STATIC STRUCTURAL ANALYSIS MODIFICATION OF A STEAM TURBINE BLADE

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ABSTRACT-- steam turbine is mechanical device which converts thermal energy in steam into mechanical work. The steam turbine gives the better thermodynamic efficiency by using multiple stages in the expansion of steam. The stages are characterized by the way of energy extraction from them is considered as impulse or reaction turbines. In this thesis the parameters of steam turbine blade varied and analysis is done for strength, life and heat transfer rates. The varied parameters are the ratio of X-axis distance of blade profile by chord length and ratio of maximum height of blade profile in Y-direction to the chord length. The 3D modelling is done by using catia software. The ANSYS software is used for static, thermal analysis, finally concluded the suitable design and material (Haste alloy, Chrome steel, Inconel 600) for steam turbine blade,

KEY WORDS: ***Steam Turbine, Thermal Energy, Impulse Turbine, Reaction Turbine, Static Analysis, Thermal Analysis***

1. INTRODUCTION

A turbine (from the Latin turbo, a vortex, related to the Greek, meaning "turbulence") is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced by a turbine can be used for generating electrical power when combined with a generator or producing thrust, as in the case of jet engines. 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.

Gas, steam, and water turbines have a casing around the blades that contains and controls the working fluid. Credit for invention of the steam turbine is given both to British engineer Sir Charles Parsons (1854–1931) for invention of the reaction turbine, and to Swedish engineer Gustaf de Laval (1845–1913) for invention of the impulse turbine. Modern steam turbines frequently employ both reaction and impulse in the same unit, typically varying the degree of reaction and impulse from the blade root to its periphery.

The word "turbine" was coined in 1822 by the French mining engineer Claude Burden from the Latin turbo, or vortex, in a memo, "Des turbines hydrauliques our machines rotatories à grande vitesse", which he submitted to the Academia royale des sciences in Paris. Benoit Fourneyron, a former student of Claude Burdin, built the first practical water turbine

FIG 1TURBINE

1.2 TYPES OF TURBINES

Steam turbine

Gas turbine

Transonic turbine

Contra-rotating turbine

Statorless turbine

Ceramic turbine

Shroudless turbine

Bladeless turbine

Water turbines

Wind turbines

Velocity compound

Pressure compound multi stage impulse

Mercury vapour turbine

1.**Steam turbine** is used for the generation of electricity in thermal power plants, such as plants using coal, fuel oil or nuclear fuel. They were once used to directly drive mechanical devices such as ships' propellers (for example the Turbinia, the first turbine-powered steam launch,[5]) but most such applications now use reduction gears or an intermediate electrical step, where the turbine is used to generate electricity, which then powers an electric motor connected to the mechanical load. Turbo electric ship machinery was particularly popular in the period immediately before and during World War II, primarily due to a lack of sufficient gear-cutting facilities in US and UK shipyards.

2.LITERATURE REVIEW

Many investigators have suggested various methods to explain the effect of stress and loading on turbine blade, roter and analysis the various parameters: John. V, T. Ramakrishna was investigated on design and analysis of Gas turbine blade, CATIA is used for design of solid model and ANSYS software for analysis for F.E. model generated, by applying boundary condition, this paper also includes specific post processing and life assessment of blade. How the program makes effective use of the ANSYS pre-processor to mesh complex geometries of turbine blade and apply boundary conditions. The principal aim of this paper is to get the natural frequencies and mode shape of the turbine blade. In this paper we have analyzed previous designs and generals of turbine blade to do further optimization, Finite element results for free standing blades give a complete picture of structural characteristics, which can utilized for the improvement in the design and optimization of the operating conditions.

Subramanyam Pavuluri, Dr. A. Siva Kumar was investigated on design of high pressure steam turbine blade addresses the issue of steam turbine efficiency. A specific focus on airfoil profile for high-pressure turbine blade, and it evaluates the effectiveness of certain Chromium and Nickel in resisting creep and fracture in turbine blades. The efficiency of the steam turbine is a key factor in both the environmental and economic impact of any coal-fired power station. Based on the research presented modifications to high-pressure steam turbine blades can made to increase turbine efficiency of the turbine.

