Optimization (Geometrical/Material) of GAS Turbine Rotor Blade and Fatigue Analysis by Using FEA

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Abstract
Gas turbine is asignificant functional part of many applications. Dropping the stresses and raising the fatigue life is the mainapprehension since they are in high temperature environment. Various methods have been anticipated for the augment of fatigue life and one such procedure is to have axial holes along the blade span. Finite element analysis is used to analyze thermal and structural performance due to the loading condition with material properties of N155, NIMONIC 80A & INCONEL 600.We are analyzed to find out the most favourable number of holes for good presentation. Counter plots for stresses for design 7 holes and for fatigue sensitivity it is found that when the number of holes of the blades is increased the stresses are concentrated and no. of cycles is increased. Thus the blade configuration with 7 holes of 2mm size is found to be optimum solution. This plandenotes how the program makes efficient use of the ANSYS workbench pre-processor to study the multifaceted turbine blade geometries and applies boundary conditions to scrutinize steady state thermal & structural coupled field analysis performance of the blade with geometrical optimization for N155, NIMONIC 80A & INCONEL 600 materials.

Keywords
Fatigue Analysis, Gas Turbine Rotor Blade, FEA, Geometrical/ Material Optimization

I. Introduction

Turbo machine rotor blades are subjected to dissimilar types of loading such as fluid or gas forces, inertia loads and centrifugal forces. Due to these forces a variety of stresses are encouraged in the rotor blades. So stress and strain mapping on rotor blade supplyvery important information regarding the turbo machine propose and lead to the detection of critical blade section. Analysis of static and dynamic behaviour of a rotor blade is a basic problem in aero elasticity of turbo machine blades. The present paper pacts with the stress scrutiny of a typical blade made up of nickel super alloy which is subjected to centrifugal loading. The study results show that stress is severed due to centrifugal forces evaluated that due to dynamic gas forces. Here in this case the effect of thickness, twist and taper of the blade was considered as the root of the blade where generally failure is occurring. The various blade shapes viz. Rectangular, argues with some angle twist, taper aerofoil are taken into consideration. In this paper linear static analysis for determining von-Moses stresses, deformation in Z direction was resolute using Finite element analysis software. The Solid brick 20-node element is used.

II. Related Work

Interms of maintained requirements, manufacturing difficulties and costs, the blades are the most critical item of the today gas turbines. These components are manufactured by some nickel and cobalt based alloy able to withstand to high temperature and mechanical stresses have undertaken several improvements aimed to increase the overall performance and the useful life. Failure analysis, chemical and metallurgical analysis, thermal and stress analysis, design review and proposed solutions are taken into the consideration's purpose of this upgrading package is to move the turbine first stage blades and vanes as much as close to the level of the other turbine stages which have already achieved an outstanding performance in terms of reliability and scrap rate. Naeem et al. carried out the failure analysis of gas turbine blades made of nickel-base alloy in two discrete sections they are Mechanical and Metallurgical By using Ansys workbench software and metallurgical investigation was carried out by using visual examination. Dhopade and Neely investigated the effects of low cycle and the effects of high cycle fatigue interaction on the aerodynamic and structural behaviour of a blade. A numerically based analysis through the interaction of CFD and FEM referred to Fluid- structure interaction.

III. Exisiting Method

Traditional methods of engineering scrutiny while endeavour to resolve an engineering problem mathematically always try for simplified formulation in order to surmount the various difficulties involved in the exact mathematical formulation.

Disadvantages

In the recenttechnicalbackground the conventional methodology of intend cannot contend with the modern trends of Computer Aided Engineering (CAE) techniques. The constant search for new innovative design in the engineering field is a common trend.

IV. Proposed Method

The Finite Element Method (FEM) has now turned out to beanextremely important tool for engineering analysis. Its adaptability is replicated in its regardbetween engineers and designers belonging to almost all the engineering disciplines. The method is being used for the study of structures/solids of compound shapes and complex boundary conditions.

Advantages

To establish thermal stresses due to high temperature incline and to maximum stress provoked in blades.To settle on the temperature distribution along with the blade profile and to determine the parameters this manipulates the stress concentration in the rotor blades.

V. System Architecture

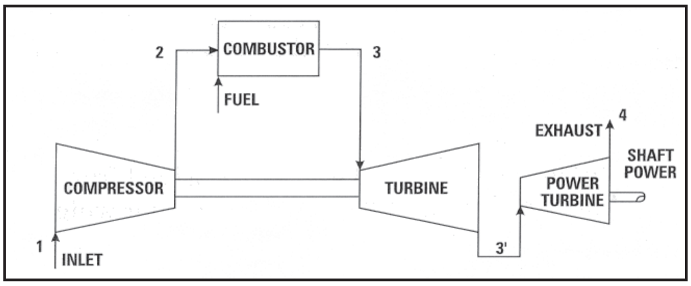

Fig. 1:

A gas turbine is an engine where fuel is incessantly burnt with compressed air to create a stream of hot, fast moving gas. This gas stream is used to power the compressor that provides the air to the engine as well as providing excess energy that may be used to do other work.The engine consists of three main parts. The Compressor, Combustor and Turbine compressor typically sit at the front of the engine. There are two main types of compressor, the centrifugal compressor and the axial compressor. The compressor will draw in air and squeeze it before it is nourish into the combustion chamber. In both types the compressor rotates and it is driven by a shaft that passes during the middle of the engine and is attached to the turbine as shown.

