VIBRATION ANALYSIS OF FLUID SUBMERGED BLADES

By

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CERTIFICATE

This is to certify that the thesis entitled "Vibration Analysis of Fluid Submerged Blades" being submitted by Mr. Dhrub Kumar Gupta to the Department of Mechanical Engineering, Indian Institute of Technology, Delhi for the award of the Degree of Doctor of Philosophy in Mechanical Engineering is a record of bonafide research work carried out by him. He has worked under our supervision and guidance and has fulfilled the requirement for the submission of this thesis, which in our opinion has reached the requisite standard.

The results contained in this work has not been submitted in part or in full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

In the design of hydraulic turbine runner blades, the determination of response of submerged structure to a dynamic loading is of considerable interest. The present study evisages the vibration analysis of a Francis turbine runner blade model in-air and underwater. The vibration of turbine runner blade in water is a fluid-structure interaction problem with relatively limited motion and long time duration.

For the turbine runner blades, only a few lowest natural frequencies are of interest and thus an approximate method that determines the lowest natural frequencies with reasonable accuracy using standard numerical techniques would be preferred. The present study aims at the following:

1. Development of an efficient finite element based computational procedure for structural analysis of a doubly curved shell type structure.
2. Development of a finite element based method for the analysis of the interaction of a structure with compressible fluid.
3. Experimental and analytical studies of a turbine runner

blade model for in-air lowest natural frequencies and fluid structure interaction.

The finite element method for the structural analysis uses Ahmad's eight noded superparametric shell element. This element is capable of dealing with thick as well as thin shells.

For the fluid-structure interaction problem, Eulerian-pressure formulation has been employed which considerably reduces the degrees of freedom of the fluid continuum and a multi-step procedure is used for determining the submerged natural frequencies. In the first step, simplification is introduced by using incompressible fluid yielding and added-mass matrix representing the loading effect of the fluid on the structure. In the second step, a secondary added-mass matrix representing the effect of compressibility of fluid is obtained. Mass lumping procedure is employed for the secondary added-mass which eliminates the problem of handling unsymmetric matrices.

The above finite element programs are extensively tested on various test examples for the accuracy of results. The numerical results compare well with those of earlier investigations.

The analysis of a turbine runner blade for in-air and underwater vibration characteristics is carried out using geometric data of a model blade. Boundary conditions similar to the prototype are simulated for laboratory tests of the model blade. The structural analysis program results compare favourably with experimental results. The submerged blade analysis also gives computed results within 4% of the experimental values.

TABLE OF CONTENTS