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OPTIMIZATION & ANALYSIS OF STEAM TURBINE BLADE

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Abstract

Steam turbine improvements will improve the system's heat rate, thereby improving efficiency of operations, as well as decreasing maintenance costs. In addition, greater steam turbine efficiency also reduces or eliminates greenhouse gas emissions. Figure 3.1 FlowChart Process in thebelow chart the approach to obtain the final expected output as accurate as possible. A three-dimensional model of blade was developed using a computer-aided design software. All materials were assumed linear, homogenous, elastic and isotropic. A 5 N widespread force was applied to the blade. The results of this study showed that longer blades are experienced higher maximum Von Mises stress and strain than shorter ones. The blade with the length of 400 mm and thickness of 20 mm experienced the lowest maximum Von Mises stress at 51 kPa. Furthermore, blade with the length of 400 mm and 600 mm experienced the lowest and highest strain at 3.07 × 10–6 and 4.3 × 10–6 respectively. In addition, thicker blades were undergone less maximum Von Mises stress and strain than thinner ones. Understanding stress and strain pattern in turbine blades provides useful knowledge which can be useful to estimate the fatigue in turbine blades.

1. INTRODUCTION

A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. A turbine is a turbo machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor. Early turbine examples are windmills and waterwheels. The first turbines to be used were the steam turbines but now on the basis of the fluid from which energy is extracted Use up high pressure steam to produce energy. These turbines are not used for producing electricity but they are used to propel jet engines. Steam turbines are the latest types of turbines. Their structure is advanced but the principle is the same.

How Do Steam Turbines Work?

Steam turbines are composed of three primary sections mounted on the same shaft: the compressor, the combustion chamber (or combustor) and the turbine.

The compressor can be either axial flow or centrifugal flow. Axial flow compressors are more common in power generation because they have higher flow rates and efficiencies. Axial flow compressors are composed of multiple stages of rotating and stationary blades (or stators) through which air is drawn in parallel to the axis of rotation and incrementally compressed as it passes through each stage. The acceleration of the air through the rotating blades and diffusion by the stators increases the pressure and reduces the volume of the air. Although no heat is added, the compression of the air also causes the temperature to increase. The compressed air is mixed with fuel injected through nozzles. The fuel and compressed air can be pre-mixed or the compressed air can be introduced directly into the combustor. The fuel-air mixture ignites under constant pressure conditions and the hot combustion products (steames) are directed through the turbine where it expands rapidly and imparts rotation to the shaft. The turbine is also comprised of stages, each with a row of stationary blades (or nozzles) to direct the expanding steames followed by a row of moving blades. The rotation of the shaft drives the compressor to draw in and compress more air to sustain continuous combustion. The remaining shaft power is used to drive a generator which produces electricity. Approximately 55 to 65 percent of the power produced by the turbine is used to drive the compressor

Existing Steam Turbines:

In order to match steam production to heat demand, there are three types of steam turbine in common use for CHP plants. The figure 1.4 depicts the Standard Blade and 1.5 shows The Turbine hub, These three are called a back pressure steam turbine, an extraction steam turbine and a condensing steam turbine. Each type will suit a different configuration of plant.

2. PROBLEM IDENTIFICATION & SOLUTION

Problem Definition:

Steam turbine blade design technology has become an important research field. The level of design is one of the most important factors restricting the performance of steam turbines, which is related to the working efficiency of the steam turbine.

Objective :

Hence to overcome this issue we are trying and performing experiments on the existing Steam turbine blade, by changing the blade dimensions, blade angle and the material composition of the blade considering the factors affecting, acting on

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the blade and performing thermal analysis inorder to find out and compare the efficiency to the existing and most widely used blade.By making changes in *CATIA V5* software , where the change in dimensions and change of blade angle is noted and the later the figure is subjected to *ANSYS* where the stresses are calculated before and after the work done , energy generated are noted down and later compared with the existing solution to provide a complete overview concluding our work.

