Aero-elastic Analysis of Turbo-Machine Blade undergoing the Fluid Structure Interaction using Reduced Order Modelling over the Higher Order Finite Element Method

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ABSTRACT

This paper presents the computationally efficient technique to solve the fully coupled fluid-structure interaction (FSI) problem using reduced order modelling (ROM). This method consists forming the ROM system of a FSI problem by projecting the governing equation over the proper orthogonal decomposition (POD) modes. Here we have taken the three dimensional problem of a fluid flow over the blade which acts like a cantilever beam vibrating because of the fluid induced forces. Cross-section of a blade is a standard NACA airfoil which can create considerable amount of lift forces which are in turn responsible for its vibration. This method has given very much close results to the solution obtained from the higher order Finite Element Method (FEM) with very good computational efficiency. The ROM technique involves two steps, first is the construction of POD and next deriving the set of reduced order equations using the Galerkin's projection or Galerkin's approximate solution whose basis are POD mode shapes. The POD modes are constructed using the snapshots obtained from the higher order FEM in ABAQUS. Snapshot is the solution of the problem for small span of time. The high computational efficiency of this method is the direct result of reduction in the degrees of freedom (dof) of the whole system to very few no. of dof (i.e. reduction from 3000 dofs to only 10 dofs). Our future aim is to make this system very flexible which can be incorporated in the commercial software making the simulation processes more time efficient.

Keywords: Fluid-structure interaction, Reduced order modelling, Proper orthogonal decomposition, Higher order finite element method, Aero-elastic analysis

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