3. 1 STEAM TURBINE NOMENCLATURE:

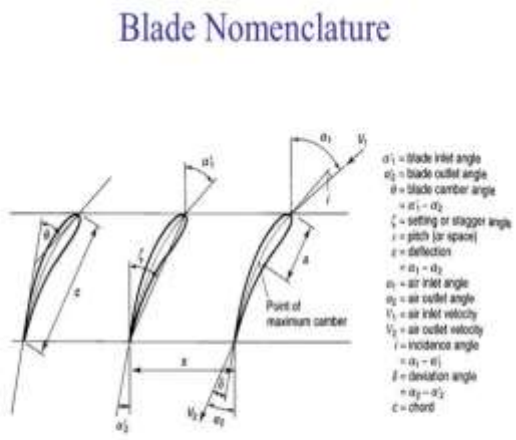


FIG 2 STEAM TURBINE BLADE NOMENCLATURE

3.2 PROBLEM DEFINITION:

All mordern steam power plants use impluse-reaction turbines as their blading efficiency is higher than that of impulse turbines. Last stage of steam turbine impluse-reaction blade are very much directly affect efficiency of plant.With the information that an understanding of the forces and stresses acting on the turbine blades is vital importance, in this work we will compute such a force acting on a last stage Low Pressure (LP) blade of a large steam turbine rotating at 3000 rpm in order to estimate the material stresses at the blade root. One such LP steam turbine blade is show in Figure 1.

We studied structural and themal analysis of blade using FEA for this work and by use of the operational data have performed by using FEA (ANSYS) and This study work involved the analyze blade and check FEA data of std. blade with various material.

3.3 OBJECTIVE

The objective of this project is to make a Steam turbine blade different 3D model of the steam turbine blade, To study the static - thermal behaviour of the steam turbine blade with different materials by performing the finite element analysis.3D modelling software (catia v5) was used for designing and analysis software (ANSYS) was used for analysis.

3.4 METHODOLOGY

THE METHODOLOGY FOLLOWED IN THE PROJECT IS AS FOLLOWS:

- Create a 3D model of the different Steam turbine blades using parametric software catia v5.
- Convert the surface model into IGS and import the model into ANSYS to do analysis.
- Perform static and thermal analysis on the steam turbine blade.
- Finally it was concluded which material is the suitable for steam turbine blade on these three materials.

3.5 SCOPE OF THE PROJECT :

The scopes of this proposed project are:

1. To generate 3-dimensional geometry model in catia workbench of the steam turbine blade

2. To perform structural analysis on the model to determine the stress, shear stress, deformation, of the component under the static- thermal load conditions

3. To compare analysis between three different materials of steam turbine blade

3.6 LOAD CALCULATION :

$$F = M \times Vm$$

M=Mass of stream flowing through turbine

Vm=velocity of steam in m/s

M=1000kg/hr

Vm=1310m/s

F=362.87N

Blade area=23319.1mm^2

Pressure =F/A

P=0.01556N/mm^2

3.7 MATERIAL PROPERTIES

TAB 1HASTELLOY PROPERTIES

Material	Hastelloy
Density	8.89g/cc
Young's modulus	205Gpa
Poisson's ratio	0.33
Tensile strength ultimate	601.2Mpa
Tensile strength yield	275
Melting point	1400^{0}c
Thermal conductivity	15.0W/m/K
Specific heat capacity	0.427J/g-^{0}C

TAB 2 INCONEL600 PROPERTIES

Material	INCONEL600
Density	8.36 g/cc
Young's modulus	210Gpa
Poisson's ratio	0.35
Tensile strength ultimate	570Mpa
Tensile strength yield	340MPa
Melting point	1370^{0}c
Thermal conductivity	13.6W/m/K
Specific heat capacity	0.419J/g-^{0}C

TAB 2 CHROME STEEL PROPERTIES

Material	CHROME STEEL
Density	7.31 g/cc
Young's modulus	200Gpa
Poisson's ratio	0.3
Tensile strength ultimate	485Mpa
Tensile strength yield	275Mpa
Melting point	1365^0c
Thermal conductivity	14.0W/m/K
Specific heat capacity	0.418J/g-^{0}C

INTRODUCTION TO CATIA

Welcome to **CATIA (Computer Aided Three Dimensional Interactive Application)**. As anew user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release.

CATIA V5, developed by Dasssault Systems, France, is a completely re-engineered, Next-generation family of CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using feature-based and parametric designs.

CATIA V5 provides three basic platforms: P1, P2, and P3. P1 is for small and medium-sized process-oriented companies that wish to grow toward the large scale digitized product definition.

P2 is for the advanced design engineering companies that require product, process, and resource modeling. P3 is for the high-end design applications and is basically for Automotive and Aerospace Industry, where high quality surfacing or Class-A surfacing is used. The subject of interpretability offered by CATIA V5 includes receiving legacy data from the other CAD systems and even between its own product data management modules. The real benefit t is that the links remain associative. As a result, any change made to this external data gets notified and the model can be updated quickly.

