International Journal of Research in Advent Technology, Special Issue, March 2019
E-ISSN: 2321-9637
3rd National Conference on Recent Trends & Innovations In Mechanical Engineering
15th & 16th March 2019
Available online at www.ijrat.org

CFD And Heat Transfer Analysis Of Air Craft Gas Turbine Blade

[1,2]MR.B.Sai Venkata Krishna, [3]DR.S.Chakradhar Goud
[1]Research Scholar, [2]Asst.Professor, [3]Principal
[1]Department of ME, Shri Jagdishprasad Jhabarmal Tibrewala University
[2]Department of ME,Megha Institute of Engineering and Technology for Women.Ghatkesar.
[3]Department of ME, Moghal College of Engineering and Technology.

Abstract : Gas turbines are widely used for propulsion aircraft, power generation on land and industrial applications. The thermal efficiency of the gas turbine has been improved by increasing the input temperature of the turbine rotor. The input temperature of the advanced gas turbine is higher than that of the blade. A sophisticated cooling system should be developed to ensure safe and continuous operation of high performance gas turbines. The gas turbines are cooled externally and internally. Several methods of cooling blades and blades were suggested. Techniques that include cooling of blades and codes using cooling methods are external cooling and internal cooling. In this paper the turbine code was designed in the CREO program. Gas turbine blades are designed for cooling methods as well as film cooling in external cooling and thermal cooling in internal cooling. The turbine blade is designed with thermal cooling for four holes and 6 holes. The film cools the air into the blade through several small holes in the chassis. CFD analysis to determine heat transfer rates, heat transfer coefficients for the blade. Thermal analysis to determine temperature distribution, heat flow and static analysis to determine the deformation, stress and stress of each of the codes in the ANSYS program. The current materials used for the blade are chromed steel. In this work, they are replaced by composite materials from ceramic matrix and silicon carbide.

Keywords: Ansys14.5, gas turbine, rotor blade, steady state thermal analysis

1. INTRODUCTION

***1.1 Introduction To Turbine*:** The word "turbine" was formulated in 1822 by the French mining engineer Claude Borden of the Latin turbines, or vortex, in the memoirs of "Des turinas hidráulicas rotatoires à grande vitas" Paris Benoit Fornoron, former student of Claude Borden, built the first practical water turbine. The turbine is a rotary engine that draws energy from the fluid flow and makes it a useful job. The simplest turbines contain a moving part, a rotating assembly, a shaft or a drum with joined vanes. The fluid moves on the blades, or the blades interact with the flow, moving and moving the rotational energy towards the rotor. Gas, steam and water turbines often contain a wrap around the blades that contain and control the working fluid.

***1.2 Steam Turbine*:** Steam turbines are a device that extracts heat energy from compressed steam and uses it to conduct mechanical work on a rotary output shaft. Its modern appearance was invented by Sir Charles Parsons in 1884. Because the turbine generates rotary motion, it is particularly suitable for use in the operation of a generator: nearly 90% of all US electricity generation is through steam turbines. The steam turbine is a form of thermal engine that derives much of its improvement in thermodynamic efficiency through the use of multiple stages in vapor expansion, leading to a closer approximation to the ideal reverse process.

Fig: 1.1 Steam Turbine

The compressor is a mechanical device that increases the pressure of the gas by reducing its size. The compressors are similar to the pumps: each one increases the pressure on the liquid, and both can transfer the fluid through a tube. As the gases are compressible, the compressor also reduces the volume of gas. The fluids are relatively compressible. While some can be compressed, the main procedure of the pump is pressure and fluid transfer. The combustion chamber is part of the engine in which the fuel is burned. Power is added to the gas stream in combustion, where the fuel mixes with the air and ignites. In a high combustion environment, the combustion of the fuel increases the temperature. The combustion products are forced into the turbine section. The turbine is a rotary engine that draws energy from the fluid flow and makes it a useful job. The simplest turbines contain a moving part, a rotating assembly, a shaft or a drum with joined vanes. The transfer of fluid acts on the blades, or the blades interact with the flow, moving and moving the energy of rotation towards the rotor.

