

Fatigue Life Estimation of Compressor Blade of Engine

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ABSTRACT: This paper summarizes the design and analysis of compressor blade, Pro-E is used for design of solid model and ANSYS software for analysis for model generated, by applying boundary condition, also includes specific post processing and life assessment of blade. How the program makes effective use of the ANSYS pre-processor to mesh complex compressor blade geometries and apply boundary conditions. And to demonstrate the pre-processing capabilities, static analyses results. This project specifies how the program makes effective use of the ANSYS pre-processor to analyze the compressor blade geometries and apply boundary conditions to examine steady state structural performance of the blade for La₂Zr₂O₇ (Lanthanum zirconium oxide), Titanium Alloy & AlSi (Aluminum Silicate) materials. Finally stating the best suited material among the three from the report generated after analysis.

KEYWORDS: Design, Pro-E, Compressor blade, Ansys.

I. INTRODUCTION

The compressor obtains its power by utilizing the energy and the air which is at high temperature and pressure by expanding through the several rings of fixed and moving blades, to get a high pressure of working fluid which is essential for expansion a compressor is required. The quantity of working fluid and speed required are more, so generally a centrifugal or axial compressor is required. If after compression the working fluid were to be expanded, then assuming that there were no losses in either component, the power developed by the compressor can be increased by increasing the volume of working fluid at constant pressure or alternatively increasing the pressure at constant volume. To acquire a higher temperature of the working fluid a chamber is essential. In each type the fast moving exhaust gas is used to spin compressor at the front of the engine, and the compressor may extract just enough energy. The rest of the exhaust gas is left to exit the rear of the engine to provide thrust as in a pure jet engine.

This paper deals with the first type is centrifugal stresses that act on the blade due to high angular speeds. The analysis of compressor blade mainly consists of the following two parts: Structural. The analysis is carried out under steady state conditions using Ansys software. The study has been conducted with three different materials i.e. La₂Zr₂O₇ (Lanthanum zirconium oxide), Titanium Alloy & AlSi (Aluminum Silicate).

II. LITERATURE REVIEW

Le- Chung shiau and Teng- Yuan Wa (1), 1997 studied the free vibration behavior of buckled composite plates by using finite element method. Unlike beams or columns, plates can carry a much-increased load after buckling without failure. Here triangular plate element is taken for finite element analysis. This element is developed based on a simplified high order plate theory and large deformation assumptions. The nonlinear governing equations of motion for plates are linearized into two sets of equations by assuming small amplitude vibration of the laminates about its buckled static equilibrium profile. In the post buckling region, the buckled plate may shift from one buckling mode to another. Due to this buckle pattern change, plate is also suddenly changed which in turn makes the natural frequencies of the

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plate to have sudden jump. The buckling mode of plates shifted from first to second. Then the stiffness of the plate is increased which makes a sudden increase in natural frequencies.

Hu.X.X and Tsuigi.T (2), 1999 had done free vibration analysis on curved and twisted cylindrical thin panels. Blades are part of turbo machinery rotating at high speed, so it is important to ensure safety while rotating. A turbo machinery blade is treated as a cylindrical thin panel twist, chord wise and span wise curvatures along lengthwise direction. The non-linear strain- displacement relations of the model are derived based on the general thin shell theory and a numerical method for analyzing the free vibrations of curved and twisted cylindrical thin panels is presented by means of the principle of virtual work for the free vibration using Raleigh-Ritz method. It is shown that the method is effective for analyzing the free vibrations of the turbo machinery blades, and can provide accurate results when the proper number of integrating points and terms of displacement functions are adopted. The effects of curvature and twist on the vibrations are studied. This method is adequate for evaluating the vibration characteristics even if the models have large curvatures and large twists.

Rao J.S (3), 1974 made a two-dimensional analysis of free vibrations in the tangential direction. The first step is to develop the potential and kinetic energies for the tangential motion of the blades and shrouds. Second, Hamilton's principle is applied to derive the differential equation of motion and the boundary conditions.

Tsuiji and Sueoka (4), 1990 deal with the free vibration of cylindrical panels by using Raleigh- Ritz method. Blades of turbo machinery are twisted in axial direction and cambered in the chord wise direction. The blade has been idealized to a twisted cantilevered cylindrical panel and numerical methods have investigated its vibratory characteristics. The convergence of frequency parameters is studied with the increase of number of strip and of terms in assumed solution functions. To demonstrates the usefulness of the method, the frequency parameters obtained.

Leissa, MacBain and Kielb (5), 1984 made a comprehensive study of the numerous previous investigations on the free vibration of twisted cantilever plates of rectangular platform which are results of a joint industry, government and university effort. Theoretical results received from different FEM programs utilizing shell theory and beam theory were compared with two independent sets of data obtained from experiments.

III. COMPUTER AIDED ANALYSIS OF COMPRESSOR BLADE

The model is formed and analyzed using Pro-E and ANSYS. For automatic mesh generation and node selection is used. The structural, thermal modal modules of ANSYS 11.0 are used for the analysis of the compressor blade. The compressor blade was analyzed for mechanical stresses, t combined mechanical stresses and radial elongations, natural frequencies and mode shapes. The blade is then analyzed with structural analysis.