4.5 DIMENSIONS AND DESIGN PROCEDURE IN CATIA:

Go to the sketcher workbench create profile blade shape by using spline and arcs as below dimensions after go to the part design workbench apply pad as shown belowfigure

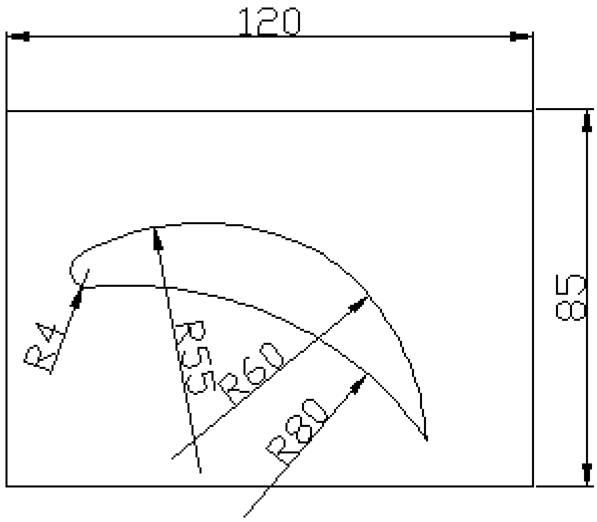
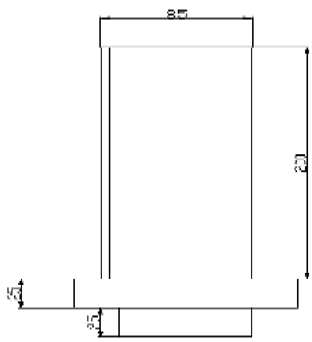


FIG 3BLADE DIMENSIONS



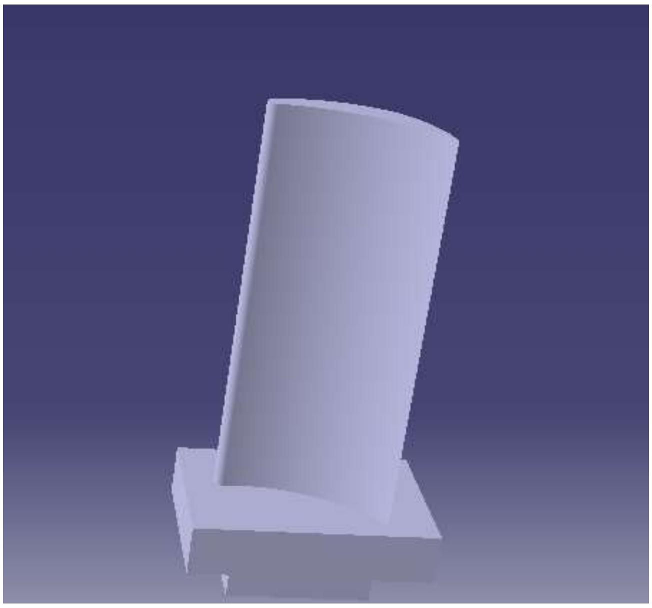


FIG 4 STEAM TURBINE BLADE IN CATIA WORK BENCH

INTRODUCTION TO ANSYS

ANSYS is a large-scale multipurpose finite element program developed and maintained by ANSYS Inc. to analyze a wide spectrum of problems encountered in engineering mechanics**.**

5.1 PROGRAM ORGANIZATION:

The ANSYS program is organized into two basic levels:

- Begin level
- Processor (or Routine) level

The Begin level acts as a gateway into and out of the ANSYS program. It is also used for certain global program controls such as changing the job name, clearing (zeroing out) the database, and copying binary files. When you first enter the program, you are at the Begin level.

At the Processor level, several processors are available. Each processor is a set of functions that perform a specific analysis task. For example, the general pre-processor (PREP7) is where you build the model, the solution processor (SOLUTION) is where you apply loads and obtain the solution, and the general postprocessor (POST1) is where you evaluate the results of a solution. An additional postprocessor, POST26, enables you to evaluate solution results at specific points in the model as a function of time.

5.1.1Material Models:

ANSYS allows several different material models like:

· Linear elastic material models (isotropic, orthotropic, and anisotropic).

· Non-linear material models (hyper elastic, multi linear elastic, inelastic and
Visco elastic)

· Heat transfer material models (isotropic and orthotropic)

· Temperature dependent material properties andCreep material models.