1.3 Working Cycle

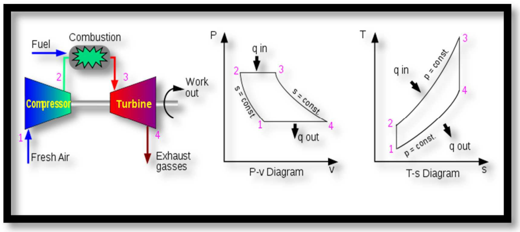


Fig: 1.2 Working Cycle

2. METHADOLOGY

A working fluid contains potential energy (pressure head) and kinetic energy (velocity head). The fluid may be compressible or incompressible. Several physical principles are employed by turbines to collect this energy:

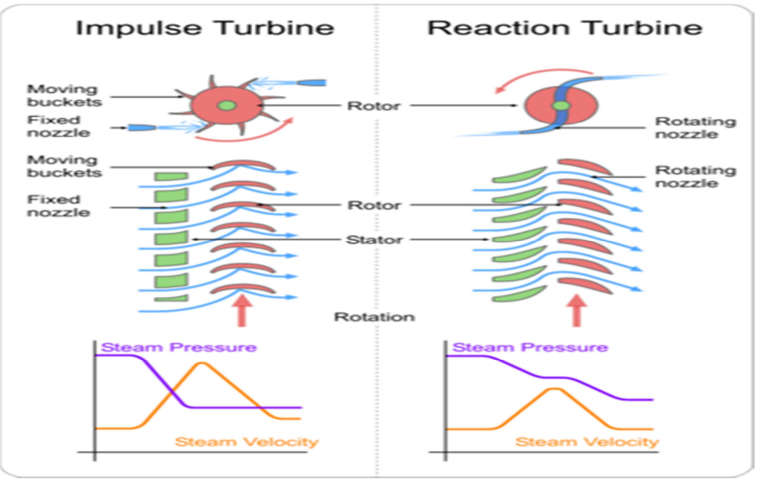


Fig: 1.3 Impulse and reaction Turbines

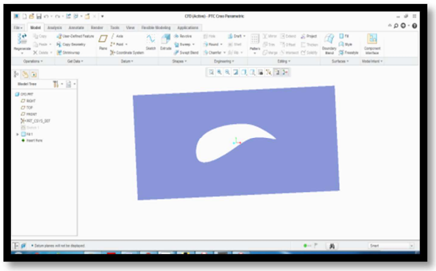
Impulse turbines Change the direction of the flow of high-speed liquid or jet gas. The resulting impulse activates the turbine and leaves fluid flow with low kinetic energy. There is no change in the pressure of the liquid or gas in the blades of the turbine (the blades in motion), as in the case of steam turbines or gas turbines, every pressure drop occurs in the fixed blades (nozzles). Before reaching the turbine, fluid pressure is changed to speed, which leads to the acceleration of the liquid using a nozzle. Belton wheels and Laval turbines use this process exclusively. The driving turbines do not require pressure movement around the rotor because the nozzle creates the liquid jet before reaching the rotor lining. Newton's Second Law describes the transfer of power to the propulsion turbines.

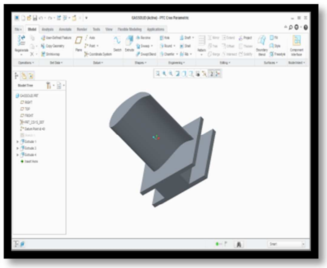
Reaction turbines Develop the torque when reacting with the pressure or mass of gas or liquids. Gas pressure or fluid changes must be submerged as they pass through the turbine phase of the rotor (or rotor) or the turbine completely into the fluid flow (eg, wind turbines). The cover contains and directs the operating fluid. For water turbines, it maintains the suction of the suction tube. Francis turbines and most steam turbines use this concept. For compressible working liquids, multiple phases of the turbine are normally used for efficient gas expansion. Newton's third law describes the transfer of energy to reaction turbines.

