Design, Stress Analysis of low Pressure Steam Turbine Blade

Suhas V. Kale
Department of Mechanical engineering
Priyadarshini Bhagwati college of engineering
Nagpur

Sandip G. Ghugal
Department of Mechanical engineering
Priyadarshini Bhagwati college of engineering
Nagpur

Saroj V. Borkar
Department of Mechanical engineering
Priyadarshini Bhagwati college of engineering
Nagpur

***Abstract*— Recently , the importance of mechanical drive steam turbine efficiency has been much highlighted in addition its reliability with drastic increase in fuel In this paper addresses the issue of steam turbine efficiency by discussing the overhaul design of low pressure steam turbine blades. A specific focus on blade profile, material used in the production of steam turbine blades, and the factors that cause turbine blade failure and therefore the failure of the turbine itself. This project enumerates design of airfoil shape of steam turbine blade , Stresses due to thermal and dynamic loads of low Pressure Steam Turbine blade of 210 MW power stations analyzed in two stages. In first stage a three dimensional model of turbine blade was prepared in CRE 2.0. This model will import in ANSYS-14.5 for Finite Element Analysis. Maximum stress and stress distribution is compute using Finite Element Analysis (FEA) at the corresponding section.**

Keywords—CAD , FEM, Steam turbine blade

INTRODUCTION

Steam turbines are major prime movers in thermal power stations. The main parts of simple impulse steam turbine are rotor, blades and nozzles. Blade is a major component of the turbine, which receives the impulse directly from the steam jet and converts this force into the driving force. Turbine blade is exposed to various loads such as thermal, inertia, and bending and may fail due to different factors like Stress-Corrosion Cracking, High-Cycle Fatigue, Corrosion-Fatigue Cracking, Temperature Creep Rupture, Low-Cycle Fatigue, corrosion etc.

The software offers a comprehensive range of stress analysis and other capabilities in an integrated package for such large-scale, complex problems. An integrated infrastructure, ANSYS Parametric Design Language customization capabilities and non linear simulation with contact plasticity work together to provide powerful simulation capabilities for this type of application. Key dimensions of the blade root were modified using ANSYS parametric Design Language (APDL) capabilities, with ANSYS Mechanical software analyzing the various combinations of parameters. In this way, engineers evaluated the sensitivity of the design to the geometric modifications in reducing the stress concentration factor (SCF).

COMPUTER AIDED DESIGN

CAD has, in recent years, become an important and widely used technology. CAD systems have the potential to improve design quality, cut design costs, and shorten the development time of new products .Companies have invested large amounts in the systems and are becoming very dependent on CAD technology for the development of new products yet the effective application of CAD technology has proven to be a difficult task in many companies. Many managers feel that CAD systems have not delivered the benefits expected of them. The results of years of CAD research show mixed and inconclusive results, Even when CAD technology is applied in ways that produce ostensible gains, these gains may not translate into overall improvements in product development effectiveness. The mixed results, reported by both researcher and practitioners, can be attributed to widely varying perceptions of the technology and its capabilities. These perceptions affect how CAD technology is applied, and will thus affect the benefits received from the technology.

CAD MODEL PART MODELLING:

The CREO modeling was carried out using the 2 D drawing provided by C.P.R.I, Nagpur. The various options used for modeling are discussed in brief as below:

Starting Out in Part Mode--Describes how to start creating a part with Pro/ENGINEER.

Sketcher--Describes how to create sketches in a stand-alone Sketcher mode.

Datum's--Describes how to create datum features: datum planes, datum points, datum curves, datum axes, coordinates features, graphs, evaluate features.

Sketching on a Model--Describes how to create 3-D sections in the process of feature creation.

Feature Creation Basics--Describes how to create extruded and revolved protrusions.

Sweeps, Blends, and Advanced Features--Describes how to create sweeps, blends, and advanced features.

Construction Features-- Describes how to create construction of features such as holes, slots, and cuts.