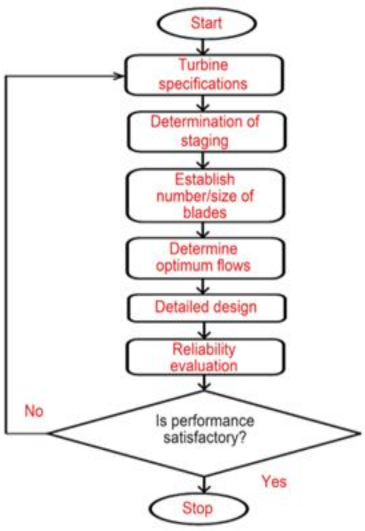

Figure 1 FlowChart Process

3. DESIGNING OF DIFFERENT PARTS OF TURBINE BLADE

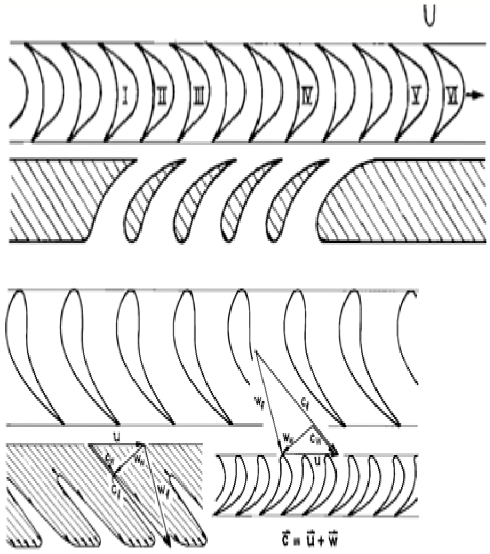

Figure 2 DESIGN OF SIDE PROFILE VIEW OF TURBINE BLADE

The above figure 2 shows the side profile 2D view of the Turbine. The breadth and thickness of the blade are shown and the angles are depicted in the figure.

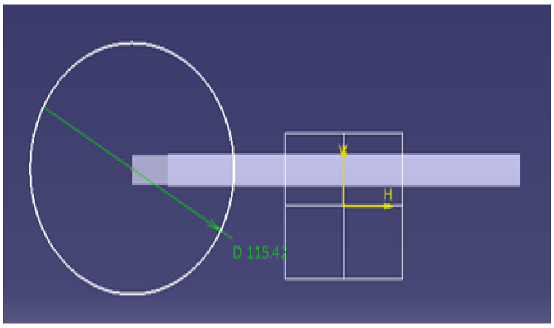

Figure 3 Sketch the circle

After pocket cut, Figure 3 Sketch the circle is shown go to plane in reference and select front plane as a reference and specify offset distance 0.45metre.

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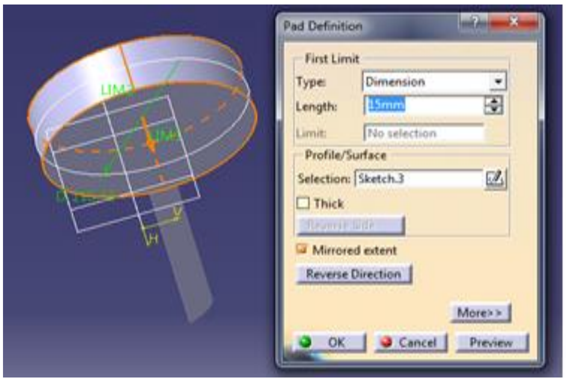

Figure 4 Extrude

On part module go to sketch. And select sketch, then create sketch as shown in figure in below

Later select on exit sketcher

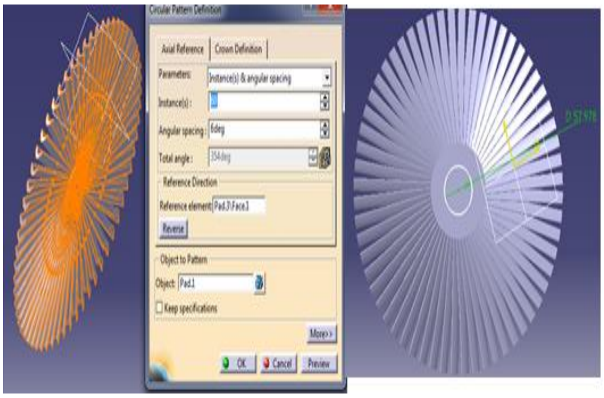

Figure 5 Sketch the circle

After sketch. Go to features and select extrude cut boss/base .In extrude cut boss, sketch above profile as a object to depth and specify direction Then click ok or click on right mark. As shown in Figure 5 Sketch the circle is formed and the turbine hub is created.