VI. Impulse Turbine

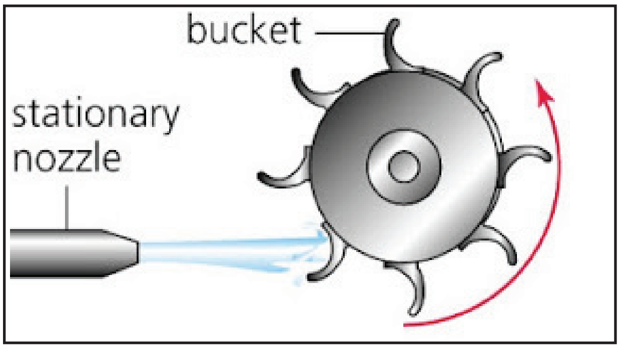

Fig. 2:

In the impulse turbine steam is stretched in the fixed nozzle only. In the nozzle the rapidity of steam augments with reduce of pressure. As the steam passes over the blades the pressure relicssteady with a decrease of velocity. As the high velocity steam imposes against the blades it changes the momentum of jet causing impetuous force on the blades. The wheel is thus made to turn in a definite direction. Here the kinetic energy is converted into mechanical work only by one set of blades.

VII. Stress Life Method

Stress life or S-N method was the first method used for fatigue computation. It was the standard Fatigue design method for 100 years before developments of other methods like Strain life and LEFM.Easy to use and simple approach based on S-N Curve also known as Wohier diagram i.e. alternating stress's versus No. of cycles 'N'. The curve is produced by conducting rotating bending test constant amplitude, uniaxial loading. Work very well for high cycle fatigue stress within elastic limit.

A. CATIA

CATIA is one of the world's leading high-end CAD/CAM/CAE software packages. CATIA computer aided three dimensional interactive application is a multi-platform PLM/CAD/CAM/CAE commercial software suite developed by Dassault systems and marketed worldwide by IBM. CATIA is written in the C++ programming language. CATIA endow with open development, architecture through the use of interfaces which can be used to modify or expand applications. The applications in programming interface supported visual basic and C++ programming languages. In CATIA V5 solid models are created by integrating a number of building blocks is called features.

B. ANSYS

It expands general-purpose finite element analysis and computational fluid dynamics software. While ANSYS has developed a range of computer-aided engineering (CAE) products it is possibly best known for its ANSYS Mechanical and ANSYS Multi-physics products.ANSYS Mechanical and ANSYS Multi--physics software are non-exportable analysis tools incorporating pre-processing (geometry creation, meshing), solver and post-processing modules in a graphical user interface.

VIII. Procedure Involved

Software: CATIA V5 R19.
Step 1: Click Start in Menu bar > Mechanical Design > Sketcher.
Step 2: Select XY Sketch plane.
Step 3: Take the geometric coordinates to construct rectangle.
Step 4: Select the sketcher
Step 5: Convert the XY plane into 3D work bench and pad the surface.
Step 6: Select the surface of the rectangle and plot the geometric coordinates by the sketcher.
Step 7: Draw the sketch of a profile with the key points shown in the reference.
Step 8: Go the work bench and pad the profile thickness up to 117mm.
Step 9: Select the top surface of the profile and go to sketcher.
Step 10: Holes are plotted on the profile by using user-defined pattern command.
Step 11: Blade drawing profile sheet modeling is done by using the design software CATIA V5 R19 is obtained by the help of catia tools 3D modeling.

IX. Results

A. Geometry Without and Holes

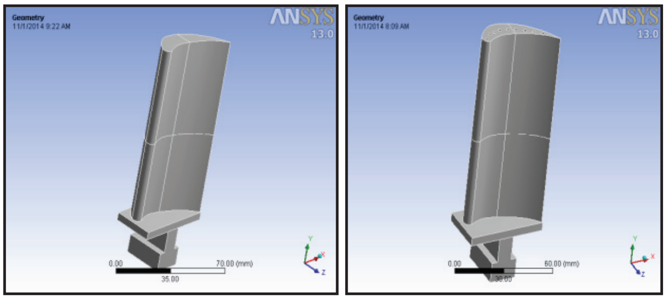

Fig. 2:

B. Steady-State Thermal Without and Holes

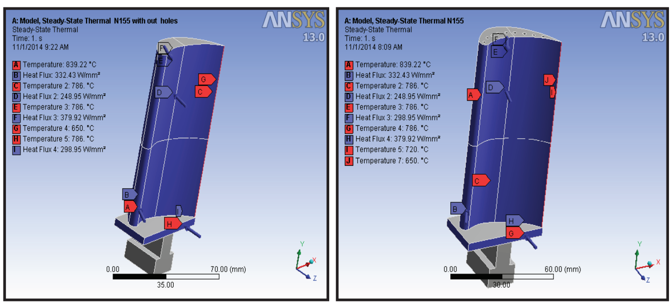

Fig. 3:

X. Conclusion

A sequence of variables describes the geometry of the tip area and characterizes the space of possible designs which has to be examined in order to find the most favourable configuration of the system. Results are plotted for the existing design it is found

 ISSN : 2249-5762 (Online) | ISSN : 2249-5770 (Print)

that when the number of holes of the blades is augmented the stresses are abridged and number of cycles are increased. Thus the blade configuration with holes, sizes and materials are found to be abest solution.By analyzed the previous designs and generals of turbine blade to do further optimizationfinite element results for free standing blades give a absolute picture of structural characteristics which can make use for the development in the design and optimization of the operating conditions. Study on different materials which are suitable for the improvement of turbine blade.

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