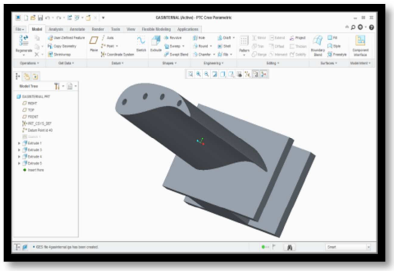
3. LITERATURE SURVEY

PAPER 1- Design and Analysis of Gas Turbine Blade by Theju V, Uday P S , PLV Gopinath Reddy , C.J.Manjunath The objective of this project is to design and analyze the turbine turbine's stress. An investigation is required to use new materials. In the current work, the turbine blade is designed with two different materials called Inconel 718 and Titanium T-6. An attempt was made to verify the effect of temperature and pressure induced on the turbine code. A thermal analysis was performed to investigate the direction of the temperature flow that evolved due to convection. A structural analysis was carried out to investigate the efforts, cutting efforts and displacement of the turbine blade that evolved due to the effect of coupling thermal loads and centrifugation. We also try to suggest the best material for the turbine code that compares the results obtained for two different substances (Inconel 718 and titanium T6). Depending on the graphics and results, Inconel718 can be considered the best economic material, in addition to having good physical properties at a higher temperature compared to titanium T6. PAPER 2- Heat Transfer Analysis of Gas Turbine Blade Through Cooling Holes by K Hari Brahmaiah , M.Lava Kumar In advanced gas turbines, the operating temperature of the turbocharger operates above the melting point of the blade material. A sophisticated cooling system must be developed to ensure the safe and continuous operation of high performance gas turbines. Various methods for cooling the blades have been proposed. One of these techniques is to have radial holes to pass the cooling air at high speed along the length of the blade. The analysis of the heat transfer of the gas turbine was carried out in four different models of blades without holes and blades with several holes (5, 9 and 13). Reinforced Wall). When evaluating the graphics for total heat transfer and heat distribution, the code is 13 holes optimal. The static thermal and structural analysis is carried out through the use of ANSYS with different materials of chromed steel blades and Inconel718. While the comparison of these materials Inconel718 is the best thermal properties, the induced pressure is lower than that of chromium steel. PAPER 3 - Film Cooling of the Gas Turbine Endwall by Discrete-Hole Injection by M. Y. Jabbari, K. C. Marston, E. R. G. Eckert and R. J. Goldstein The cooling performance of the film for injection is investigated through discrete orifices at the end of a turbine blade. Effectiveness is measured at 60 locations in the region covered by injection. Three nominal blow rates, two density ratios and two approach Reynolds flow numbers are examined. The analysis of the data reveals that even 60 locations are insufficient to determine the field of film cooling effect with its strong local variations. The visualization of the traces of the coolant jets on the surface of the terminal wall, using diazo ammonium paper, provides qualitative information useful for the interpretation of the measurements, revealing the trajectories and the interaction of the jets, which change with the speed of blowing and the density ratio.

