Thermal Analysis of Turbine Blade Using Ansys Software

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Abstract:

In this thesis thermal analysis of turbine blade using the Titanium –based alloy with the ANSYS workbench 14.0 was carried out. The goal is here is to reduced the temperature of the turbine blade then automatically decreased the cost and fuel efficiency as well as the increased the life of the turbine blade with the using of ANSYS workbench 14.0.and find the optimum solution of thermal analysis of turbine blade in steady state gas flow carried out.

In there were a challenging how to reduced the temperature in high environment we find out the optimization solution in Using ANSYS Workbench 14.0 software a steady state gas flow analysis was carried out, and the pressure and temperature distributions and velocity vectors and streamlines were delineated. Then, by mapping these results on the other section of it equivalent stresses and total deformation were determined.

Keywords: ANSYS, CATIA, Turbine Blades, Titanium alloy.

1 INTRODUCTION:

Gas turbines play a vital role in the today's industrialized society, and as the demands for power increase, the power output and thermal efficiency of gas turbines must also increase.

The gas turbine is an internal combustion engine that uses air as the working fluid. using the gaseous energy of the working fluid (air) to drive the engine and propeller, which, in turn, propel the airplane .Gas turbine is an Important functional part of many applications. Cooling of blades has been a major concern since they are in a high temperature environment.

A gas turbine, also called a combustion turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between. The basic operation of the gas turbine is similar to that of the steam power plant except that air is used instead of water. Fresh atmospheric air flows through a compressor that brings it to higher pressure. Energy is then added by spraying fuel into the air and igniting it so the combustion generates a high-temperature flow. This high-temperature high-pressure gas enters a turbine, where it expands down to the exhaust pressure, producing a shaft work output in the process. The turbine shaft work is used to drive the compressor and other devices such as an electric generator that may be coupled to the shaft. The energy that is not used for shaft work comes out in the exhaust gases, so these have either a high temperature or a high velocity. The purpose of the gas turbine determines the design so that the most desirable energy form is maximized. Gas turbines are used to power aircraft, trains, ships, electrical generators, or even tanks.

The number of turbine stages varies in different types of engines, with high bypass ratio engines tending to have the most turbine stages. The number of turbine stages can have a great effect on how the turbine blades are designed for each stage. Many gas turbine engines are twin spool designs, meaning that there is a high pressure spool and a low pressure spool. Other gas turbines used three spools, adding an intermediate pressure spool between the high and low pressure spool.

The high pressure turbine is exposed to the hottest, highest pressure, air, and the low pressure turbine is subjected to cooler, lower pressure air. That difference in conditions leads the design of high pressure and low pressure turbine blades to be significantly different in material and cooling choices even though the aerodynamic and thermodynamic principles are the same.

2 EXPERIMENTAL DETAILS:

2.1 CATIA software:

CATIA (Computer Aided Three-dimensional Interactive Application) (in English usually pronounced /kəˈtiə/) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Desalt Systems. Written in the C++ programming language, CATIA is the cornerstone of the Desalt Systems product lifecycle management software suite.

2.1.1 Scope of application:

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development (CAx), from conceptualization, design (CAD), manufacturing (CAM), and engineering (CAE). CATIA facilitates collaborative engineering across disciplines, including surfacing & shape design, mechanical engineering, equipment and systems engineering. CATIA provides a suite of surfacing, reverse engineering, and visualization solutions to create, modify, and validate complex innovative shapes. From subdivision, styling, and Class A surfaces to mechanical functional surfaces.

2.2 ANSYS :

ANSYS is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers. So ANSYS, which enables to simulate tests or working conditions, enables to test in virtual environment before manufacturing prototypes of products. Furthermore, determining and improving weak points, computing life and foreseeing probable problems are possible by 3D simulations in virtual environment. ANSYS software with its modular structure as seen in the table below gives an opportunity for taking only needed features. ANSYS can work integrated with other used engineering software on desktop by adding CAD and FEA connection modules. A steady state gas flow analysis ANSYS Workbench 14.0 software.