Rounds--Describes how to add rounds to part geometry Tweak Features--Describes how to create tweak features, such as draft, local push, and section dome. The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

STRESSES IN STEAM TURBINE BLADE

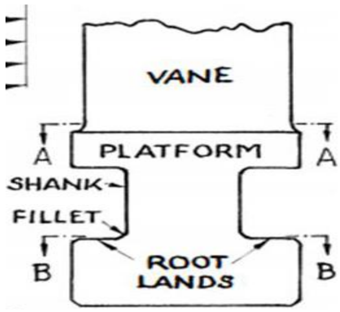
Steam turbines operate at similar speeds, usually in the range of 3000-3600 rpm for fossil-fired plants and 1500-1800 rpm for nuclear-powered plants. Because the speeds are similar, the stresses in the turbine blades, which arise because of their movement, are also similar. The first main categories of stresses that the blades experience are: 1) Static stresses, consisting of centrifugal stresses, stress due to steam loads, and steam loads, and 2) Dynamic stresses, due to non-uniform steam flow and synchronous resonance of the blade with the operating speed of the turbine. The second category of stress acting on the blade is thermal stress that may arise because of substantial temperature gradient within the blade that may be caused by high intensity thermal cooling. However, the majority of blade stresses are due to centrifugal Abbreviations and Acronyms

A. Material of steam turbine blade

The selection of materials for steam turbines is very competitive and an important factor in the overall cost. Generally shafts of these steam turbines are manufactured from either rolled bars or forging. The materials that are used for these steam turbines are different types of steels such as stainless steel and alloy steels like12% Chromium steel and 2NiCrMoV steel. Choosing the optimum blade material is an ongoing tradeoff between desirable material properties. In addition, it is important that blading material be weldable, particularly last-stage LP blading, as many designs require that cover bands, tie-wires, and erosion shields be attached by thermal joining.

B. Blade Root Geometry and Load Transfer

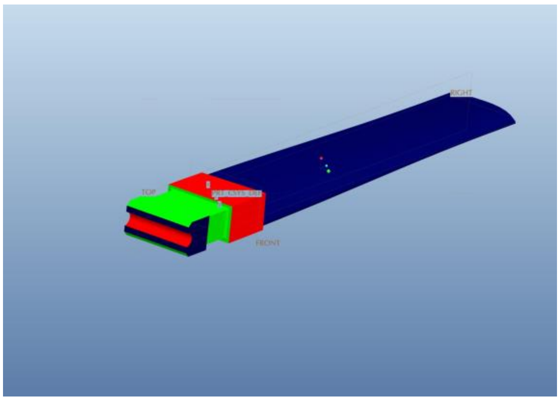
The blade forces, centrifugal forces (radial) and into axial and circumferential bending forces. For the consideration of stiffness effects of both the rotor (drum or disc) and the blade root, the reduction of the bending force into its axial and circumferential component is required.



The blade forces, centrifugal forces (radial) and into axial and circumferential bending forces. For the consideration of stiffness effects of both the rotor (drum or disc) and the blade root, the reduction of the bending force into its axial and circumferential component is required.

MODELLING OF STEAM TURBINE BLADE

Modeling is nothing but the design of any product or element by consideration of parameters which will be previously used. As per the input drawings of low Pressure (HP) turbine blade received from CPRI, complete modeling was done using CREO modeling

