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DESIGN AND THERMAL ANALYSIS OF STEAM TURBINE BLADE USING FEM METHOD

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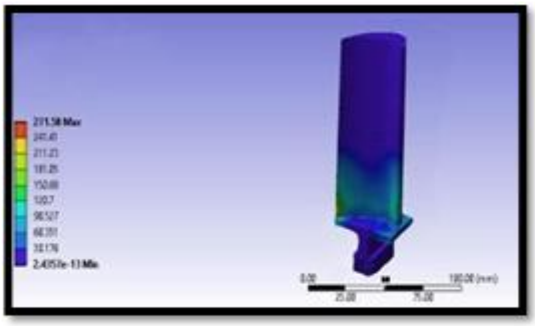
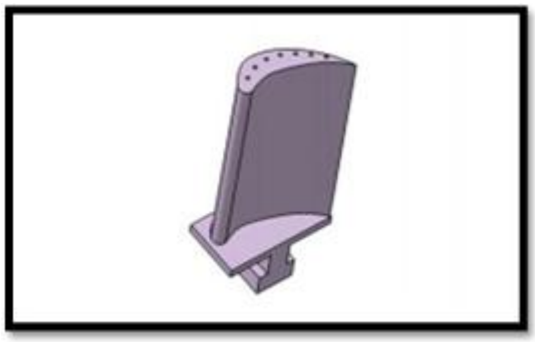
ABSTRACT
The rotor blade of the Steam turbine has been analyses for the static and thermal stresses resulting from the tangential, axial and centrifugal forces. The Steam forces namely tangential, axial was determined by constructing velocity triangles at the inlet and exit of rotor blades. The rotary-wing was then analyzed for the temperature distribution. For obtaining temperature distribution, the convective heat transfer coefficients on the blade surface exposed to the Steam. A steam turbine is an important functional part ofmany applications. Reducing the stresses and increasing fatigue life is the major concern since they are in a high-temperature environment. Various techniques have been proposed for the increase of fatigue life and one such technique is to have axial holes along the blade span. A finite component analysis is used to research thermal and structural performance because of the loading condition, with material properties of structural steel. The finite element analysis of a gas turbine rotor blade is carried out using 20 nodes brick element. Static and thermal analysis is carried out. The temperature contains a vital impact on the general stresses within the rotary engine blades. Thus, blade with 2mm hole is better for suing because thestress obtained is less and the number ofcycles increased when compared to blades with 2, 3 and 4mm holes.

Block Diagrams:





Advantages:

- Thermal efficiency of a steam turbine is usually higher than that of a reciprocating engine
- Very high power-to-weight ratio, compared to reciprocating engines

CHAPTER – 1 INTRODUCTION

1.1INTRODUCTION

Turbo machine rotor blades are subjected to different types of loading such as fluid or gas forces, inertia loads and centrifugal forces.

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Due to these forces various stresses are induced in rotor blades. So, stress and strain mapping on a rotor blade provide a vital information concerning the turbo machine design and lead to the detection of critical blade section. Analysis of static and dynamic behavior of a rotor blade is a basic problem in aero elasticity of turbo machine blades.

PRINCIPLE OF STEAM TURBINE:

The steam energy is converted mechanical work. Expansion takes place through an expansion through the turbine. series of fixed. In each row fixed blades (nozzles) andmoving blades Blade and moving blade are called stage.

Impulse steam turbine:

The steam turbine is a device for obtaining mechanical work from the energy stored in steam. There are two main types of turbines, the 'impulse' and the 'reaction'. The names refer to the type of force which acts on the blades to turn the turbine wheel. The impulse arrangement is made up of a ring of nozzles followed by a ring of blades.

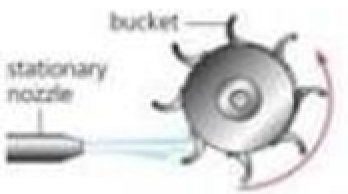

Fig -1.2: IMPULSE STEAM TURBINE

The high-pressure, high-energy steam is expanded in the nozzle to a lower pressure, high-velocity jet of steam. This jet of steam is directed into the impulse blades and leavesin a different direction. The changing direction and therefore velocity produces an impulsive force which mainly acts in the direction of rotation of the turbine blades. There is only a very small end thrust on the turbine shaft.

