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Stress Simulation of General Steam Turbine Blade Materials

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Abstract

In Industries the Turbines are used for converting the forms of energy, the Blades are the key elements for turbines where the blades of the turbines experiences different types of failures. The common reason of these types of failures is the thermal stress which is experienced by the blades. The breakage point of blades depends upon the material used to make it. If we can have thermal stress analysis of the blade materials then it is easy to determine that under different conditions & up to which point, materials can resist. Having this information, a system having turbine can be analysed, according to that materials can be used to make blades. These blades can resist better than any other blades which can be used. In this work, models have been generated based on actual measurement of the blades which are used in industries for steam turbines. Applying the properties of different materials on these models, the simulation of thermal stress has been observed in this paper.

Keywords: Materials, Thermal Loading, Stress analysis, Simulation.

Introduction

First of all let's introduce the Turbines, where Neilson defines a turbine as "a machine in which a rotary motion is obtained by the gradual change of momentum of a fluid." The turbine is a device often used to produce or recover energy in a fluid by method using a series of vanes known as "blades" or "buckets".[1] Turbines extract kinetic energy from a moving fluid and convert that energy into power.[2] Turbines can be broken down into two main categories: axial and radial (centrifugal). In an axial flow turbine, the majority of the flow remains parallel to the shaft of the turbine. Conversely in a centrifugal flow turbine, the flow travels the hub to the tip of the turbine.[1] The flow in a turbine stage (stator/rotor) is complex and is still the subject of many ongoing research activities in the turbine community. The flow is inherently three dimensional due to the vane/blade passage geometry with features such as twisting of the vane/blade along the span, clearance between the blade tip and the shroud, fi lm cooling holes, and end wall contouring[3]. The passage flow is characterized by boundary layer effects, secondary flows generated by the passage pressure gradients, and vortical flow structures such as the leading edge horse-shoe vortices, tip-leakage flow vortices, and corner vortices [4], which is called Profile Blading. The three dimensional complex flow structures near the hub end wall region and in the blade tip-shroud clearance have been simulated in annular vane/blade passages with and without rotating blade row [5]. Studies of the complex end-wall flows have also been performed in stationary cascades with three dimensional airfoil shapes [6].

Fig-1 Cross Sections of Various Types of Profile Blade

For the manufacturing of turbine blades, we used some specific materials like Modern alloys, Super alloys, Nickel based alloys and CF-8. But in our research work we have selected the following materials: SS 304, SS 4340, DIN SS, Crome SS and Ti6Al4V.

Methodology

In this section after selection of the materials, we have the following steps to be performed:

1. Gathering of the detailed specifications of the turbine blade. The parameters which are needed for designing blade are length, width, thickness, speed, angular velocity, steam temperature,

steam pressure, tapper angle, fillet, angle of twist & bend.

2. Generation of the model with suitable design software. Here, ANSYS and Solidworks can be taken into consideration. But it should be noted that current simulation is done with the help of Solidworks.
3. For each material, all the parameters are applied to model recursively.
4. The results are gathered for each material and compared with one another to get optimum point of solution.

Results

With help of the software named Solidworks, we found the following results for stress analysis for the given selected materials.

