International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 763-767

Thermal Analysis of Steam Turbine Blade

Pramod Kale[1, a *], Soham Deshkhaire[2, b], Shubham Gurjar[3, c] ,Indrajeet Sadamate[4, d], Prathamesh Yadav[5, e]
Production Engineering Department, Vishwakarma Institute of Technology, Pune, India
[a] Pramod.kale@vit.edu[*], [b] soham.deshkhaire20@vit.edu, [c] shubham.gurjar20@vit.edu, [d] indrajeet.sadamate20@vit.edu, [e] prathamesh.yadav20@vit.edu

Abstract- *The thermal analysis of steam turbine blades is an important aspect of turbine design and performance evaluation. This analysis involves the investigation of heat transfer and temperature distribution within the blade as a result of the operating conditions and the fluid flow. In this study, a numerical approach is used to simulate the thermal behavior of a steam turbine blade. The analysis is performed using finite element analysis (FEA) to solve the governing equations of fluid flow and heat transfer. The results of the simulation provide insight into the thermal behavior of the blade, including temperature distribution, heat transfer coefficient, and heat flux. The findings can be used to optimize the design of the steam turbine blade and improve its efficiency.*
Keywords – *Thermal analysis, Heat transfer, Heat flux*

Date of Submission: 14-05-2023 Date of acceptance: 26-05-2023

I. INTRODUCTION

Steam turbines are widely used in various industries, including power generation, oil and gas, and chemical processing. They are highly efficient and can convert thermal energy into mechanical energy to generate electricity or drive other equipment. However, the high temperature and pressure conditions within the turbine can cause thermal stresses and deformation in the blades, which can lead to reduced performance and even catastrophic failure. Therefore, it is important to understand the thermal behavior of steam turbine blades to optimize their design and ensure their safe operation.

Thermal analysis of steam turbine blades involves the investigation of the heat transfer and temperature distribution within the blade under different operating conditions. The analysis can be performed using numerical methods, such as finite element analysis (FEA), which enable the simulation of the fluid flow and heat transfer within the blade. The result of the analysis can provide valuable insights into the thermal behavior of the blade, including the temperature distribution, heat transfer coefficient and heat flux.

In this paper, we will present a study on the thermal analysis of a steam turbine blade using FEA. The objective of this study is to investigate the thermal behavior of the blade under different operating conditions and to identify the factors that affect its performance. The findings of this study can be used to optimize the design of the steam turbine blade and improve its efficiency, reliability and safety

II. METHODOLOGY

Material selection based on the specific requirements of the steam turbine blade. Considering factors such as thermal conductivity (to ensure efficient heat transfer), mechanical strength (to withstand operational loads), and compatibility with the working fluid (to prevent corrosion or erosion).

Identifying potential aluminum alloys that meet the defined criteria and after consulting material databases, research papers, and industry standards aluminum alloy was shortlisted for their thermal conductivity, strength, and corrosion resistance.

Proposing thermal properties of the selected aluminum alloy, including thermal conductivity, specific heat capacity, and thermal expansion coefficient.

The thermal analysis of steam turbine blades is typically carried out using a numerical approach, we have used Solidworks to design the model of a turbine blade and then exporting the model, thermal analysis was performed using ANSYS.

method to generate a fine mesh for our model of steam turbine blade. The details of the mesh are as follows:

TABLE I

Element Order:	Quadratic
Element Size:	1.8 mm
Nodes:	77591
Elements:	21961

As general boundary conditions, fixed support was applied at the shank or the root of the turbine blade. Further we applied rotational velocity to the X axis as 500 radians per second (fig.1) at the shank keeping its Y and Z axis fixed.

To obtain precise results we used the Hex-dominant

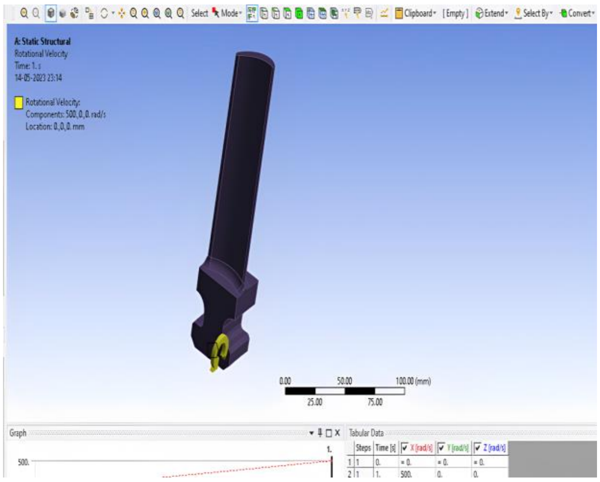

Fig . 1

To be precise with the results, the external factors such as stresses and total deformation affecting the study were analyzed using static structural analysis.

