

Analysis of Two Phase Flow Induced Vibration in Piping Systems

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Abstract — Flow induced vibration with internal fluid flow for long slender cylindrical pipe conveying fluid is studied in this thesis. The fourth order partial differential equation of motion for lateral vibration is employed to develop the stiffness and inertia matrix corresponding to two of the terms of the equations of motion. The Equation of motion further includes a mixed-derivative term that was treated as a source for a dissipative function. Four type of boundary condition namely pinned-pinned, clamped-pinned, clamped-clamped and clamped-free were considered for the pipe. Analytical approach is used which are based on Galerkin's method to finding the natural frequency at different boundary conditions and velocities. Further, ANSYS 15.0 is used as a tool for computational analysis for different boundary conditions and velocities. A comparison are made between these two methods and evaluate the percentage error to check the accuracy of the solutions. Pipe buckling or divergence is observed by increasing the flow velocity of fluid for different boundary conditions. The velocity at which the buckling starts is called critical velocity and natural frequency is diminishes at the onset of divergence for pinned-pinned, clamped-pinned, clamped-clamped boundary conditions. But very little effect was observed for the velocity ranges used. The instability of pipe in pinned-pinned, clamped-pinned, clamped-clamped boundary conditions are due to centrifugal forces in the pipe is observed. But, for clamped-free pipe the Coriolis component of force causes instability in pipe.

Keywords- cascade induced vibration; Mechanics of fluid; Momentum transfer; Slender cylindrical pipe; clamped free pipe.

I. INTRODUCTION

1.1 Overview of Internal Flow Induced Vibrations in Pipes The vibration brought on by a liquid flowing in or around a body is known as Flow Induced Vibration (FIV). FIV best portray the cooperation that happens between the liquid's dynamic strengths and a structure's inertial, damping and flexible forces. The flow of a liquid through a pipe can force pressure on the walls of the pipe making it deflect under certain conditions. This deflection of the pipe may cause structural instability of the pipe. The fundamental natural frequency of a pipe for the most part reduces with increasing speed of liquid flow. There are sure situations where reduction in the natural frequency can be critical, for example, those utilized as a part of sustain lines to rocket engines and water turbines. The pipe ends up noticeably to resonance or fatigue failure if its natural frequency decreases up to certain limits. With expansive liquid speeds the pipe may become unstable. The most common type of this instability is the whipping of an unlimited garden hose. The investigation of dynamic reaction of a liquid passing on pipe in conjunction with the transient vibration of cracked pipes uncovers that if a pipe breaks through its cross area, then an adaptable length of unsupported pipe is left spewing out fluid and is allowed to whip about and affect different structures. In power plant plumbing pipe whip is one of probable condition for a failure of pipe. An investigation of the impact of the subsequent high speed liquid on the static and dynamic qualities of the pipe is accordingly vital.

1.2 Classification Of Flow Induced Vibration The classification of flow induced vibration is shown in the figure 1. The classification is categorize according to the type of flow:

1. Steady
2. Unsteady

In steady flow the vibration in pipes is due to two phenomenon. The first is instability and other is vortex induced. The instability in pipes occurs due to flutter, galloping and fluid elastic instability. Flutter basically occurs in pinned-pinned and pinned-clamped pipes. When fluid velocity reaches a critical velocity the buckling (divergence) phenomenon occurs due to centrifugal forces and pipe will become unstable. This phenomenon is called flutter. The fundamental frequency is zero due to flutter and instability in pipes occurs.

1.3 Slender structures in axial flow practically, the dynamics of the problems are often too difficult to fully describe starting purely from the fundamentals of Mechanics such as Newton's Laws or Hamilton's principle. Rather, a multi-faceted investigation involving empiricism, experience, numerical simulation, experiments and analogy to simpler problems is necessary; unfortunately, by being so specific, rarely can the results be generally applicable. Luckily, there exist more than a few cases for which general theory can be established under a set of reasonable assumptions, and from

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Seismic Engineering ,1999 **Scientific and Technical Aerospace Reports** ,1976 Numerical Analysis on Flow-induced Vibration of Pipe System Jiann-Chang Lo,1986 **Flow Induced Vibration Analysis of the Guide Tubes Of reactivity Mechanisms of 500 MWe PHWR.** A. Kakodkar,H. S. Kushwaha,S. C. Mahajan,B. Murali,K. K. Vaze,1992