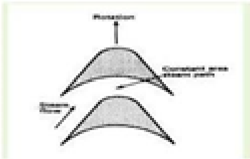

Fig -1.3: IMPLUSE BLADING

The turbine consists of a single rotor he single stage impulse turbine to which impulse blades are attached. The steam is fed through one or several convergent nozzles. If high velocity of steam is allowed to flow through one row of moving blades. It produces a rotor speed of. about 30000 rpm which is too high for practical use.

Reaction steam turbine:

The reaction arrangement is made upof a ring of fixed blades attached to the casing, and a row of similar blades mounted on the rotor, i.e., moving blades. The blades are mounted and shaped to produce a narrowing passage which, like a nozzle, increases the steam velocity. There is also a change in velocity of the steam as a result ofa change in direction and an impulsive force is also produced with this type of blading. The more correct term for this blade arrangement is 'impulse reaction'. A reactionturbine utilizes a jet of Reaction steam turbine: steam
that flows from a nozzle on the rotor

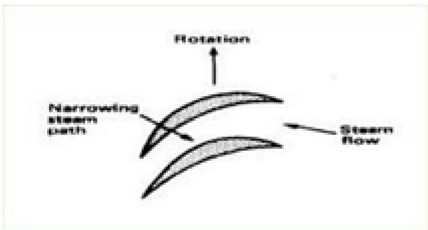

Fig -1.4: REATION TURBINE BLADE

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INTRODUCTION TO CATIA

Program that can combinebetween drawing and design, animation and simulation production and Manufacturing, without need to use more than one program, to produce a single project, until found everything I need in the most comprehensiveprogram on earth "CATIA". This program, which change my point of view in the scienceof mechanical drawing, where it became easier, more flexible and more accurate.

1.1 Module in CATIA:

CATIA consists of modules each Module specialized in specific design field, And I will review now the most famous of these modules

Fig 1.5: Some of CATIA Modules

1.1INTRODUCTION TO ANSYS:

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software Implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then canbe presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex dueto their geometry, scale, or governing equations.

CHAPTER – 2 LITERATURE SURVEY

Many investigators have suggested various methods to explain the effect of stress and loading on turbine blade, rotter 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 andmode shape of the turbine blade. In this paperwe 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 be utilized for the improvement in the design and optimization of the operating conditions.

DR. SHANTHARAJA.M, DR. Kumar.K., was work on the large variety of turbo machinery blade root geometries used in industry prompted the question if an optimum geometry could be found. An optimum blade root was defined, as a root with practical geometry which, when loaded returns the minimum fillet stress concentration factor. The present paper outlines the design modification for fillet stresses and a special

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attention made on SCF of the blade root (T-root) which fails and to guarantee for safe and reliable operation under all possible service conditions. Finite Element Analysis is used to determine the fillet stresses and Peterson's StressConcentration Factor chart is effectively utilized to modify the blade root. The root modified due to the difficulty inmanufacturing the butting surface of the tang that grips the blade to the disk crowns A Review on Analysis of Low-Pressure Stage of Steam Turbine Blade with FEA (ANSYS Software) (IJSRD/Vol. 1/Issue 10/2013/0003). Verify the same using FiniteElement Analysis for two cases with and without the tang in the blade. Firstly, to study the fillet stresses with tang and then Petersonschart is used to reduce the peak stresses with the modification to the butting area and reducing the fillet radius. To conduct the sensitivity analysis for the fillet stresses in blade and disk using FEA.

