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Vibration Analysis of Distributor using Multiphase Flow Analysis

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ABSTRACT : *Stress analysis plays important role in the structural safety. Engineering problems are becoming complex with the improvement in the technology and requirements of the industry. Flow induced vibrations are becoming critical in failure of the components. Since flow study and vibrational study are the mix of branches of engineering, these studies are complex and are made possible by advances in finite element based software's using coupled field algorithms. In the present work, a distributor is facing problem of failure due to unexpected vibration. So cause of vibration need to be explored. In the present study, main concentration is given to flow induced vibration. At the distributor, a gas and fluid are mixing. So a multiphase study is required using fluent software. Later the resulting pressure loads need to be considered for prestressed modal analysis to explore possibility of failure of the distributor by Vibration. Vibration analysis is a complicated iterative study which needs coupling of fluid structural interface loads*. [1]

Keywords: *Stability behavior, physical properties, parametric instability, Vibration instability,*

I. INTRODUCTION

The limiting strengths of materials, commonly used in engineering, have been increased many folds due to the rapid development of technology in the field of material science. This has resulted in the design of slender structures or slender machine components. But the slenderness of these components has forced the technologists to shift their focus from strength aspects towards the stability behaviour of structures.

In the case of beams and plates the nature of external loads destabilizes the structure, whereas in the case of pipes the velocity of fluid in the pipe causes instability. The materials and cross sectional properties of the pipe and physical properties of the fluid are some other additional parameters, which affect the stability behaviour of pipes.

The loss of stability may be of two types: (i) by divergence or (ii) by Vibration. One can visualize the Vibration behaviour of a hose in the garden as the water is allowed to flow through it.

If the in-plane load is time dependent, then the stress field will be temporal as well as spatial in nature and hence develops a state of loss of stability, called parametric instability. Further, there are situations where in loss of stability can take place in dynamic form even though such an element is subjected to static follower forces. This type of instability is called Vibration instability.

The Vibration instability is one of the crucial problems that are encountered in hydroelectric installations, in space structures, in naval vessels. In the present work, the aim of investigation is to examine the Vibration behaviour of isotropic and composite Cantilevered Pipes of Circular/Non-circular sections conveying Ideal/Real Fluids. [3]

II. TERMINOLOGY RELATED TO RESEARCH

2.1 Vibration

Structures are generally subjected to load, which varies with time. In fact, with the possible exception of dead load, no structural load can really be considered as static. However, in many cases the variation of the force is slow enough, which allows the structures to be treated as static. For high-rise buildings subjected to wind and earthquake, off-shore platforms surrounded by waves, aircraft flying through storms, vehicles moving on the road, reciprocating engines, rotors placed on the floor and many other categories of loading, the dynamic effect associated with the load must be accounted for in the proper evaluation of safety, performance and reliability of these systems.[2]

2.2 Mathematical Treatise

If the loading is non-conservative, the loss of stability may not show up by the system going into another equilibrium state but by going into unbounded motion. To encompass this possibility one must consider the dynamic behaviour of the system because stability is essentially a dynamic concept. The instability behaviour can be determined by investigating the motion of a system that occurs due to some initial perturbation. From the nature of the motion of the system one can infer or deny stability. It if turns out that the perturbed motion consists of oscillations of increasing amplitude, or is a rapidly increasing departure from the equilibrium state, the equilibrium is unstable; otherwise it is stable. The practicality of this approach depends crucially on the linearisation of the equations of motion of the perturbation. Tracing the ensemble of time histories for every conceivable dynamic departure from equilibrium would clearly be a computationally forbidding task for a system with many degrees of freedom. Hence, by linearising one can express the perturbation motion as the superposition of complex exponential elementary solutions. The characteristic exponents of these solutions can be determined through a characteristic value problem or eigenproblem. This problem includes the free-vibration natural frequency eigenproblem as particular case when the system is conservative and the tangent stiffness matrix is symmetric. Through the stability criterion, the set of characteristic exponents gives complete information on the linearised stability of the system at the given equilibrium configuration. In practical studies the characteristic exponents are functions of the control parameter λ. Assuming that the system is stable for sufficiently small λ values, say $\lambda = 0$, one is primarily concerned with finding the first occurrence of λ at which the system loses stability. The transition to instability may occur in two different ways, i.e. divergence or Vibration.[2]

2.3 Divergence and Vibration

The structural elements are subjected to a wide variety of static and dynamic loads, including follower forces. These elements may fail in many situations not because of high stresses, surpassing the strength of material, but due to loss of stability. Past research reveals that, under the influence of follower forces, the loss of stability of these elements may be either due to divergence or due to Vibration. If the loss of stability is due to a unidirectional unbounded motion, then it is called failure by divergence. Instead, if the motion is periodic and unbounded then the failure is termed as by Vibration.[8]