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3.1 Details of Compressor blade:



IV. RESULTS AND DISCUSSIONS:

Properties of material:

Properties	Suggested La ₂ Zr ₂ O ₇ (Lanthanum oxide)	Material zirconium	Titanium Alloy	AlSi (Aluminum Silicate)
Young's Modulus (Pa)	1.75E+11		9.60E+10	7.10E+10
Poisson's Ratio	0.2		0.36	0.33
Density (Kg/m ³)	5740		4620	2770
Thermal Expansion (1/°C)	9.10E-06		9.40E-06	2.30E-05

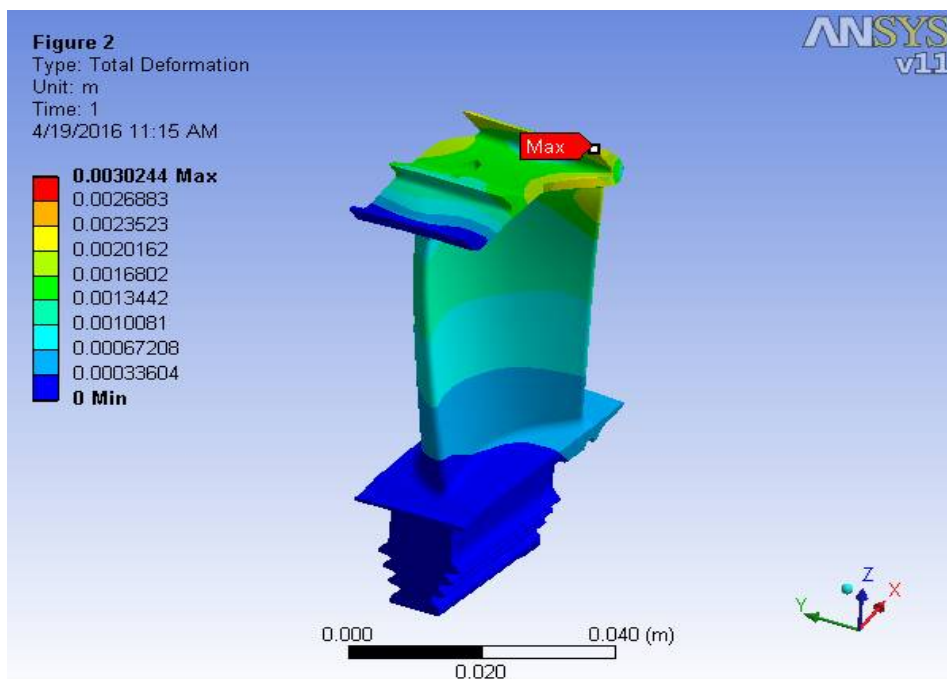
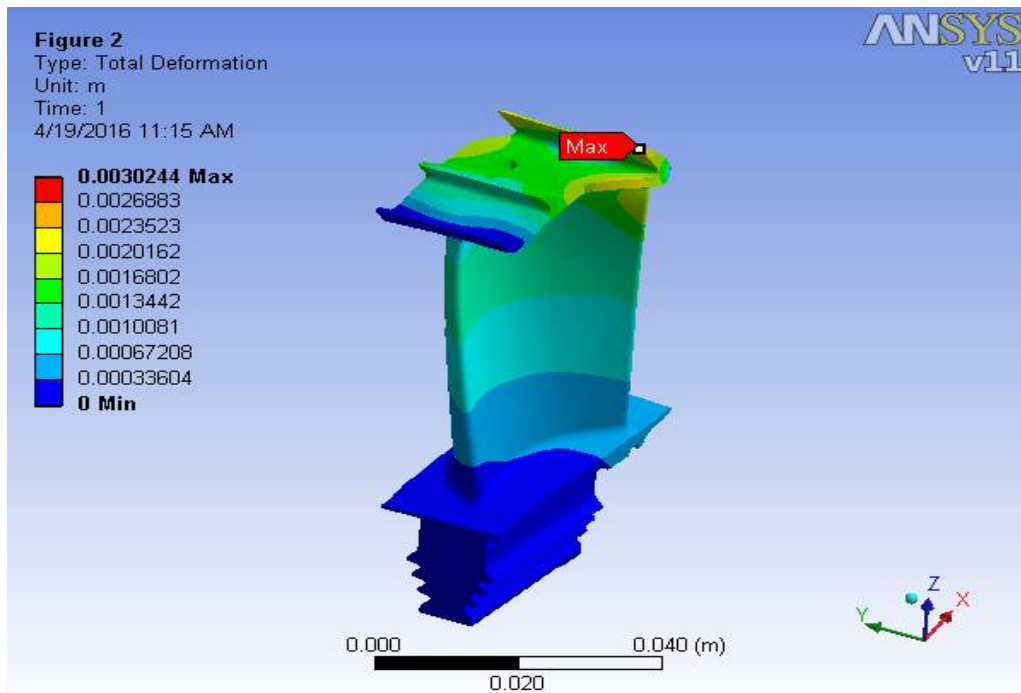