CHAPTER – 3 MODELLING OF STEAM TURBINE BLADE

3.1 TERMINOLOGY OF STEAM TURBINE BLADE AND BASIC DEFINITIONS

3.1.1. STEAM TURBINE BLADE TERMINOLOGY:

It is necessary to define the parameters used in describing blade shapes and configurations of blade. Blade profiles are usually of airfoil shape for optimum performance, althoughcost is more important than the ultimate in efficiency, simple geometrical shapes composed of circular areas and straight line are often used. Journal of Engineering and Development, Vol. 11, No. 3, December (2007) ISSN 1813-7822 85 The spacing or pitch of the blade is the distance between corresponding points of adjacent blade and is expressed either by the pitch-chord ratio or alternatively the solidity. When the blades are evenly spaced around a rotor, the pitch is the circumference at any radius divided by the number of blades.

NOMINCLATURE OF BLADE

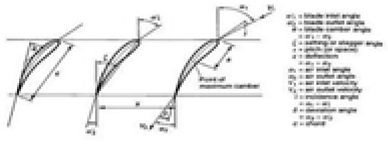

FIGURE4: STEAM TURBINE BLADE NOMENCLATURE

LOAD CALCULATION:

- $F = M \times Vm$
- M=Mass of stream flowing throughturbine
- Vm=velocity of steam in m/s
- M=1000kg/hr
- Vm=1310m/s
- F=362.87N
- Blade area=23319.1mm2
- Pressure =F/A P=0.01556N/mm2

MATERIAL PROPERTIES TAB PROPERTIES:

S.NO	MATERIAL PROPERTIES	STEEL
1.	Density	7860 Kg_m3
2.	Poisson Ratio	0.266
3.	Young's Modulus	2e+011 N_m2
4.	Thermal Expansion	1.17e-005_Kdeg
5.	Yield Strength	2.5e+008 N_m2
6.	Thermal Conductivity	14.0 W/m/K
7.	Melting point	2500-2800

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3D MODELLING OF TURBINEBLADE IN CATIA V5

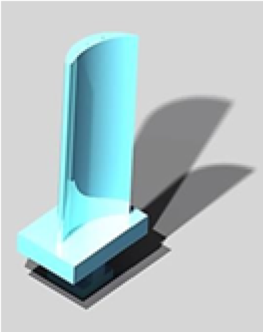
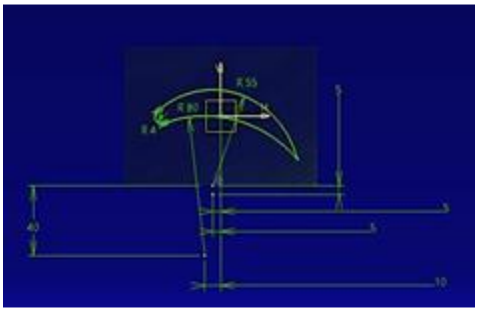
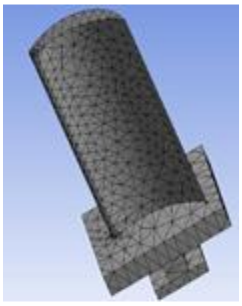


Fig 3.1 STEAM TURBINE

Fig 3.2 CATIA MODELLING OF BLADE





AERO DYNAMIC PROFILE

Height = 200mm Structure = Aerodynamic Thickness = 15.263mm ~ 15.5mm.

CHAPTER – 4 THERMAL ANALYSIS OFSTEAM TURBINE BLADE

Case 1: Turbine Blade with our hole

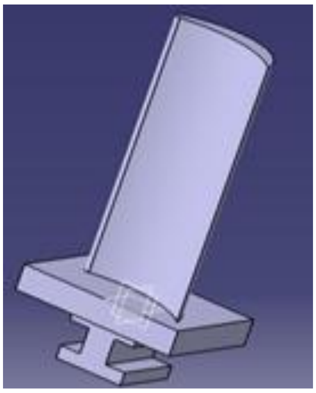


Fig4.1 CAD Model

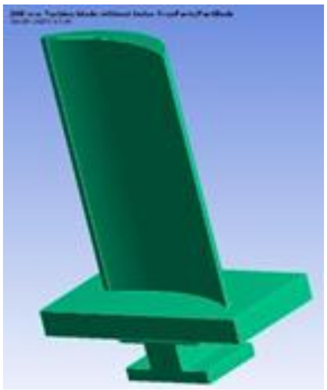


Fig4.2 Ansys Import model

Fig4.3 Mesh Model

Boundary Condition: Temperature: 229deg andConventional Co-efficient:2.5E-3 W/mm^2 ^{o}C