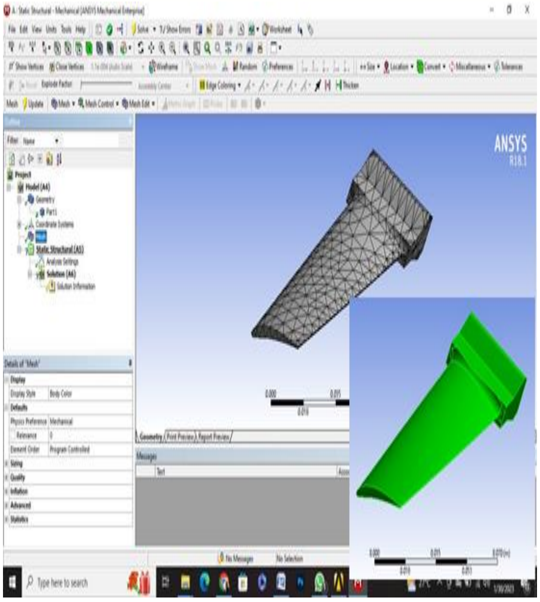

Figure 6 Mesh Generated With Default Mesh Controls

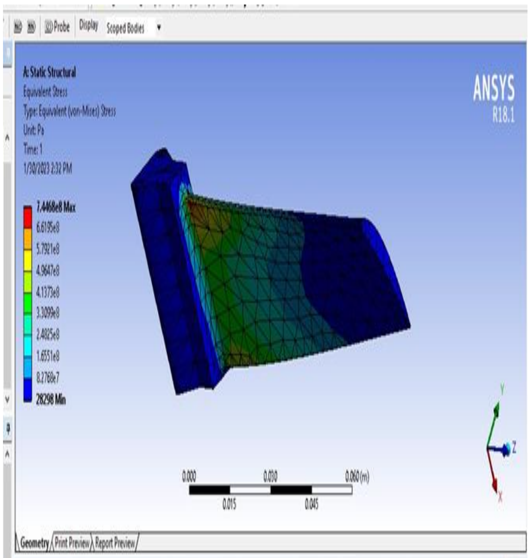

Figure: 7 Total Equivalent Stress

4. RESULTS

The final resultant values obtained for the turbine blades for various materials at various loads in the form of;

Table 1 Results for Inconel

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INCONEL 600 Load	Stress *(Min- Max)*	Equivalent Strain *(Min-Max)*	Total Deformation
300 N	$2.417x10^8$ pa - 13584	0.001163 - $1.6933x10^{-7}$	0.00088467 m
600 N	$4.8339 x10^8$ pa - 27168	0.002326- $3.3867 x10^{-7}$	0.0017693 m
900 N	$7.2509 x 10^8$pa - 40752	0.0034889 - $5.08x10^{-7}$	0.002654 m

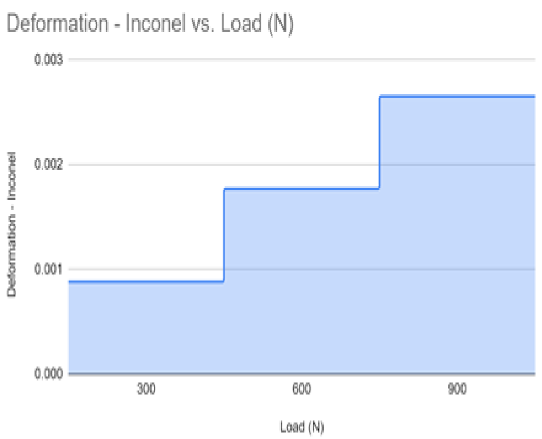

Figure 8 Deformation v/s Load graph for Inconel

Table 2 Results for Titanium

Titanium Load	Stress *(Min- Max)*	Equivalent Strain *(Min- Max)*	Total Deformation
300 N	$2.399 x10^8$ pa 16395	0.0025252 $3.7559x10^{-7}$	0.0019301 m
600 N	$4.7981x 10^8$ pa 32791	0.0050504 $7.511x10^{-7}$	0.0038602 m
900 N	$7.1972x10^8$ pa 49186	0.0075756 $1.268x10^{-6}$	0.0057903 m

5. CONCLUSION

We have successfully made a change and followed an approach " Design and Optimization of Steam Turbine Blades" . In this task I here consider a Standard Stream turbine blade which is made with the proper existing turbine blade dimensions and thereby reduced and adjusted the dimensions of the existing turbine blade. In this project we have combined the specifically designed turbine blade which is made by using CATIA V5 and combined it with various materials like in this report we have chosen 3 materials 1. Inconel 600, 2. Titanium, 3. Stainless Steel.Consequently, finding out the stresses induced on a turbine blade at a normal load and at higher loads can be helpful to find out and determine the maximum deformation and conclude the suitable material which can be used to manufacture the turbine blade.Initially the blade is designed in CATIA V5 and later the designed blade is transferred to ANSYS for the further process, Static Analysis and Structural Analysis is done on the turbine blade at various loads where the blade is made of various materials. The total deformation, Stress and Strain is calculated so that the behavior of the blade is found out, finally a Stress vs Strain graph is plotted for all the materials to show the deformation of the blade. We can say that Titanium material is more suitable for high Pressure Turbines. And Inconel for Low and Intermediate Turbines,

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