Figure Total deformation in the blade geometry

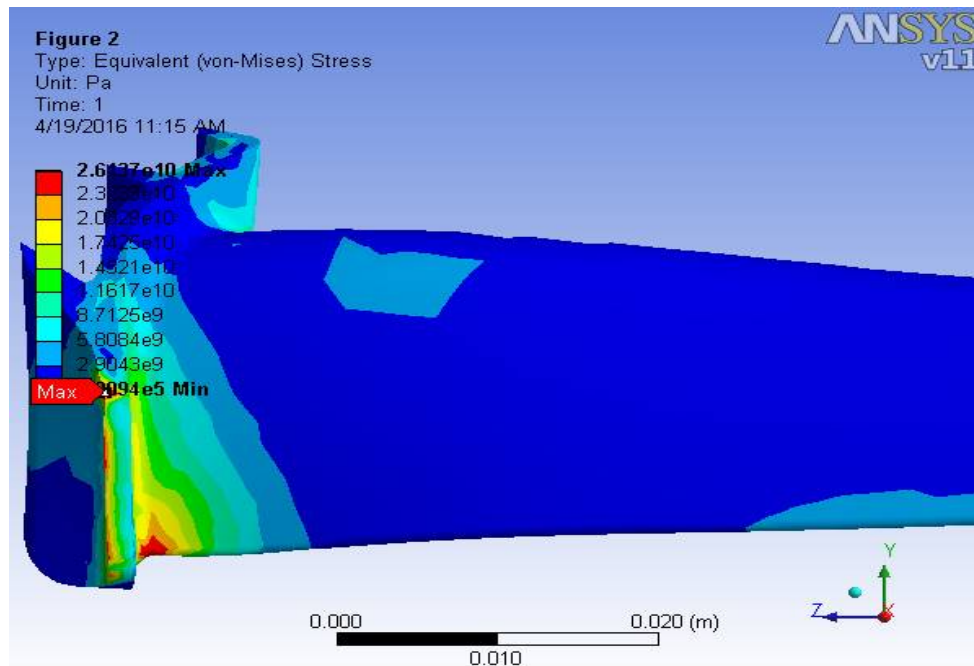


Figure 4.1 Equivalent stress in the blade geometry

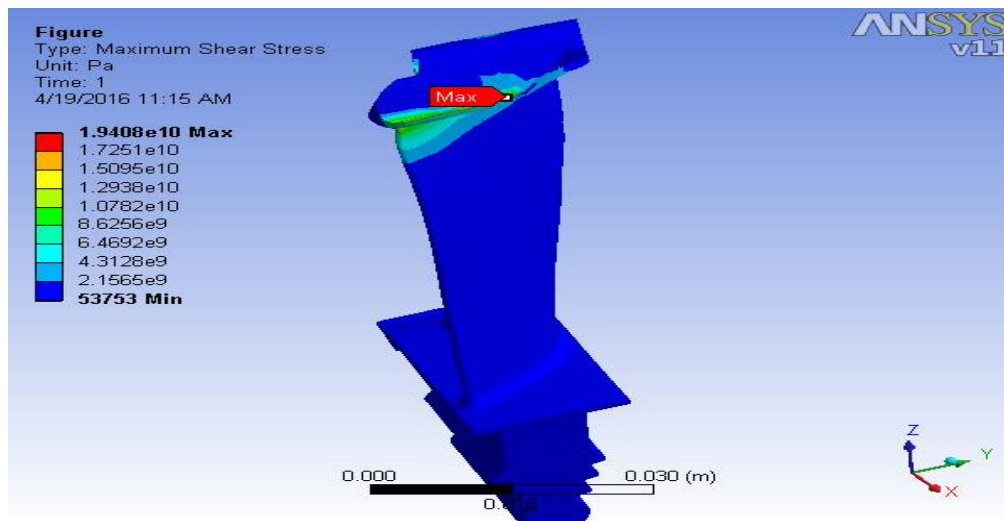


Figure Maximum shear stress stress in the blade geometry

From the post processing, the stress and deformation variation obtained as shown in fig. From figure, it is observed that the stress and deformation variations from leading edge to the trailing edge on the blade profile are varying throughout the blade and the variation is linear along the path from both inside and outside of the blade. These structural analysis done for the same three material as mentioned above with properties. The results are obtained from the free standing stati

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	Suggested La ₂ Zr ₂ O ₇ zirconiumoxide)	Material (Lanthanum Titanium Alloy	AlSi Silicate) (Aluminium
Total Deformation (mm)	3.5358	6.2710	7.4681
Equivalent Stress (Pa)	17.5699	17.6048	18.0377
Maximum Shear Stress (Pa)	15.2756	13.7596	14.3450

V. CONCLUSION

In this paper, analyzed designs of the compressor blade to do further optimization, Finite element results for free standing blades give a complete image of structural characteristics, which can utilized for the improvement in the design and the operating conditions. These analysis process of blade it obtained that the most suitable material for blade is Lanthanum Zirconium oxide.

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