Analysis of Induced Vibrations in Fully-developed Turbulent Pipe Flow Using a Coupled LES and FEA Approach Thomas P. Shurtz,2009

Turbulent flow induced pipe vibration is a phenomenon that has been observed but not fully characterized This thesis presents research involving numerical simulations that have been used to characterize pipe vibration resulting from fully developed turbulent flow The vibration levels as indicated by pipe surface displacement velocity and acceleration are characterized in terms of the parameters that exert influence The influences of geometric and material properties of the pipe are investigated for pipe thickness in the range 1 to 8 mm at a diameter of 0 1015 m The effects of pipe elastic modulus are explored from 3 to 200 GPa The range of pipe densities investigated is 3 000 to 12 000 kg m³ All pipe parameters are varied for both a short pipe length to diameter ratio 3 and a long pipe length to diameter ratio 24 Further the effects of varying flow velocity fluid density and fluid viscosity are also explored for Reynolds numbers ranging from 9.1×10^4 to 1.4×10^6 A large eddy simulation fluid model has been coupled with a finite element structural model to simulate the fluid structure interaction using both one way and two way coupled techniques The results indicate a strong nearly quadratic dependence of pipe wall acceleration on average fluid velocity This relationship has also been verified in experimental investigations of pipe vibration The results also indicate the pipe wall acceleration is inversely dependant on wall thickness and has a power law type dependence on several other variables The short pipe and long pipe models exhibit fundamentally different behavior The short pipe is not sensitive to dynamic effects and responds primarily through shell modes of vibration The long pipe is influenced by dynamic effects and responds through bending modes Dependencies on the investigated variables have been non dimensionalized and assembled to develop a functional relationship that characterizes turbulence induced pipe vibration in terms of the relevant parameters The functional relationships are presented for both the long and short pipe models The functional relationships can be used in applications including non intrusive flow measurement techniques These findings also have applications in developing design tools in pipe systems where vibration is a problem

Flow-induced Vibrations ,1979 **Flow-induced Vibration** ,1999 *Flow Induced Vibration Analysis of the Guide Tubes of Reactivity Mechanisms of 500 MWe PHWR* ,1992 **Flow-induced Vibration of Power and Process Plant Components** M. K. Au-Yang,2001

Information on the most common flow induced vibration problems in power and process plant components Based on the author s own experience that most errors in engineering analysis come from confusions in the units the author begins with a short chapter on units and dimensions He then provides step by step examples in dual US and SI units leading to the final objective of design analysis problem solving diagnosis and trouble shooting *Flow-induced*

Vibration, 2001: Axial flow, piping systems, other topics, 2001 **Common Mistakes and Misconceptions in Flow Induced Vibration and Coupled Fluid Structural Dynamics Analysis** M. K. Au-Yang, 1999 *Flow-induced Vibration of Circular Cylindrical Structures* American Society of Mechanical Engineers. Pressure Vessels and Piping Division, Flow Induced Vibrations in Pipes Ivan Grant, 2010

Flow induced vibrations of pipes with internal fluid flow is studied in this work. Finite Element Analysis methodology is used to determine the critical fluid velocity that induces the threshold of pipe instability. The partial differential equation of motion governing the lateral vibrations of the pipe is employed to develop the stiffness and inertia matrices corresponding to two of the terms of the equations of motion. The equation of motion further includes a mixed derivative term that was treated as a source for a dissipative function. The corresponding matrix with this dissipative function was developed and recognized as the potentially destabilizing factor for the lateral vibrations of the fluid carrying pipe. Two types of boundary conditions, namely simply supported and cantilevered, were considered for the pipe. The appropriate mass, stiffness, and dissipative matrices were developed at an elemental level for the fluid carrying pipe. These matrices were then assembled to form the overall mass, stiffness, and dissipative matrices of the entire system. Employing the finite element model developed in this work, two series of parametric studies were conducted. First, a pipe with a constant wall thickness of 1 mm was analyzed. Then, the parametric studies were extended to a pipe with variable wall thickness. In this case, the wall thickness of the pipe was modeled to taper down from 2.54 mm to 0.01 mm. This study shows that the critical velocity of a pipe carrying fluid can be increased by a factor of six as the result of tapering the wall thickness.