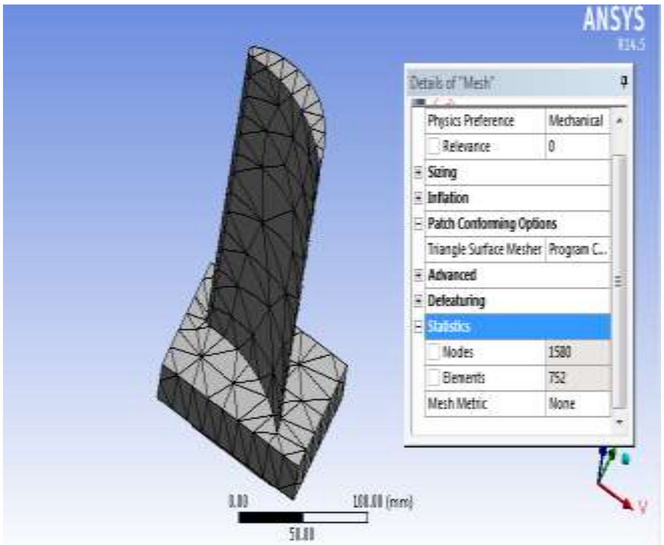


FIG 5MESHING

6.10 BOUNDARY CONDITION

In static analysis fixed the bottom side after apply pressure on blade face

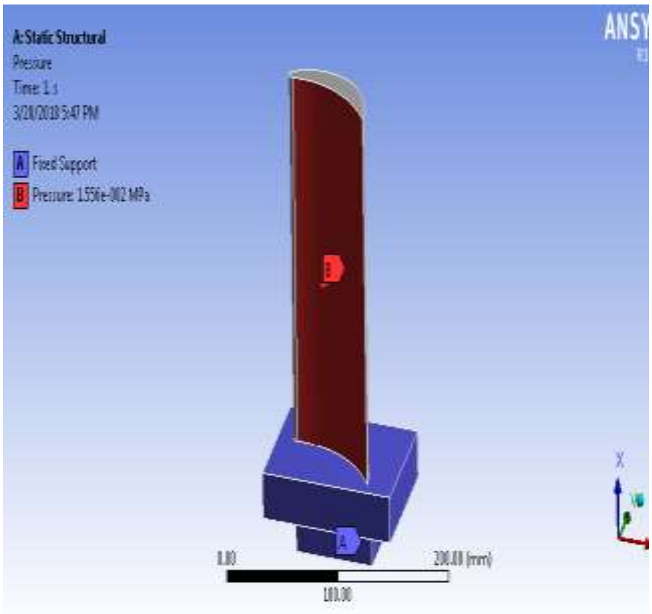


FIG 6 BOUNDARY CONDITION IN STATIC ANALYSIS

Boundary condition in steady state thermal analysis: apply temperature 229^{0}c, apply convection 22^{0}cfilm coefficient is 0.0025w/mm2^{o}c

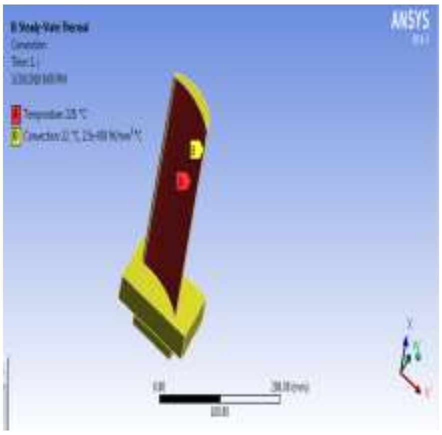


FIG 7 BOUNDARY CONDITION IN STEADY STATE THERMAL ANALYSIS

CHAPTER 2 RESULTS AND DISCUSSION

7.1 STATIC ANALYSIS:

This analysis is performed to find Structural parameters such as Stresses,shearstress, Deformation, Here we observed results on three materials namely chrome steel, hastelloy, and Inconel as shown below figures

7.1.2 Chrome steel

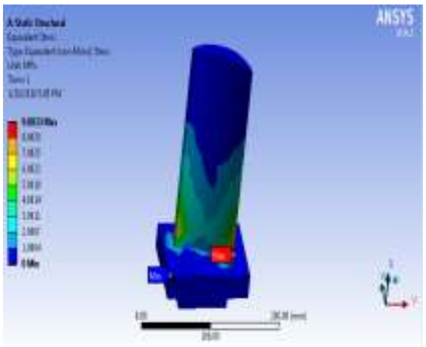
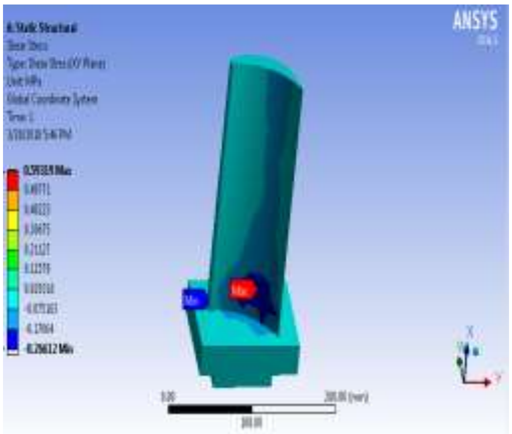


