Engineering Failure Analysis 18 (2011) 1037–1048

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

# Numerical simulation of the pneumatic elasticity for the blade of a big axial-flow fan

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ARTICLE INFO

*Article history:*
Received 25 October 2009
Received in revised form 27 December 2010
Accepted 29 December 2010
Available online 12 January 2011

*Keywords:*
Fluid–solid coupling
Partitioned but loosely coupled
Numeric simulation
Pneumatic elasticity
Fan blade

ABSTRACT

It is very important to study fluid–solid coupling problems of turbomachines which occur in the large revolving fluid machinery. Especially, the coupling between the fluid and the elastic solid is the most difficult problem in fluid–solid coupling of turbomachines. In order to solve this, the effect of the deformation and vibration of the elastic solid on the flow field and the reaction from the vibrating flow field on the solid need to be considered. The No. 18 axial-flow fan in Beijing's subway is selected as illustration to discuss the computational method for solving the fluid–solid coupling problem by considering the interaction of the blade deformation and the flow field using a numeric simulation analysis of the blade's pneumatic elasticity. The kind of coupling used is partitioned but loosely coupled with the software CFX to describe the flow field and the software ANSYS to describe the reaction of the structure. Both computational results will be shared on the exchanging platform MFX-ANSYS/CFX and compared with the situation where no elastic deformation is considered. It is indicated that the maximum stress including the pneumatic elasticity is twice the maximum stress without the pneumatic elasticity considered. The minimum safety coefficients approximate the permitted safety coefficients with the pneumatic elasticity considered. Contrarily, the actual minimum safety coefficients are far over the permitted safety coefficient, this is not consistent with the real situation and will magnify the safety of the blade structure, which demand the necessity of the pneumatic elastic analysis.



## 1. Introduction

The stability of the blade is related to the safety performance of the machinery directly, which is based on the blade pneumatic load and the occurrence of deformations and vibrations, and has been regarded as a very important issue in the large revolving trubomachines. Taking a large fan, an air compressor, and a pump as examples, a non-stable force will be set on the blade due to the non-stable flow of the working gas and liquid. Therefore, the vibration of the gas–solid coupling and the liquid–solid coupling are the typical features of this kind of problem. In essence, the blade cannot be regarded as a rigid body, but as an elastically deformable body, which needs considering the impact of the elastic deformation and vibration of the blade on the flow field and the reaction to the blade by the flow field. So it is very difficult to study problems of this kind. In order to study the flow field coupling with the blade oscillation (pneumatic elasticity), Wu [1] reduced the blade to be a single particle of the elastic system with damping based on using the discrete vortex method. However, in fact, when a non-stable force is imposed on an elastic structure of the three-dimensional blade, the dynamic response of points on the blade is

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doi:10.1016/j.engfailanal.2010.12.021