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Computational technique for weight reduction of aero-engine rotor

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1. Introduction

Stress and failure analysis of Aero-Engine components, especially rotating parts such as blades, discs, shaft of compressor or turbine play a very vital role in the performance of gas turbine engines, as they constitute nearly 30 per cent of overall engine weight. Reduction of disc weight would not only increase the over-all engine thrust-to-weight ratio, but would also have an impact on the weight of the associated supporting structures like shafts, bearings etc. High rotational speed and thermal gradients, across the disc bore and rim, force the bladed disc to operate at high stress levels. There is extensive coverage in literature on the assessment of peak stresses at the dovetail / fir-tree roots and flange bolt-holes (Gayda and Kantzos, 2004). Usage of new materials including those with dual-grain structure, assessment of over-speed and burst-speed margins, usage of advanced finite element methods and experimental validation have been covered in detail in the available literature (1,2,3, & 4).

This paper however gives an overview of the critical rotating structures of compressor spool which were optimized using a general purpose linear optimization program and also highlights additional unique features, specific to the requirements of aero-engines, which were incorporated into the program. The components, which were analyzed and optimized and discussed in this paper with reference to enhancement of the versatility of optimization program, are High Pressure Compressor Rotor (HPC) It has been possible to measure the versatility and use existing linear software quite successfully not only in the area of weight reduction but also in designing feasible components and structures, starting from designs that initially violated critical design constraints

2. Analysis model

Figure 1 indicates the base-line independent disc models of a typical aero engine compressor discs with shape variables to be optimized for weight with necessary design constraints. It represents last three stages and has conventional circumferential dovetail root configuration. Using the base line model, having axi-symmetric boundary conditions imposed on the disc, with objectives to minimize the peak stresses, carried out shape optimization. Shape variables were used as design variables and optimization was carried out at 16000 rpm with elastic properties. The base line geometry consisted of approximately 20,000 grids and 9,000 elements. It was, as expected, subjected to blade centrifugal loads, thermal loads and disc centrifugal loads. Case 1: In case of significant displacement, typically for fan stages (Kemp and Moseson, 1952), a non linear analysis is required. The

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