Material: Titanium Alloy

Table 1.1 Statistic

Nodes	**140285**
Elements	**81910**
Mesh Metric	**None**

Table 1.2 Steady State Thermal

Physics Type	**Thermal**
Analysis Type	**Steady- State**
Solver Type	**Mechanical APDL**

Table 1.3 Steady-State Thermal Initial Condition

Initial Temperature	**Uniform Temperature**
Initial Temperature value	**22^0C**

Material Data:

Titanium Alloy:

Table 1.4 Steady-State Thermal Analysis

Step Controls

Density	**4620 kg/m^3**
Coefficient of Thermal Expansion	**9.4e-006 C^{-1}**
Specific Heat	**522 Jkg $^{-1}C^{-1}$**
Thermal Conductivity	**21.9 Wm^{-1} C^{-1}**
Resistivity	**1.7e-006 ohm m**

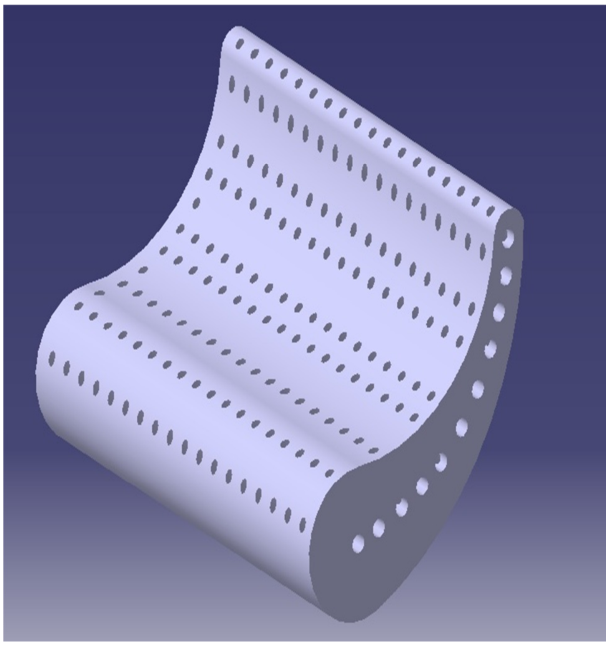

Figure 1.2 In this figure blade consisting of holes.

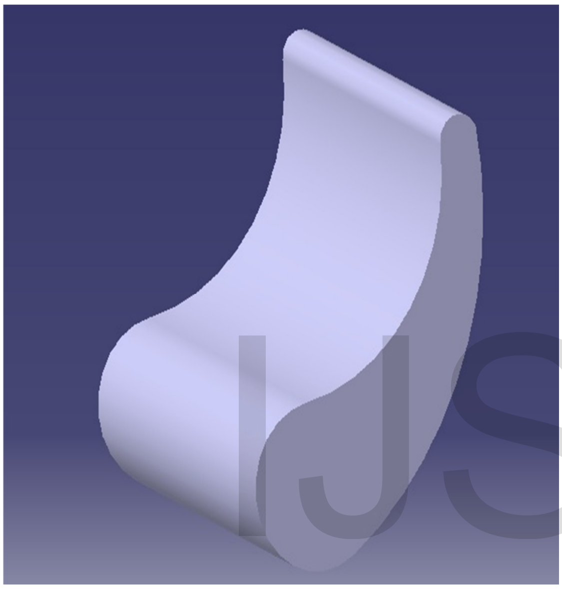

Figure 1.1 Solid diagram of turbine blade in CATIA

Step	Step End Time
1	1.s
2	2.s
3	3.s
4	4.s
5	5.s
6	6.s
7	7.s
8	8.s
9	9.s
10	10.s

Table 1.5 Steady-State Thermal Temperatures

Step	Time	Temperature [°C]
0	0	0
1	1	500
2	2	1000
3	3	1500
4	4	2000
5	5	2500
6	6	3000
7	7	3500
8	8	4000
9	9	4500
10	10	5000