2.4 Hydraulic Distributor

A hydraulic manifold is a manifold that regulates fluid flow between pumps and actuators and other components in a hydraulic system. It is like a switchboard in an electrical circuit because it lets the operator control how much fluid flows between which components of a hydraulic machinery. For example, in a backhoe loader a manifold turns on or shuts off or diverts flow to the telescopic arms of the front bucket and the back bucket. The manifold is connected to the levers in the operator's cabin which the operator uses to achieve the desired manifold behaviour. [6]

A manifold is composed of assorted hydraulic valves connected to each other. It is the various combinations of states of these valves that allow complex control behaviour in a manifold.

Type of distributor: 3 way manifold distributor

Purpose : to add certain additional properties to the fluid.

What is multiphase: Where the fluids are not in the same chemical composition?

In this problem, top two accumulators are maintained at same chemical composition and the bottom one is not maintained with same chemical composition. Bottom one is added with certain additives which makes it a multiphase flow.[10]

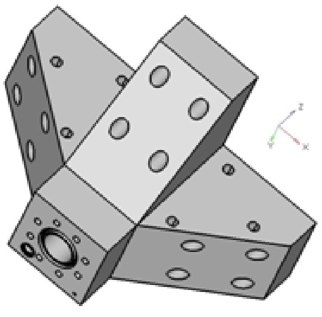
III. PROBLEM DEFINITION AND FINITE ELEMENT MODEL DEVELOPMENT

Problem Definition

Vibration analysis of distributor through CFD and structural analysis is the main definition of the problem. Here the objectives include

- Analysis for Vibration behavior of the distributor

Requirement of analysis: During sudden opening of the distributor main outlet, there is possibility sudden vibration at the end. This may create overall structural behavior of the distributor. This may lead to resonance in the system. So finding the resonant frequency which is linked to flow velocity is important by which Vibration nature of the system can be avoided.[11]



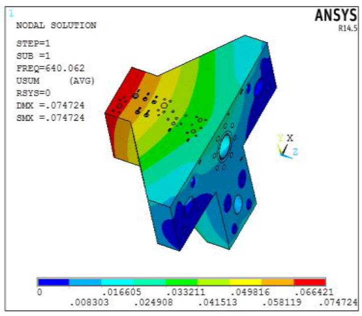


Fig.1 Fig.2 Fig.3

First set of natural frequencies:

1 640.06 1 1 1	6 1709.8 1 6 6
2 922.49 1 2 2	7 2122.7 1 7 7
3 1233.7 1 3 3	8 2202.1 1 8 8
4 1284.0 1 4 4	9 2823.8 1 9 9
5 1613.0 1 5 5	10 2917.3 1 10 10

next set of natural frequencies with higher mass flow:

1 645.06 1 1 1	1 650.01 1 1 1	1 655.02 1 1 1	1 657.45 1 1 1
2 927.49 1 2 2	2 932.65 1 2 2	2 937.32 1 2 2	2 933.56 1 2 2
3 1239.7 1 3 3	3 1246.1 1 3 3	3 1256.2 1 3 3	3 1260.2 1 3 3
4 1288.0 1 4 4	4 1299.8 1 4 4	4 1305.6 1 4 4	4 1313.4 1 4 4
5 1620.0 1 5 5	5 1628.5 1 5 5	5 1635.4 1 5 5	5 1640.3 1 5 5
6 1719.8 1 6 6	6 1729.8 1 6 6	6 1735.3 1 6 6	6 1736.2 1 6 6
7 2130.7 1 7 7	7 2142.6 1 7 7	7 2146.2 1 7 7	7 2148.4 1 7 7
8 2212.1 1 8 8	8 2213.5 1 8 8	8 2216.3 1 8 8	8 2219.2 1 8 8
9 2833.8 1 9 9	9 2840.2 1 9 9	9 2845.9 1 9 9	9 2846.1 1 9 9
10 2927.3 1 10 10	10 2935.6 1 10 10	10 2941.4 1 10 10	10 2952.6 1 10 10

CONCLUSION

The results table, results shows drop in 2nd natural frequency which indicates Vibration will take place in this range. The mass flow rate corresponding to Vibration can be calculated graphically.Finding the Vibration frequency and structural stability during fluid distributor sudden opening condition is achieved by this analysis. So frequency calculation will be done to find Vibration velocity of the fluid for the given distributor. (10)

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