Flow-induced vibration of process system components : vibration analysis of steam generators and liquid heat exchangers : an overview M. J. Pettigrew, 1996 **FLINOVIA - Flow Induced Noise and Vibration Issues and Aspects** Elena Ciappi, Sergio De Rosa, Francesco Franco, Jean-Louis Guyader, Stephen A. Hambric, 2014-12-09

Flow induced vibration and noise (FIVN) remains a critical research topic. Even after over 50 years of intensive research, accurate and cost-effective FIVN simulation and measurement techniques remain elusive. This book gathers the latest research from some of the most prominent experts in the field. It describes methods for characterizing wall pressure fluctuations including subsonic and supersonic turbulent boundary layer flows over smooth and rough surfaces using computational methods like Large Eddy Simulation for inferring wall pressure fluctuations using inverse techniques based on panel vibrations or holographic pressure sensor arrays for calculating the resulting structural vibrations and radiated sound using traditional finite element methods as well as advanced methods like Energy Finite Elements for using scaling approaches to universally collapse flow excited vibration and noise spectra and for computing time histories of structural response including alternating stresses. This book presents the proceedings of the First International Workshop on Flow Induced Noise and Vibration (FLINOVIA) which was held in Rome, Italy, in November 2013. The authors' backgrounds represent a mix of academia, government, and industry, and several papers include applications to important problems for underwater vehicles, aerospace structures, and

commercial transportation The book offers a valuable reference guide for all those working in the area of flow induced vibration and noise Large Eddy Simulation Based Turbulent Flow-induced Vibration of Fully Developed Pipe Flow Matthew Thurlow Pittard,2003 Flow induced vibration caused by fully developed pipe flow has been recognized but not fully investigated under turbulent conditions This thesis focuses on the development of a numerical Fluid Structure Interaction FSI model that will help define the relationship between pipe wall vibration and the physical characteristics of turbulent flow Commercial FSI software packages are based on Reynolds Averaged Navier Stokes RANS fluid models which do not compute the instantaneous fluctuations in turbulent flow This thesis presents an FSI approach based on Large Eddy Simulation LES flow models which do compute the instantaneous fluctuations in turbulent flow The results based on the LES models indicate that these fluctuations contribute to the pipe vibration It is shown that there is a near quadratic relationship between the standard deviation of the pressure field on the pipe wall and the flow rate It is also shown that a strong relationship between pipe vibration and flow rate exists This research has a direct impact on the geothermal nuclear and other fluid transport industries **Analysis and Design Significance of A-11 Flow-Induced Vibration Test, Phases I and III.** ,1964 Comparisons of the experimental data on seal pressure distributions obtained from the A 11 Flow Induced Vibration Test Phases I and III with analytical results including porous flow through the unimpregnated inner reflector cylinder for the same operating conditions show generally very good agreement The principal deviations between analysis and experiment occurs when high pressure ratios exist across the last seal Additional investigation both in the relationship used in the analytical model and in the experimental area are required to determine the cause of the deviation found between analysis and experiment when the pressure ratio across the last seal is near critical As a result of this comparison it appears that the analytical methods and assumptions made in predicting unheated seal pressure distributions are resonable and may be used with confidence in the test prediction of the NRX A1 cold flow test **Symposium on Flow Induced Structural Vibrations** Symposium on Flow Induced Structural Vibrations,1972 *Stability and Control of Pipes Conveying Fluid* M. P. Paidoussis,Navaratnam Sri Namachchivaya,1992 Flow Induced Vibration of a Cylinder Pair Carlos A. Bonilla,2002

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web leaves of grass i celebrate myself and what i assume you shall assume for every atom belonging to me as good belongs to you i loafe and invite my soul i lean and loafe at my ease observing a spear of summer grass houses and rooms are full of perfumes the shelves are crowded with perfumes

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web oct 10 2020 by the city s quadrangular houses in log huts camping with lumber men along the ruts of the turnpike along the dry gulch and rivulet bed weeding my onion patch or hosing rows of carrots and parsnips crossing savannas trailing in forests prospecting gold digging girdling the trees of a new purchase scorch d ankle deep

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web leaves of grass largely self taught walt whitman read voraciously becoming acquainted with the works of homer dante

shakespeare and the bible he worked as a printer in new york city until a devastating fire in the printing district demolished the industry

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