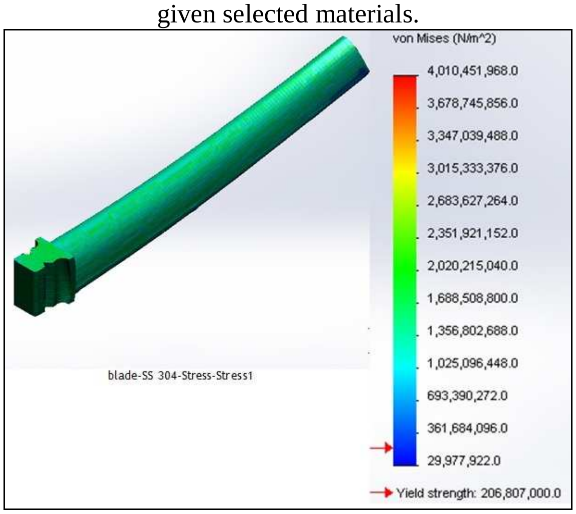

Fig-2 Stress- Stress1 Analysis for SS-304 Blade

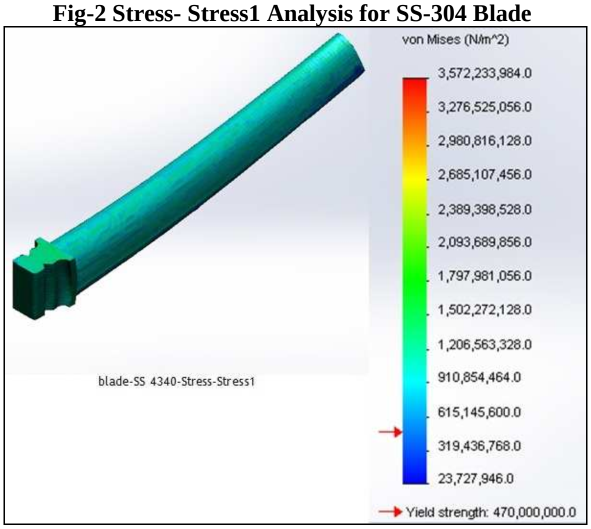

Fig-3 Stress- Stress1 Analysis for SS-4340 Blade

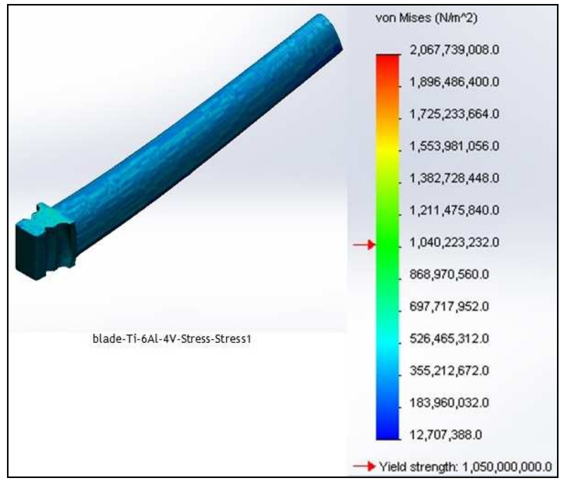

Fig-4 Stress- Stress1 Analysis for Ti-6Al-4V Blad

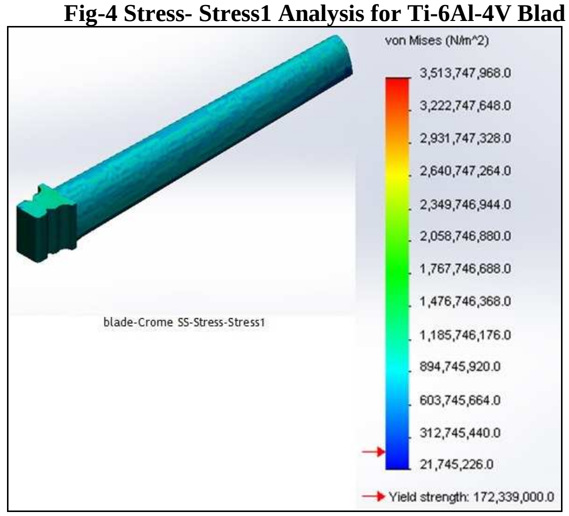

Fig-5 Stress- Stress1 Analysis for Crome SS Blade

Fig-6 Stress – Stress1 Analysis for DIN-SS Blade

As we analyse above representation of stress of various materials, we came to know that SS-304 is having maximum stress value and Ti-6Al-4V is having minimum stress value. Apart from that, remaining three materials are denoting average cases of induced stress.

Conclusion

The graphical representation of data of Result section is shown in Fig-7.

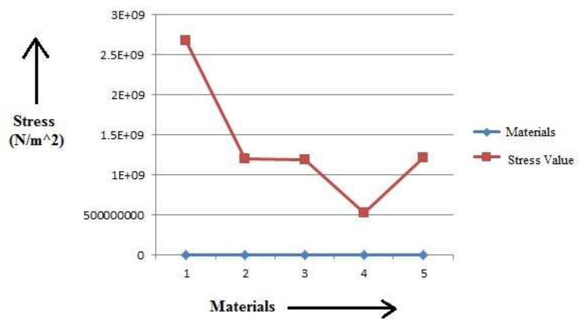

Fig-7 Simulation of Stress. (Material Indicators- 1: SS-304, 2: Crome SS, 3: DIN SS, 4: Ti6Al4V, 5: SS 4340)

For stress analysis of various steam turbine blade materials, we have taken mainly five materials, namely Chrome SS, Din SS, SS 4340, SS 304 and Ti6Al4V. As we know that the material which induces minimum stress is the one which is best suited. So, Ti6Al4V is the best one and SS -304 shows worst case. But, if we see the remaining three materials then they are on the mid way, showing average cases of induced stress. So, it can be concluded that based on the need of operation, one of the four materials i.e. Chrome SS, DIN SS, SS 4340, Ti6Al4V can be selected.

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