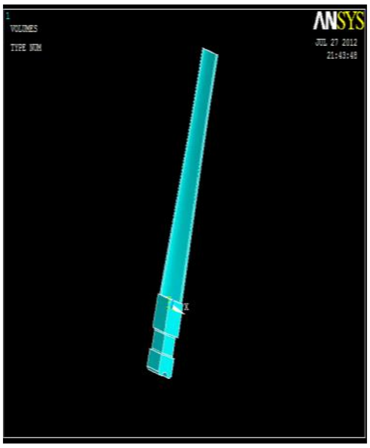


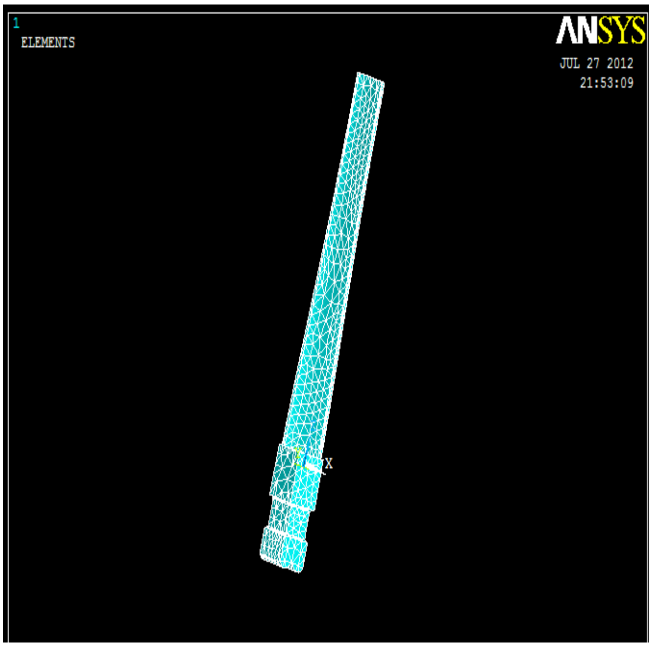
FINITE ELEMENT ANALYSIS

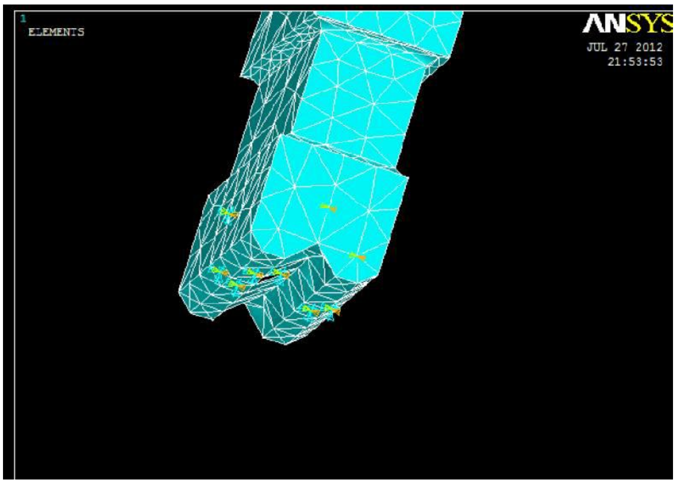
The intention of the FE analysis was to determine the stress and Fatigue life of the components at the critical location of the blade. It has been found out that the critical location of the blade is situated at the T root of the blade. More precisely, at the convex side of the neck. However, it is required to assess the fatigue life of the whole blade-disc connection. For the purpose of simple solving and solution time in ANSYS the 3D model of blade is simplified by removing the tenon on the blade

Finite element modelling of any solid component consists of geometry generation, applying material properties, meshing the component, defining the boundary constraints, And applying the proper load type. These steps will lead to the stresses and displacements in the component. In this work, similar analysis procedures were performed for steam turbine

- Finite element modeling using ANSYS 11
- Mesh generation
- Boundary condition (structural)







RESULTS & CONCLUSION

The results and conclusions are presented for a study concerning the durability problems experienced with steam turbine blades Existing blade design is good enough for stresses in theoretical calculation. But there is a problem in finite element analysis. In theoretical calculation blade model is getting infinite life . but during the Ansys analysis there is problem at the root of the blade .

REFERENCES

[1] Subramanian Pavuluri, Dr.A.Siva Kumar, "Experimental Investigation on Design of High Pressure Steam Turbine Blade" International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET) ISSN: 2319-8753, Vol. 2, Issue 5, May 2013, pp:1469-1476.

[2] Rao, J.S., 1974 "Application of variational principle to shrouded turbine blades", Proceedings of 19th cong, ISTAM. pp. 93-97.

[3] Leissa, A.W., Macbain, J.C., and Keilb, R.E., 1984, "Vibration of twisted cantilever plates summary of provisions. Current studies", Journal of Sound and Vibration, vol. 96(20), pp. 159-167.

[4] Tsuneo Tsuiji, Teisuke Sueoka, 1990, "Vibrational analysis of twisted thin cylindrical panels by using Raleigh-Ritz method", JSME International Journal, Series iii, vol. 33, pp. 501-505.

[5] Le-Chung Shiau. Teng – Yuan Wu., October 1997, " Free Vibration of bucked laminated plates by finite element method", Transactions of the ASME, Journal of Vibrations and Acoustics, vol. 111, pp. 635-644.

[6] Hu, XX., and Tsuiji, T., Jan 7, 1999, "Free Vibrational analysis of curved and twisted cylindrical thin panels", Journal of sound and vibration, vol 219 (1). pp. 63-68.

[7] Yoo, H.H., Kwak, J.Y., and Chung, J., Mar 2001, "Vibrational analysis of rotating pre twisted blades with a concentrated mass", Journal of sound and vibration, vol 240(5), pp.891-908.

[8] Park, Jung –Youg., Jung, Yong-Keun., Park, Jong-Jin., Kang, Young-Ho., 2001, "Dynamic analysis method for prevention of failure in the 1st stage low pressure turbine blade with 2 fingers root". Proceeding of SPIE – the international Society for Optical Engineering, vol 4537, pp. 209-212.

[9] Shah, A.H., Ramsekhar, G.S., and Desai, Y.M., 2002, "Natural vibrations of laminated composite beams by using fixed finite element modeling", Journal of sound and vibration, vol. 257, pp. 635-651.

[10] Rao, J.S., 1993, "Life estimation of turbine blades", B.H.E.L (R&D), vol. 14-16, pp. 1-11