FIG 8 STRESS ON CHROME STEEL



SHEAR STRESS ON CHROME STEEL

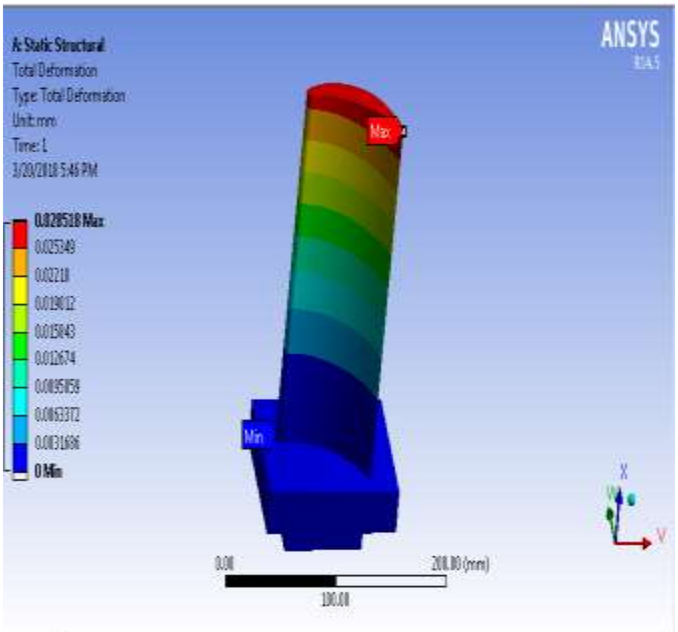


FIG 9 DEFORMATION ON CHROME STEEL

7.1.2 Inconel material

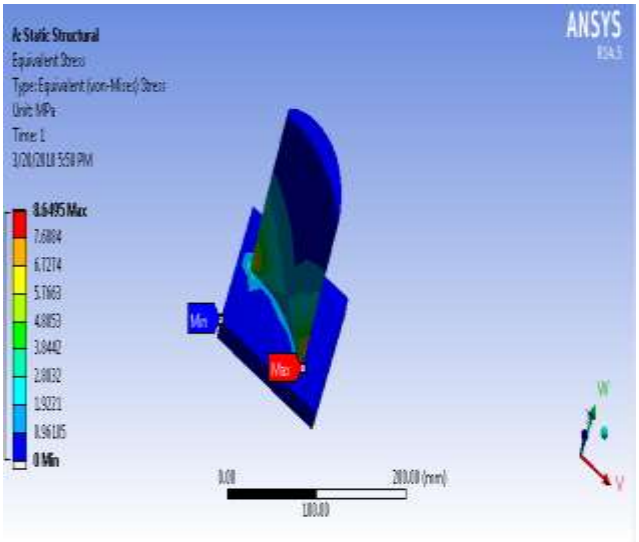
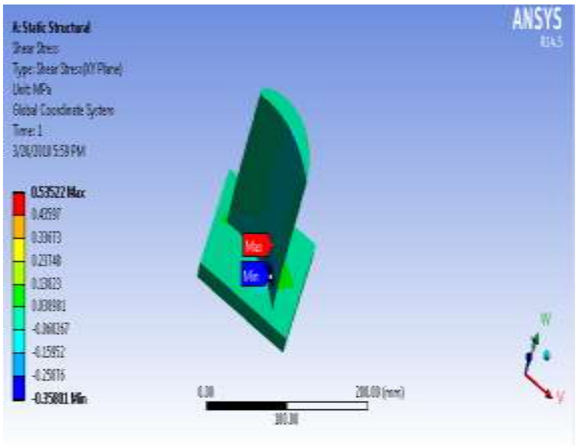


FIG 10 STRESS ON INCONEL



SHEAR STRESS ON INCONEL

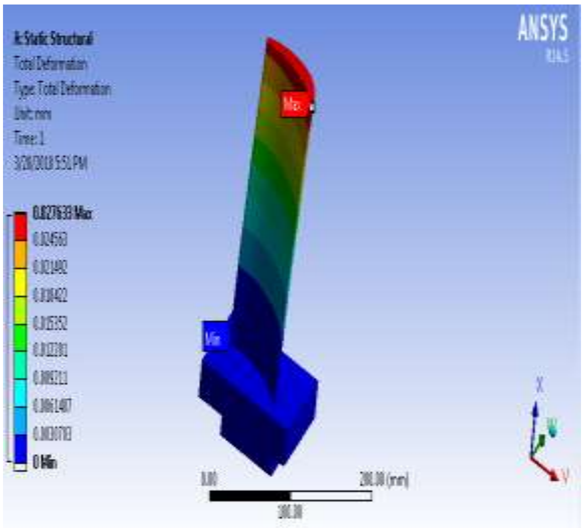
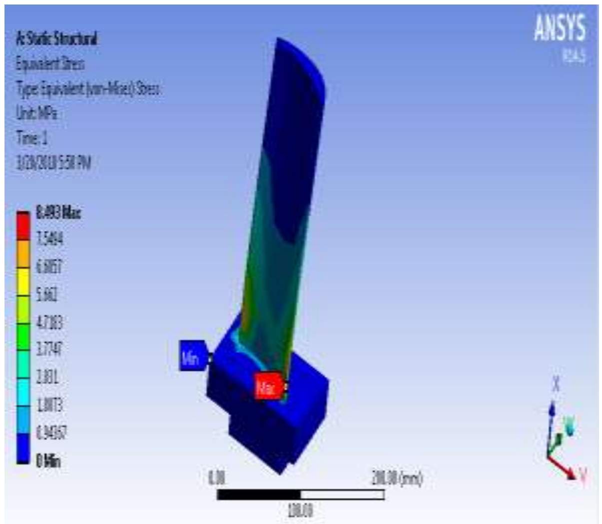
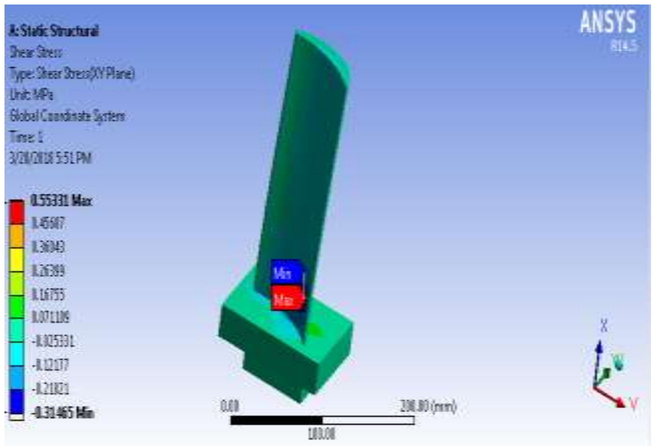