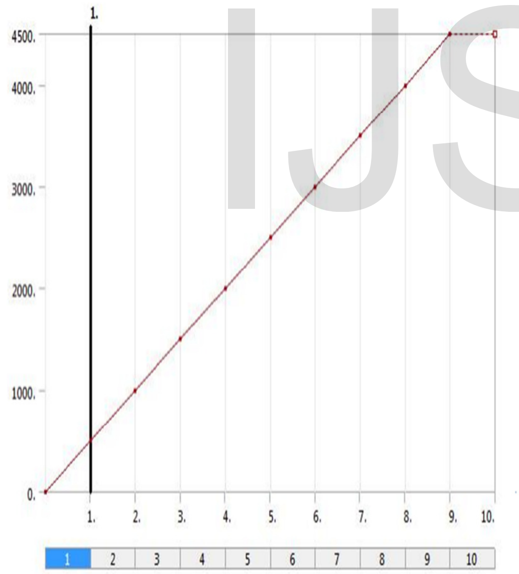

Figure 1.3 temperature and time

Figure 1.4 mesh part of turbine blade using ANSYS software .

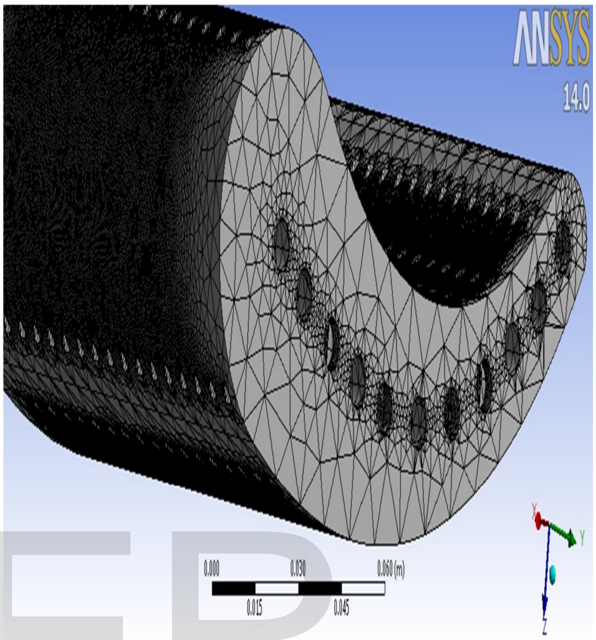

Figure 1.5 mesh part of turbine blade using ANSYS software .