In Steady State Thermal Analysis, we applied boundary conditions in the way given in the table below:

TABLE II

Boundary Conditions	Geometry	Magnitude
Initial Temperature	All bodies	22°C
Temperature (fig.3)	Face	229°C
Convection (fig.2)	Face	$2.5*10^{-3}$W/mm^2 °C
Temperature 2 (fig.4)	All bodies (external faces only)	22°C+00

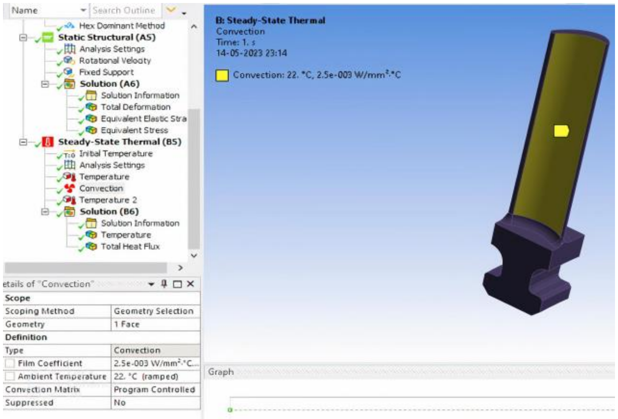

Fig . 2

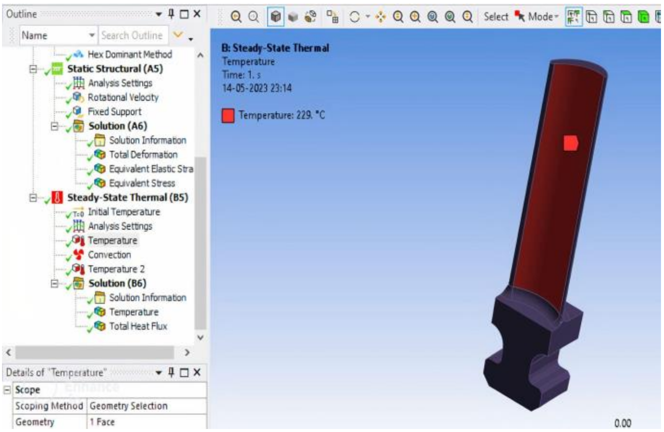

Fig . 3

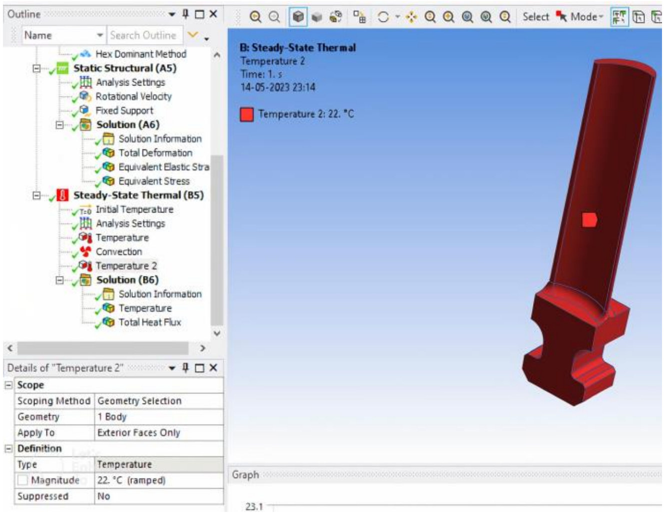

Fig . 4

The pressure side of the blade has the maximum temperature and the shank of the blade has the minimum temperature as it has inappreciable interaction with the steam.
There is heat flux generated due to convection and the transition of energy which is one of the major outcomes which affect the blade.

III. RESULT AND DISCUSSION

Following are the results of Steady State Thermal Analysis of the Steam Turbine Blade.
The maximum temperature was found to be at the pressure side of the blade that is 229°C and 22°C at the shank.

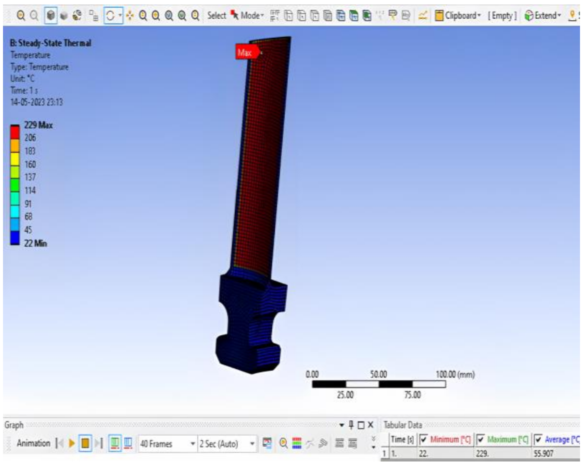

Fig . 5

The average temperature throughout the body occurred as 55°C.

