickness ratio 0.8 when compared with that of pipe with fixing at larger end. By observing above graphs, the stress is reducing by increasing the thickness ratio. The stresses are more when fixed at the larger end. The stress values are decreasing for pipe with fixing at smaller end by 80.59% for thickness ratio 0.2, by 61.5% for thickness ratio 0.4, by 41.8% for thickness ratio 0.6 and by 21.5% for thickness ratio 0.8when compared with that of pipe with fixing at larger end.By observing Modal analysis results, the deformation is reducing by increasing the thickness ratio. The deformations are more when fixed at the smaller end. The deformation values are increasing for pipe with fixing at smaller end by 80.86% for thickness ratio 0.2, by 18.4% for thickness ratio 0.4, by 48.5% for thickness ratio 0.6 and by 4.8% for thickness ratio 0.8 when compared with that of pipe with fixing at larger end. By observing above graphs, the frequency is increasing by increasing the thickness ratio. The frequencies are more when fixed at the smaller end. The frequency values are increasing for pipe with fixing at smaller end by 28% for thickness ratio 0.2, by 35.1% for thickness ratio 0.4, by 44.3% for thickness ratio 0.6 and by 10.74% for thickness ratio 0.8 when compared with that of pipe with fixing at larger end.

REFERENCES

[1] Nawal H. Al Raheimy, Theoretical Study on Pipe of Tapered Thickness with an Internal Flow to Estimate Natural Frequency,International Journal of Mechanical Engineering and Technology, 7(2), 2016, pp. 105–120.

[2] Nabeel K. Abid Al-Sahib a, Adnan N. Jameel b, Osama F. Abdulateef a*, Investigation into the Vibration Characteristics and Stability of a Welded Pipe Conveying Fluid, J. (JJMIE), 4(3), 2010.

[3] Mohsin J. Jwege&Zahid I. Mohammed, Vibration characteristics of different cross section pipes with different end conditions, Journal of Eng, & Tech., 28(8), 2010, 1634-1654.

[4] Wang & Bloom, Stability issues of concentric pipes containing steady and pulsatile flows, J.F. and structure, 2001.

[5] A. Marzania, M. Mazzottia, E. Viola, P. Vittorib& I. Elishakoffb*,"FEM Formulation for Dynamic Instability of Fluid-Conveying Pipe on Non uniform Elastic Foundation", J. of Mechanics Based Design of Structures and Machines, Vol. 40, Issue 1, pp. 83-95, 2011.

[6] A. K. Misra, M. P. Pa¨ıdoussis, and K. S. Van, "On the dynamics of curved pipes transporting fluid. Part I: inextensible

theory, "Journal of Fluids and Structures, vol. 2, no. 3, pp. 221–244, 1988

[7] H.-B. Zhai, Z.-Y.Wu,Y.-S. Liu, and Z.-F.Yue, "In-plane dynamic response analysis of curved pipe conveying fluid subjected to random excitation," Nuclear Engineering and Design, vol. 256,pp. 214–226, 2013.

[8] Q. Ni, M. Tang, Y. Wang, and L. Wang, "In-plane and out-ofplanedynamics of a curved pipe conveying pulsating fluid, "Nonlinear Dynamics, vol. 75, no. 3, pp. 603–619, 2014.

[9] A. R. Setoodeh and S. Afrahim, "Nonlinear dynamic analysis of FG micro-pipes conveying fluid based on strain gradient theory," Composite Structures, vol. 116, no. 1, pp. 128–135, 2014.

[10] R. A. Ibrahim Fellow ASME Department of Mechanical Engineering, Wayne State University, Detroit, MI 48202 Overview of Mechanics of Pipes Conveying Fluids.