Thermal Stress Analysis of a Turbine Stator Blade with the Help of COMSOL

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Abstract: The stator blades of turbine used in the thermal power plants are subjected to sudden and rapid temperature changes. The turbines are used for converting the forms of fluid molecules energy in mechanical energy, the stator blade having different types of failures when pressure is reached up to30bars and the temperature rose up to 1000 K. The turbine stator blade carefully designed to be able to withstand thermal stress, vibrations due to rotating machinery and aerodynamic loads exerted by the fluid rushing through the turbine. If we can have thermal stress analysis of the blade materials then it is easy to determine that under applied pressure and temperature on the turbine stator blade. Having this information, a system having turbine can be analyzed and then accordingly materials can be used to make blades. These blades can perform better under higher pressure and temperature.

Keywords: Stator Blade Materials, Thermal Stress Analysis, Simulation, Pressure, Temperature, COMSOL.

I. INTRODUCTION

The conditions within gas turbines are extreme. The pressure can be as high as 40 bars, and the temperature far above 1000 K. The component of turbine must therefore be carefully designed to be able to withstand thermal stress, vibrations due to the rotating machinery and aerodynamic loads exerted by the fluid rushing through the turbine. If a component of turbine fails, the high rotational speeds can result in a complete rupture of the whole turbine. The most extreme conditions are found in the high pressure part downstream of the combustion chamber where hot combustion gas flows through a cascade of rotors and stators. To prevent the parts from melting, relatively “cold” air is taken from bleeding vanes located in the high-pressure compressor casing, then led past the combustion chamber into the turbine casing in order to be used as a coolant. Directly behind the combustion chamber, both internal cooling within ducts and film cooling over the blade side surfaces are applied. Further downstream, where the temperature is somewhat lower, it may suffice with internal cooling.

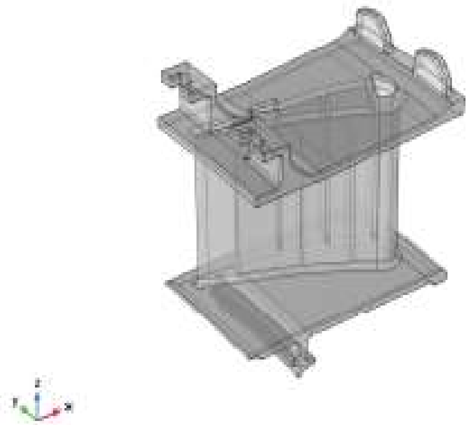

Fig.No.1.A Stator Blade.

For the manufacturing of turbine stator blades, we used some specific materials like Iron alloys.Since the physics within a gas turbine is very complex, simplified approaches are often used at initial stages of the development of the new components. In this case the thermal stresses in a stator blade with internal cooling are analyzed.

II. PROPOSED METHODOLOGY

Thermal stress are analyzed by COMSOL multiphasic software which following some step. After the section of the physics and materials, we are the following steps to be performed. Enter the detailed specifications of the turbine stator blade. This is given in the table.

S.No	**Name**	**Value**	**Expression**	**Description**
1	U_suction side	450m/s	450/s	Gas velocity on stator suction side
2	U_pressure side	300m/s	300m/s	Gas velocity on stator pressure side
3	U_platform	350m/s	350m/s	Gas velocity on stator platform walls side
4	Pr_cool	.71	.71	Cooling prandtl number
5	T_gas	1100K	1100K	Gas temperature
6	P_high	30[bar]	3.E6Pa	High pressure level
7	mu_cool	3.1e-5[Pa*s]	3.1E-5 Pa·s	Viscosity of the cooling air
8	Cp_cool	770[J/kg/K]	770J/(kg.K)	Heat capacity of the cooling air
9	T_cool	800K	800K	Cooling air temperature
10	H_cool	.01[m]	.01m	Characteristics Length scale of cooling Channels
11	T_work	950K	950K	Working temperature
12	Nu_cool	400	400	Average Nusselt number in cooling Channel

The thermal stress are analyzed from the structural mechanics module to set up the model when the turbine stator blade to be made of the iron alloy. This is having high tensile strength. In addition to the data covered by the material library, the linear elastic model requires a reference that is set to 300K and a Poisson's ratio .33**, a** number comparable to that for other stainless steels. Any coating has been neglected.

III. EXPERIMENTAL SETUP& SOFTWARE

COMSOL Metaphysics software is used for analyzed thermal stresses on the turbine stator blade and stator wall. Thermal stress is calculated by following equation.