3 RESULT:

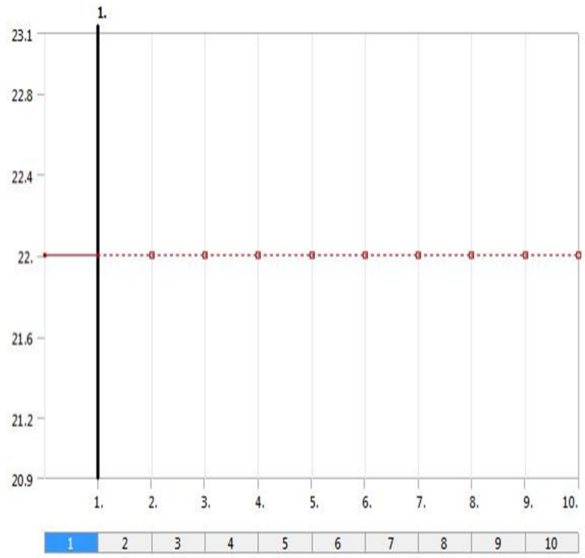

Figure 1.6 Ambient temperature and time

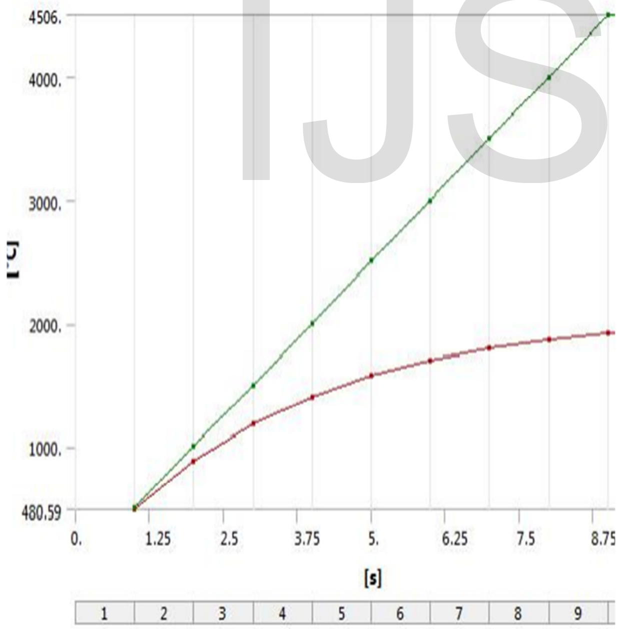

Figure 1.7 Steady- Solution Thermal State Thermal Error

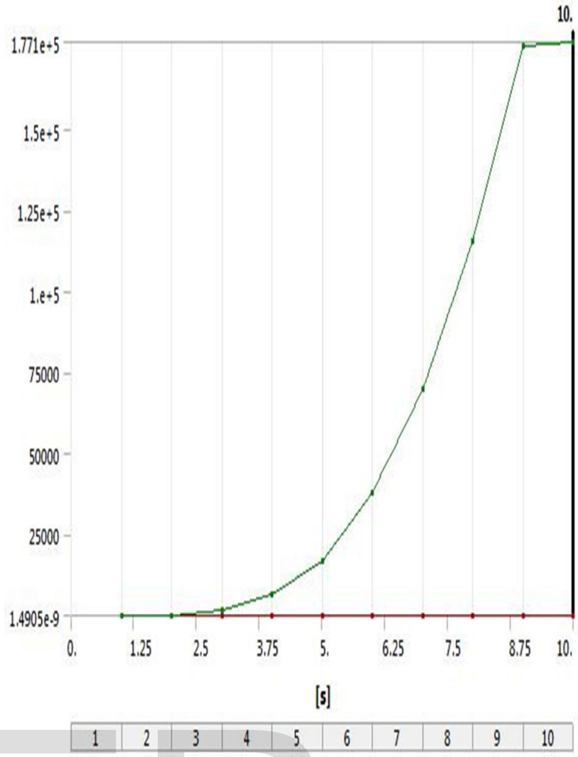

Figure 1. Steady- Solution Thermal State Thermal Error

Tabel 1.6 Steady- Solution Thermal State Thermal Error

Time	Minimum	Maximum
1	1.4905e-009	4.5255
2	6.7211e-008	184.41
3	6.6858e-007	1607.1
4	3.1525e-006	**6650.8**
5	8.5968e-006	16790
6	2.1646e-005	37772
7	4.3778e-005	**69912**
8	7.7679e-005	1.1545e+005
9	1.2545e-004	1.757e+005
10	1.267e-004	1.771e+005

Table1.7Steady-State Thermal Solution Directional Heat Flux

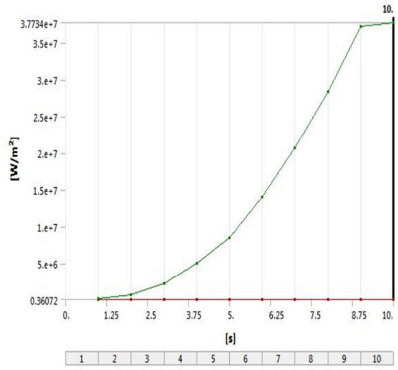

Figure 1.9 **Steady state thermal heat flux**

Time [s]	Minimum [W/m²]	Maximum [W/m²]
1.	**0.36072**	**1.0237e+005**
2.	**2.3532**	**6.6489e+005**
3.	**7.0225**	**2.1943e+006**
4.	**14.138**	**4.9904e+006**
5.	**22.256**	**8.4467e+006**
6.	**32.015**	**1.3971e+007**
7.	**41.392**	**2.0616e+007**
8.	**50.436**	**2.8401e+007**
9.	**58.993**	**3.7241e+007**
10.	**58.728**	**3.7734e+007**

