EVALUATION OF STRESS CONCENTRATION FACTORS AT THE CUT-OUT OF LOCATING PINS IN A COMPRESSOR FAN DISC

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The design of a disc and blade attachment is of vital consideration in the development of modern-high speed and high performance turbine engines. Although the design problems are established by finite-element method, it is the intent of this paper to describe and to demonstrate its application to the design of a disc and blade attachment.

INTRODUCTION

Manufacturing and assembly constraints have made unavoidable necessity for attaching large compressor blades to the compressor discs, though more efficient devices are in practice for this purpose. These pins need cut-outs in the heavily stressed and tapered rim of a front-stage disc which is subjected to very large hoop stress (σ_h) as well as bending stress (σ_b).

It was observed that the complex stress situation in a three-dimensional model assembly was due to axial component of load which was transferred by the blade having large twist to the disc through pins (Fig. 1). The pins instead of bearing the load uniformly on the internal surface of the circular cut-out tilts about its own axis and alters the existing stress distribution to critical levels (Fig. 2). This mal- distribution is a function of the axial load transferred by the blade, the weight of the blades, the disc sectional geometry and speed of rotation of the disc. Not many publication data is available for evaluating the stress-concentration factors for these cut-outs which reach high values under bird impact conditions. The load transfered by the blade in the plane of the dove-tail root is shown (Fig. 2).

Depending on the slope of the dove-tail root of the disc and the point of bird impacts, the load shared by each of the pins is studied. A finite-element approach is attempted to carry out the exercise on the compressor discs with varying blade centrifugal loads in order to study the influence of all these factors. Three-dimensional photoelastic analysis was carried to assess the stress concentration factor at the cut-outs.

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EXPERIMENTAL INVESTIGATION

In order to establish stress distribution on the aerofoil root of various compressor disc and blade and to evaluate stress-concentration factors in the cut-out of the compressor disc, three-dimensional photoelastic models of the disc and blade was made of special photoelastic material.

The loads on the pins were estimated by using actual photo-elastic blades and equivalent models in which the blade aerofoil was replaced by rectangular blocks of equal weights (Fig. 3).

Full scale model of the disc-blade assembly was stress frozen at one constant speed and stress-freezing of all the disc and blade was carried out in a special stress freezing furnace at a critical temperature of the hot-setting epoxy used (100°C). The cooling rates being of the order of 5° to 10°C/hr.

Conventional slicing method was adopted for the analysis of fringes, with the use of Tardy's compensation method for fractional-fringe measurements wherever required.

EXPERIMENTAL DATA AND DISCUSSION OF RESULTS

The stress distribution around the blade-holding dowel holes is an indicator of the tangential hoop-stress acting at the rim boundary of the disc, and the bending stress at was due to large twist-rate of the blade aerofoil, and due to the aerodynamic loads during spinning. From the analysis it was observed that the stress concentration varied from 2.8 upto 4 for actual epoxy model blade and epoxy equivalent blade (Fig. 4).

REFERENCES

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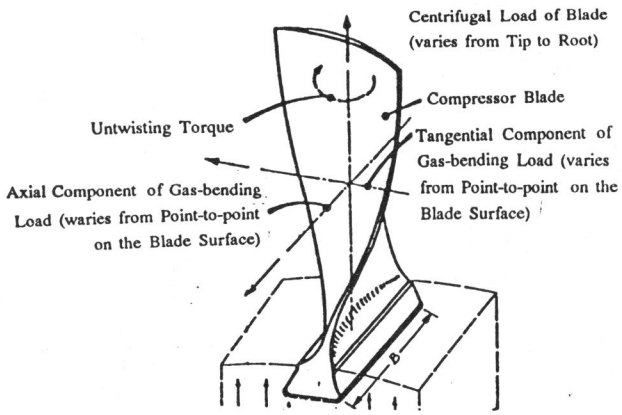
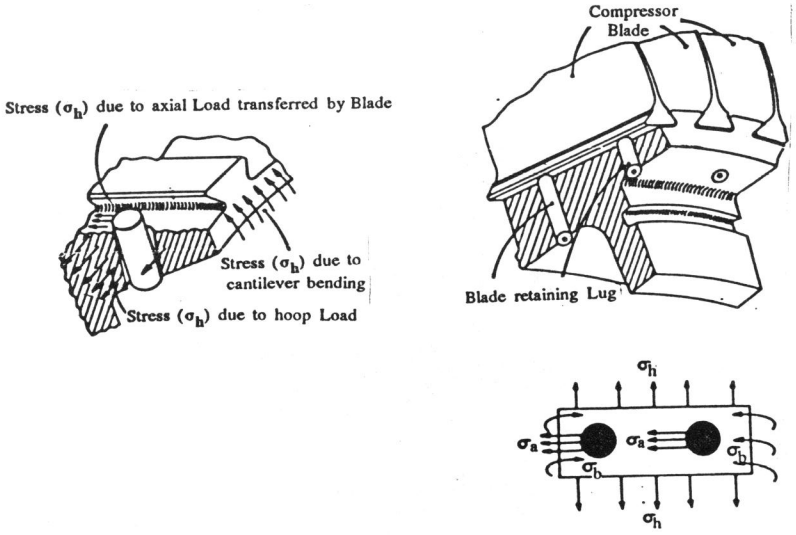
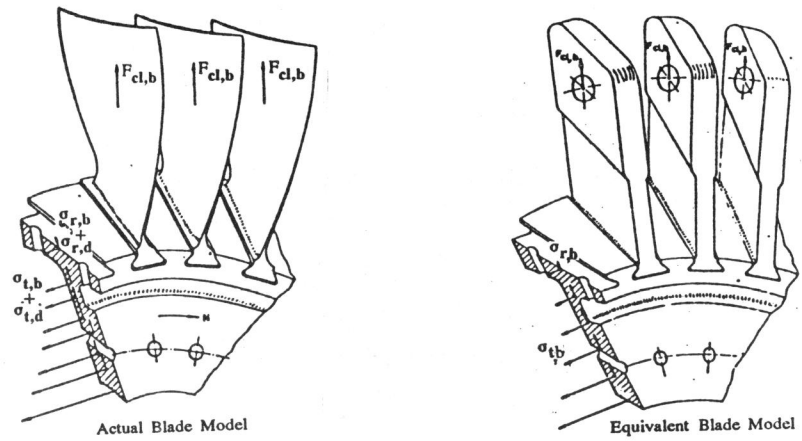


Figure 1 Compressor blade with large twist



Fugure 2 Stresses around dowel holes



$F_{cl,b}$-Centrifugal Load due to Blade
$\sigma_{t,b}$-Tangential Stress due to Blade
$\sigma_{t,d}$-Tangential Stress due to Disc-body Forces
$\sigma_{r,b}$-Radial Stress due to Blade Load
$\sigma_{r,d}$-Radial Stress due to Disc-body Forces
N-Speed of Rotation

Figure 3 Loads acting on rotor-discs

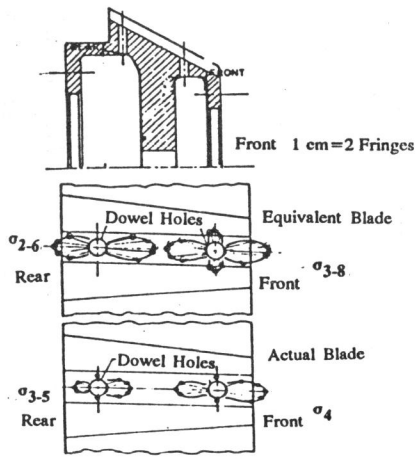


Figure 4 Stress distribution-dowel holes