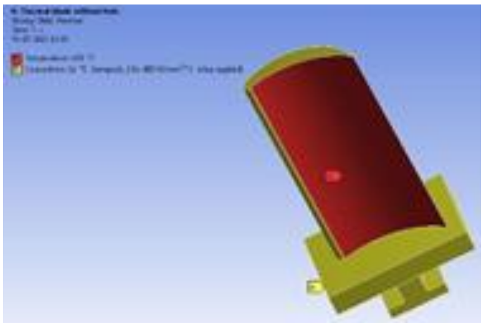


Fig4.4 Temperature and Convectional Co-efficient

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Result:

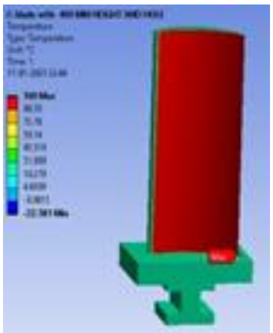

Fig4.5Temperatur Distribution

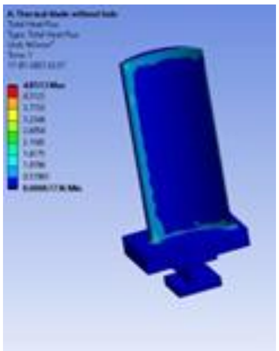

Fig4.6 Heat Flux

CHAPTER – 5 STATIC THERMAL ANALYSISOF STEAM TURBINE BLADE

Case 1&2: Turbine Blade with out hole & TurbineBlade with Hole height 200mm

Load and Boundary Condition:Fixed bottom and Pressure load: 1.55E-2 MPA

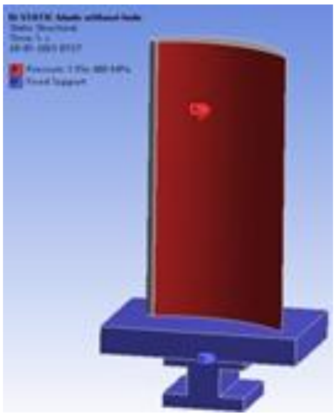

Fig5.1 Blade without hole

Fig5.3 Blade with Hole height400mm

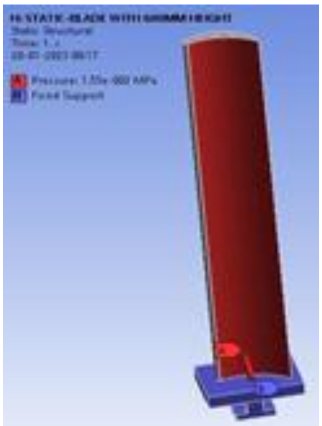

Fig5.4 Blade with Hole height600mm

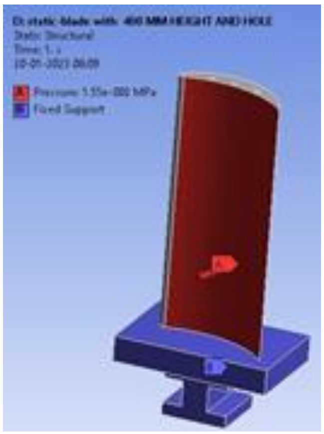

Fig5.2 Blade with Hole height200mm

Case 3 & 4: Turbine Blade with Holeheight 400mm & Turbine Blade with Hole height 600mm