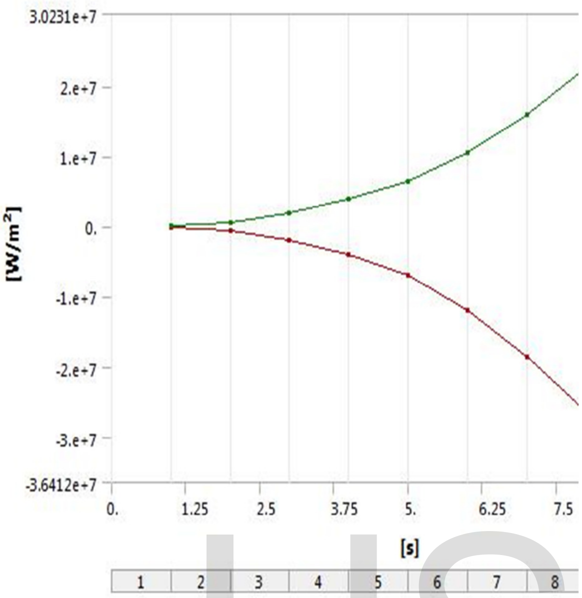

Figure 1.10 **Directional Heat Flux**

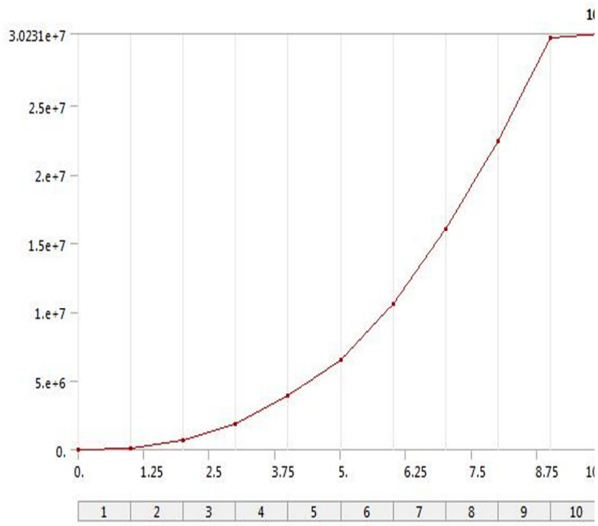

Figure 1.11 Steady-State Thermal Solution Heat Flux Probe

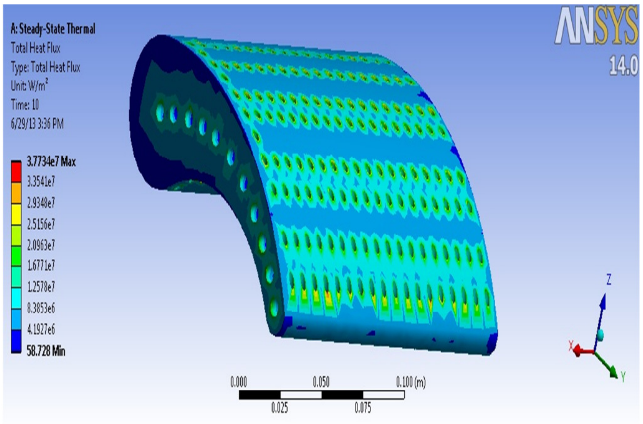

Figure 1.12 HEAT FLUX IN TURBINE BLADE

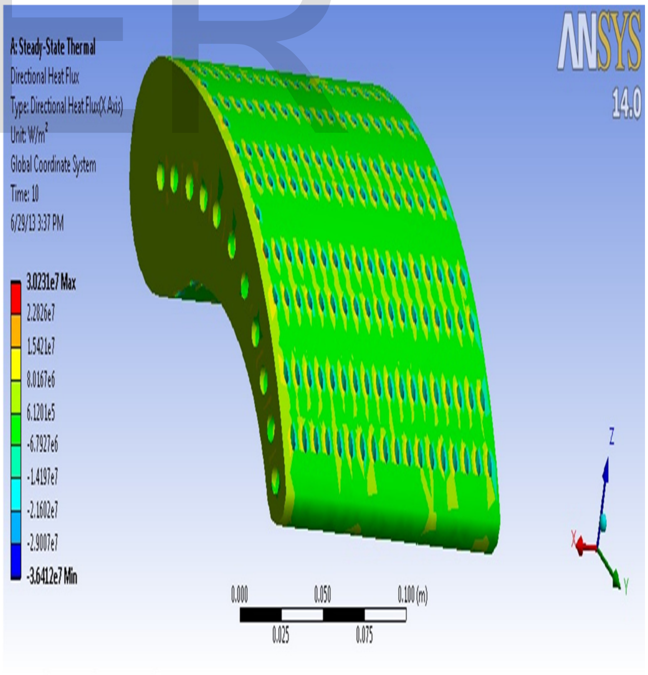

***Figure 1.13 this figure the turbine blade using* ANSYS software .**

in this figure a steady state thermal and applied the total heat flux

in X direction of the turbine blade modal.

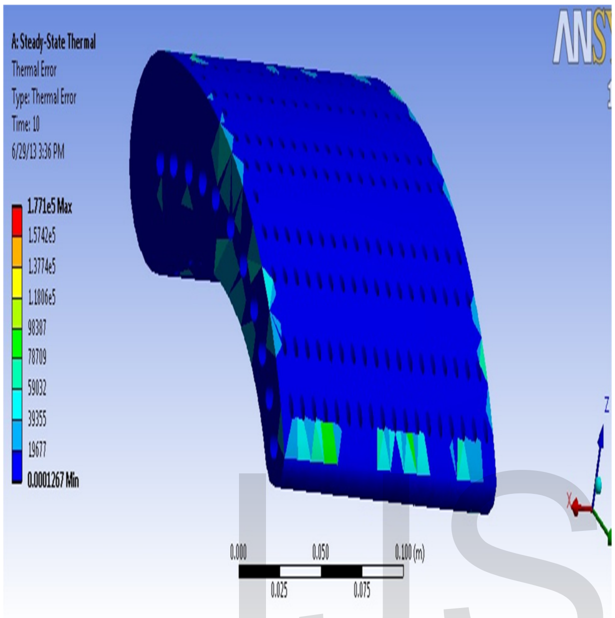

Figure 1.14 Thermal \Error

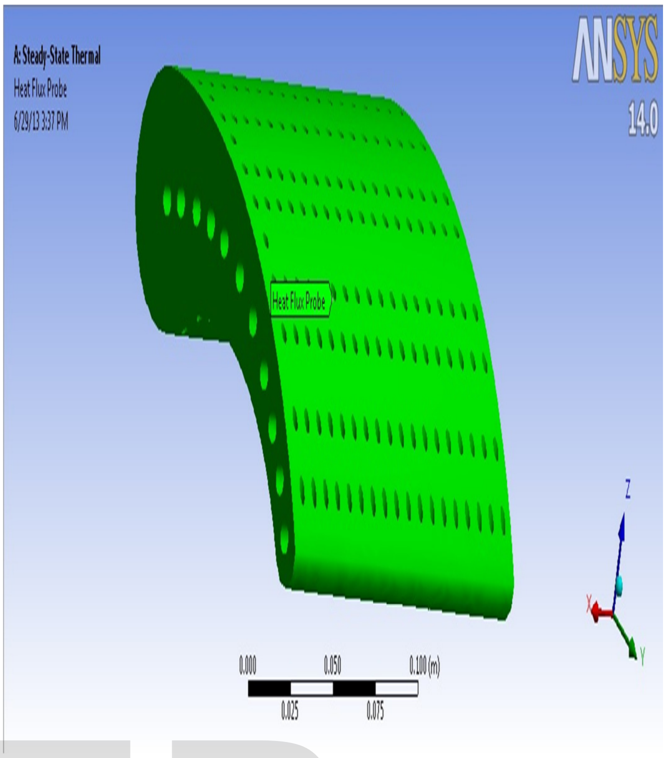

Figure 1.15 this figure the turbine blade using ANSYS software .

in this figure a steady state thermal and applied the total heat flux

in probe the turbine blade modal.

4 CONCLUSION:

As a conclusion the objective in thermal analysis of turbine blade has been achieved by using ANSYS workbench 14.0. The failure analysis of a gas turbine blades made of Titanium –based alloy . There were a large number of cracks at different regions of blades because of operation at high temperatures and stresses for a long period of time.

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