FIG 11 DEFORMATION NIMONIC 80A

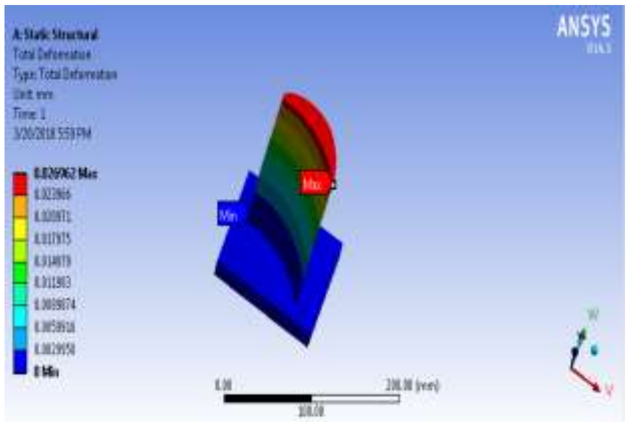
HASTELLOY:



STRESS ON HASTELLOY



SHEAR STRESS ON HASTELLOY



DEFORMATION ON HASTEALLOY

7.2 THERMAL ANALYSIS:

This analysis is performed to find thermal parameters such as Here we observed results on four materials chrome steel, hostelry, and Inconel as shown below figures