Load and Boundary Condition:Fixed bottom and Pressure load: 1.55E-2 MPA

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CHAPTER – 6 DEFORMATION & VON MISESSTRESS IN STEAM TURBINE BLADE

Case 3: Turbine Blade withHole height 400mm

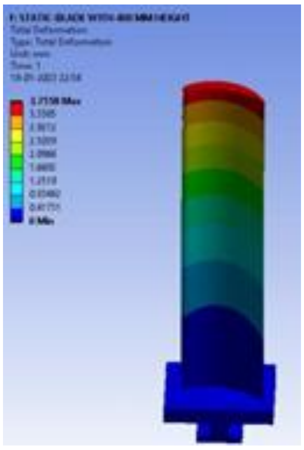

Fig6.1 DEFORMATION

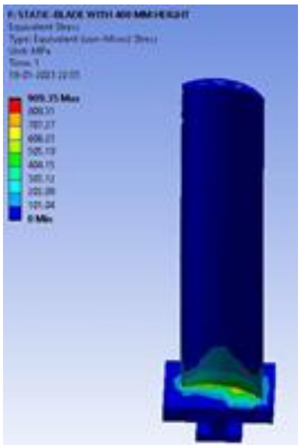

Fig6.2 VONMIESES STRESS

CHAPTER – 7 VONMISSES STRAIN AND SHEAR STRESS FORMED IN STEAM TURBINE BLADE

Case 3: Turbine Blade withHole height 400mm

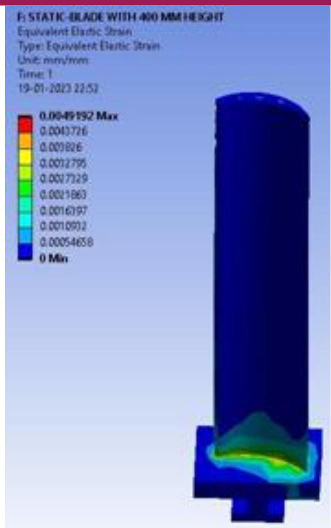

Fig7.1 VON MISES STRAIN

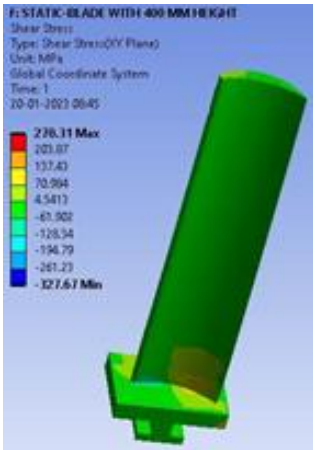

Fig7.2 SHEAR STRESS

RESULTS

THERMAL ANALYS RESULT TABLE

S.NO.	DETAILS	TEMP(DEG)	HEAT FLUX (W/MM2)
1	SOLID MODEL	229	4.851
2	200MM HT	229	3.641
3	400MM HT	229	3.634
3	600MM HT	229	2.524

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STATIC THERMAL ANALYS RESULT TABLE

S. NO.	DETAILS	DEF(MM)	STRESS (MPA)	STRAIN (MM/MM)	SHEAR STRESS (MPA)
1	SOLID MODEL	1.01	153.65	0.00574	170.54
2	200MM HT	1.06	188.18	0.00435	199.74
3	400MM HT	3.75	202.08	0.00491	203.31
3	600MM HT	9.72	279.87	0.0487	283.09

CONCLUSION AND FUTURESCOPE OF WORK

Modelling of steam turbine blades with (2mm,3mm,4mm) and without holes is done by using CATIAV5 Software and then the model is imported into ANSYS Software for Structural analysis and thermal analysis on the steam turbine blade to check the quality of materials such as Stainless Steel. Vo misses Stress obtained for the steam turbine blade with 2mm Stainless Steel is 11.693Mpa this is best output compared to remaining materials. Equivalent strain also concluded the Stainless Steel material with 2mm holes obtained value is 0.056, In temperature distribution point of view Stainless Steel is the better temperature distribution obtained value is 1.127, finally Total heat flux also Stainless Steel Material is rate of heat transfer also high obtained value is 1.7452 in all conditions satisfied this material this corrosion resistance of Stainless Steel in oxidising atmospheres is excellent - this includes heating and cooling conditions. This protection is due to the chromium oxide film formed on the surface of the alloy, which also offers resistance at elevated temperatures.

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