1. Inward heat flux

Q_0=h (T_{ext}-T)

2. Heat transfer coefficient

h=(Nu_cool·mu_cool·Cp_cool/2·Pr_cool·H_cool)

3. External forced convection

4. Creating mesh and run the simulation

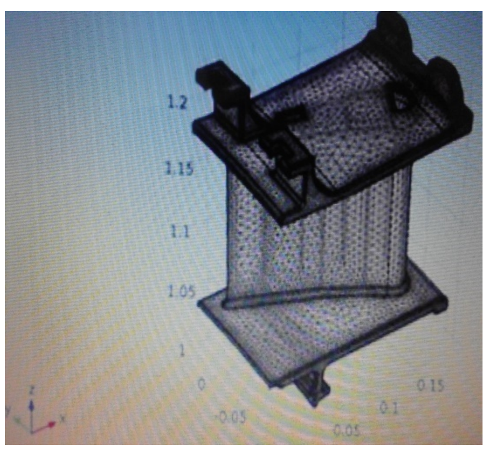

Fig.No.2.Creating Mesh Turbine Stator Blade.

IV. RESULTS AND ANALYSIS

The internal cooling creates significant temperature gradients within the stator blade. However, the trailing edge reaches a temperature close to that of the combustion gases, which indicate that the cooling can be beneficial.

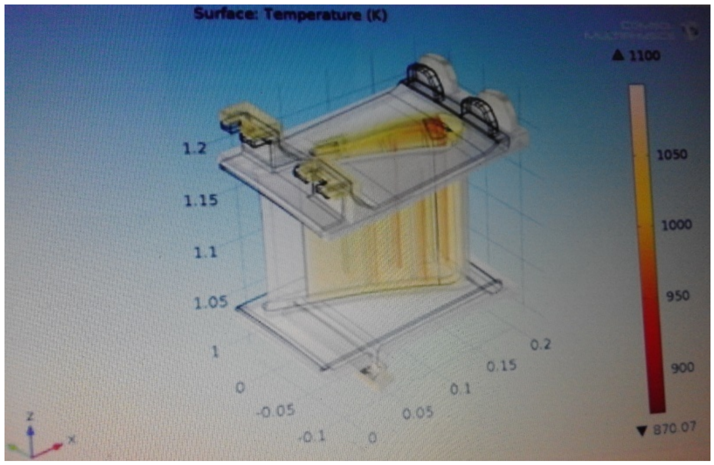

Fig.No.3. Surface Temperatures plot.

The maximum stress with a value close to the yield stress for the material occurs in the internal cooling duct.no definite assessment can however be made without conducting a more advanced analysis that includes details of the flow inside the duct.

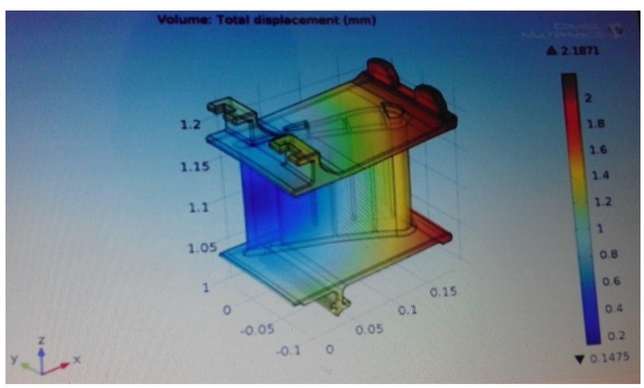

Fig.No.4.Surface plot of the displacement

The thermal stresses in turbine stator blades researched are calculated on with the help of the COMSOL multiphysics software when the structural mechanics module dedicated to the analysis in the 2D or 3D coordinate system and the heat transfer module to investigate the effect of heating or cooling in the turbine stator blade.

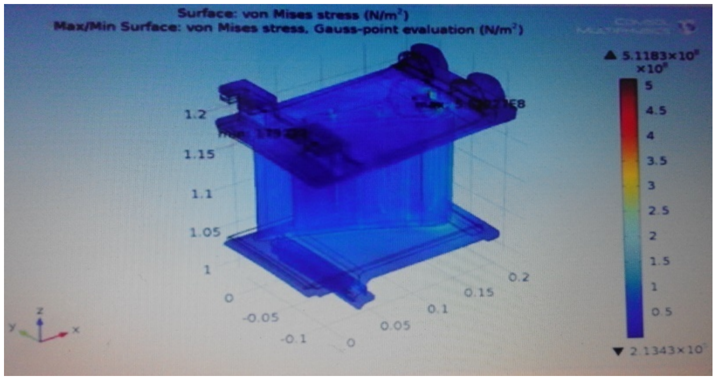

Fig.No.5.Surface plot of the von Mises stress

The analyzed of thermo stress is based on the motion equation as well as on the heat transfer equation using the FME Method. (Ref-2)

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