7.2.1 CHROME STEEL :

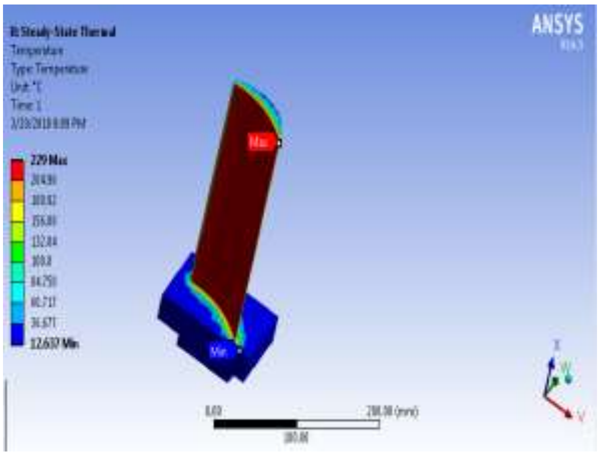


FIG 12 TEMPERATURE DISTRIBUTION CHROME STEEL

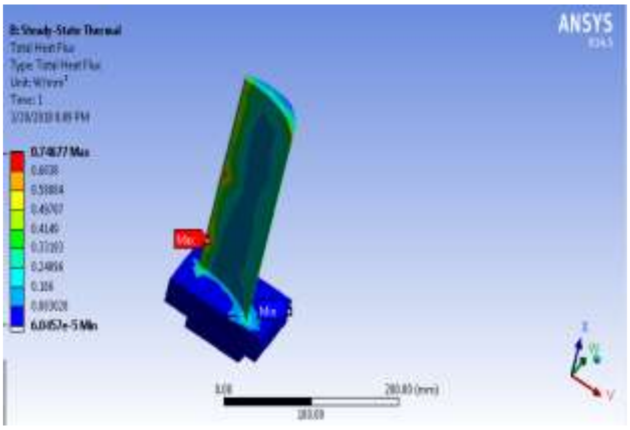


FIG 13 HEAT FLUX CHROME STEEL

32

7.2.2 HASTELLOY:

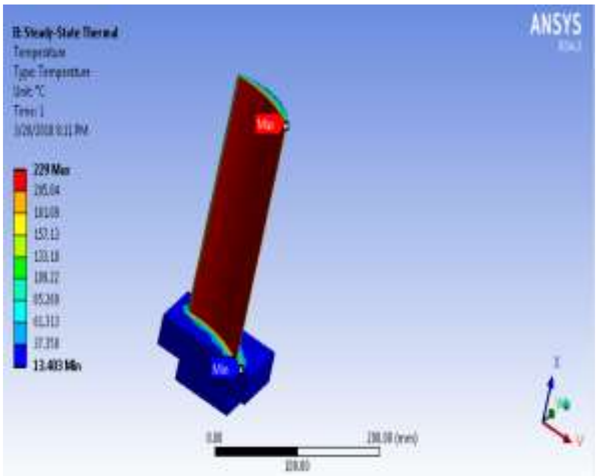


FIG 14TEMPERATURE DISTRIBUTION ON HASTELLOY

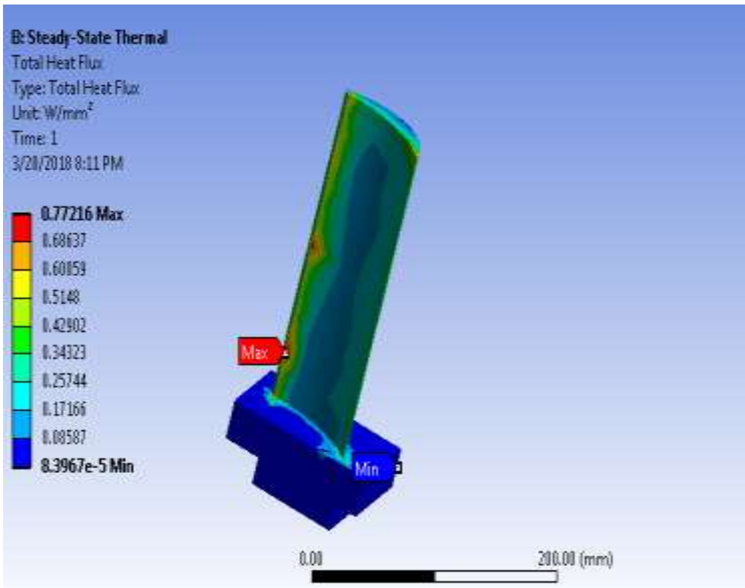
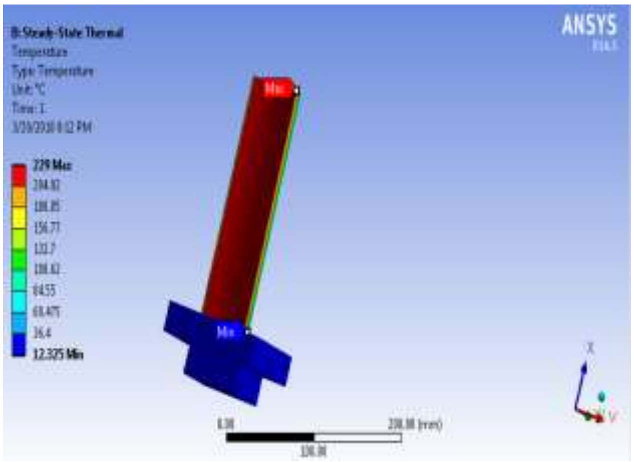
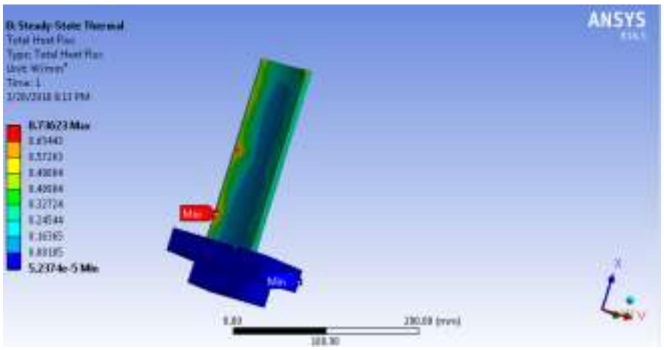


FIG 15 HEAT FLUX ON HASTELLOY

INCONEL 600:



TEMPERATURE DISTRIBUTION ON HASTELLOY



HEAT FLUX ON HASTELLOY

7.3 GRAPH

7.3.1 Stress graph

This graph shows the different maximum stress values in different materials, chrome steel, hastelloy, and Inconel materials, hastelloy has least shear stress value of 8.49Mpa compared to another materials as shown in the graph 1