The second stage of the Thermal analysis included determination of total heat flux over the Steam Turbine Blade. The results of analysis of total heat flux show that the heat flux has minimal deviations in its magnitude. The variation of heat flux is seen on the trailing and leading edges of the blade ranging from 2.3025 W/mm^2 to 3.4537 W/mm^2 .

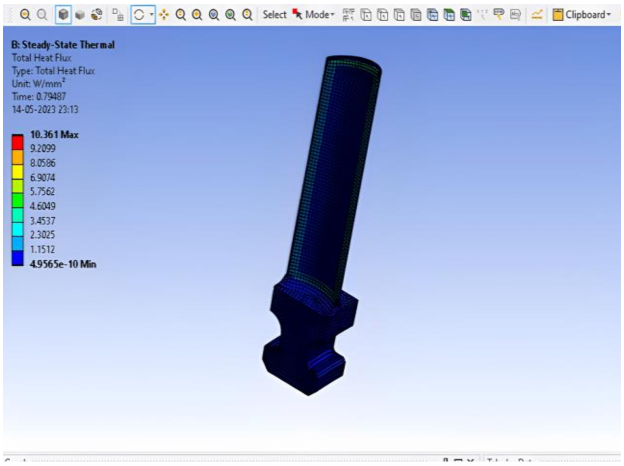

Fig . 6

The total heat flux can be seen with a negligible change in its magnitude over the blade, which implies that convection taking place might not affect the performance of the steam turbine. Regardless of the negligible variation of the total heat flux and convection, the blade life might deteriorate over a long period of time.

IV. LIMITATIONS

The accuracy of the simulation results is dependent on the accuracy of the boundary conditions defined for the simulation. Uncertainties in the inlet and outlet conditions, as well as the initial temperature of the blade, can lead to significant errors in the simulation results. Therefore, it is important to use experimental data to validate the boundary conditions used in the simulations.

The accuracy of the steam turbine blade gets limited as the model gets more and more complicated and the computational time also increases.

V. FUTURE SCOPE

The development of understanding for the significance of the differences between different designs of turbines as per their strength and life will be increased so that the user has a better judgment over the usage of the turbines efficiently.

Considering the following study, various other mechanisms of causes of blade fatigue and decrease in strength as per the usage will be countered with suitable solutions.

VI. CONCLUSION

In conclusion, thermal analysis is an essential aspect of the design and operation of steam turbines. It allows engineers to predict the thermal behavior of the turbine blades under different operating conditions, and optimize their design for maximum efficiency and reliability.

ACKNOWLEDGEMENT

We would like to thank our project guide prof. Pramod Kale for their valuable feedback and suggestions. Their expertise in their respective fields has helped us to develop a more comprehensive understanding of the subject matter.

We are extremely grateful for the support and guidance provided by our professors, without which this project would not have been possible.

REFERENCES

[1]. N. Balaji, S. K. Khadem, K. Subramanyam, and R. K. Vishwakarma, "Thermal Analysis of Steam Turbine Blade," International Journal of Engineering Research and General Science, vol. 2, no. 4, pp. 1197-1202, June-July 2014.

[2]. B. K. Banger and S. S. Thipse, "Thermal Analysis of Turbine Blade Using Ansys," International Journal of Engineering Research and Applications, vol. 4, no. 7, pp. 60-67, July 2014.

[3]. M. Al-Betar and M. S. Al-Garni, "Thermal Analysis of a Steam Turbine Blade," Journal of Mechanical Engineering and Technology, vol. 5, no. 1, pp. 30-40, January 2017.

[4]. M. R. Salimpour, A. Bahrami, and A. S. Safari, "Thermal Analysis of Steam Turbine Blade Using Finite Element Method," Journal of Mechanical Engineering and Sciences, vol. 10, no. 1, pp. 2438-2446, January 2016.

[5]. A. T. Mohammed, A. K. Al-Falahi, and N. A. Ahmed, "Thermal Analysis of Steam Turbine Blade with Different Cooling Configurations," Journal of Thermal Science and Engineering Applications, vol. 11, no. 4, pp. 041003-1-041003-10, August 2019.