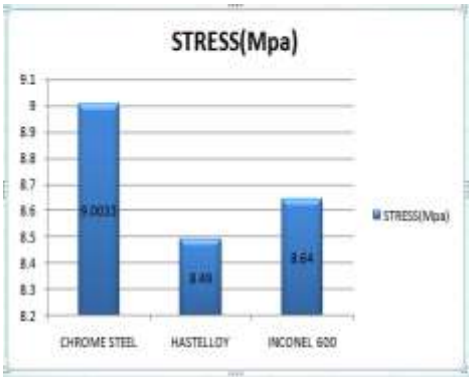


FIG 16 STRESSS GRAPH

7.3.2 Total deformation graph

This graph shows the different total deformation values in different materials, chrome steel, hastelloy, and Inconel, hastelloy material has least total deformation value of 0.0026mm compared to another materials as shown in the graph 1

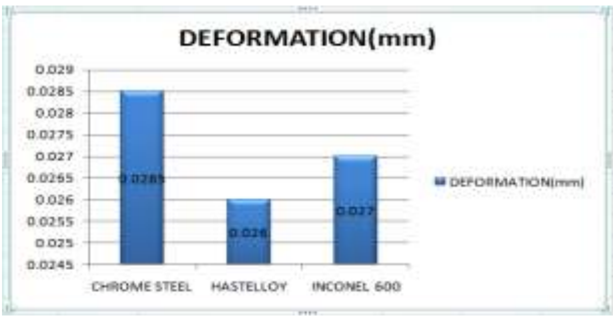
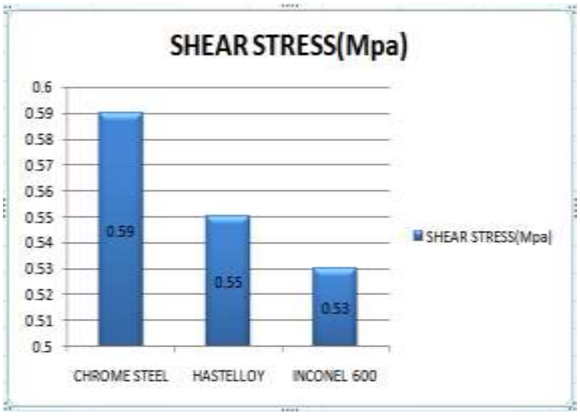


FIG 17 TOTAL DEFORMATION GRAPH

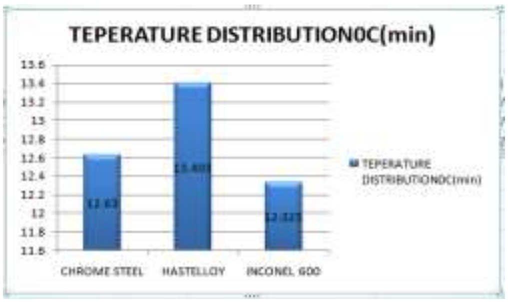
7.3.2 Shearstress graph

This graph shows the different total deformation values in different materials, chrome steel, hastelloy, and Inconel , inconel material has least shear stress compared to another materials 0.53mpa as shown in the graph 1



7.3.3 Temperature distribution graph

This graph shows the different temperature distribution values in different materials, chrome steel, hastelloy, and Inconel , hastelloy has highest temp distribution value of 13.403 (^{0}c)(min) compared to another materials as shown in the graph 2

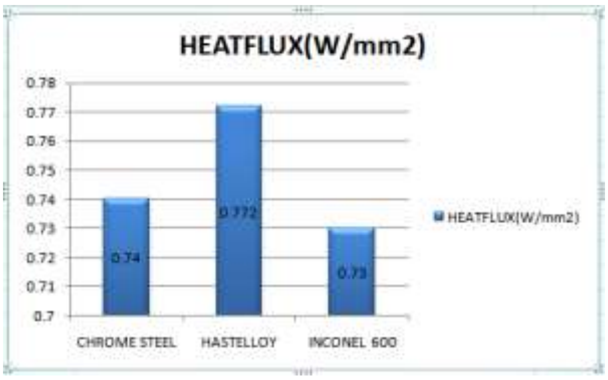


TEMPERATURE DISTRIBUTION (^{0}C)

FIG 18 TEMPERATURE DISTRIBUTION GRAPH

7.3.4 Heat flux graph

This graph shows the different heat flux values in different materials, chrome steel, hastelloy, and Inconel, hastelloy has highest heat flux value of 0.772w/mm^2 compared to another materials as shown in the graph 1



CONCLUSION

Modeling of steam turbine blade is done by using CATIAV5 Software and then the model is imported into ANSYS Software for Structural analysis on the steam turbine blade to check the quality of materials such as, chrome steel, hastelloy, and Inconel. From the obtained Von-misses stresses, shear stress , deformation, temperature distribution and heat flux for the materials, respectively Compared with all materials hastelloy material have less stresses, deformations, and High temperature distribution and heat flux values .Finally from structural analysis and thermal analysis based on results it is concluded that hastealloy material is suitable material for stream turbine .

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