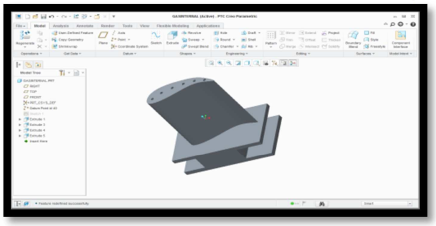
4. RELEATED STUDY

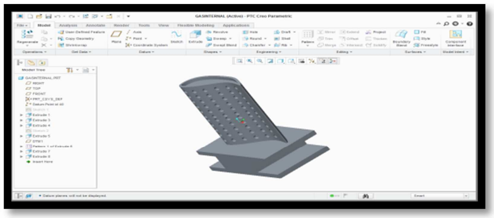

Model of Gas Turbine Blade

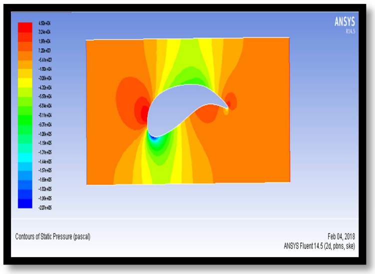

Without Holes


With 4 Holes

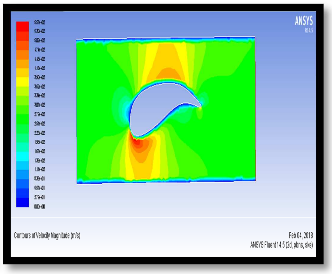
WITH 6 HOLES WITH HOLES (FILM COOLING) GAS TURBINE MODEL



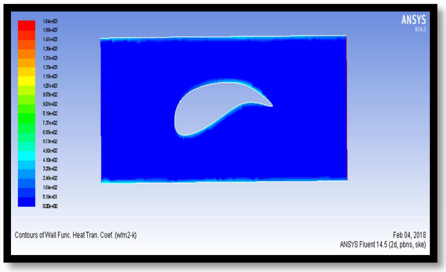




PRESSURE



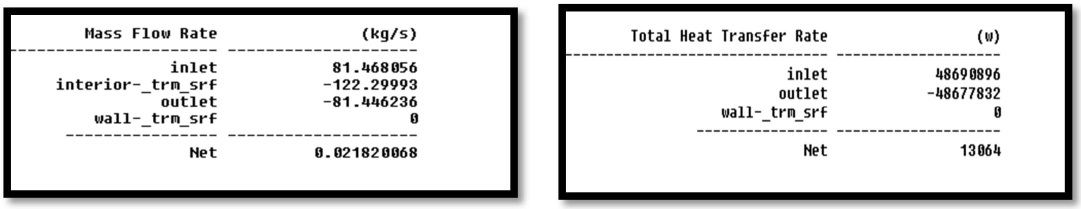
VELOCITY



HEAT TRANSFER COEFFICIENT

MASS FLOW RATE

HEAT TRANSFER RATE

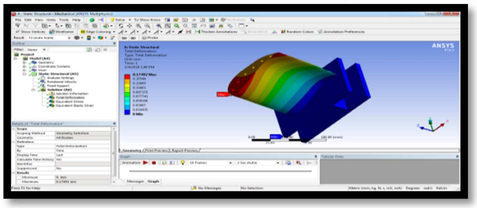


```
         Mass Flow Rate                 (kg/s)
-------------------------------- --------------------
                  inlet               81.468056
      interior-_trm_srf              -122.29993
                 outlet              -81.446236
           wall-_trm_srf                      0
         ----------------------- --------------------
                    Net             0.021820068
```

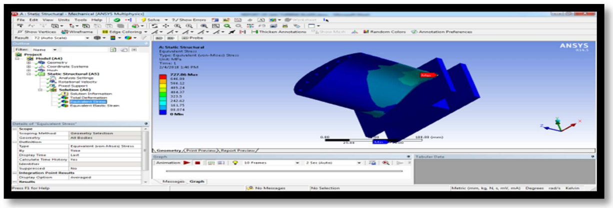
```
         Total Heat Transfer Rate                  (w)
-------------------------------- --------------------
                           inlet             48690896
                          outlet            -48677832
                    wall-_trm_srf                   0
                ---------------- --------------------
                             Net                13064
```

Fig: CFD Analysis of Gas Turbine Blade

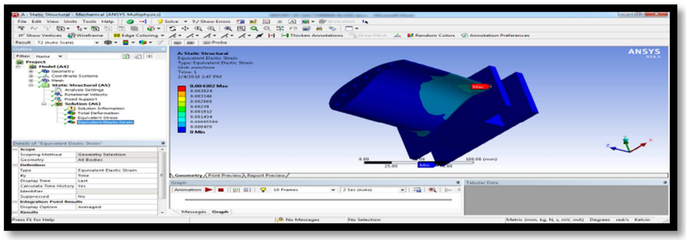
WITH 6 HOLES (convection cooling) MATERIAL - CHROMIUM STEEL



DEFORMATION

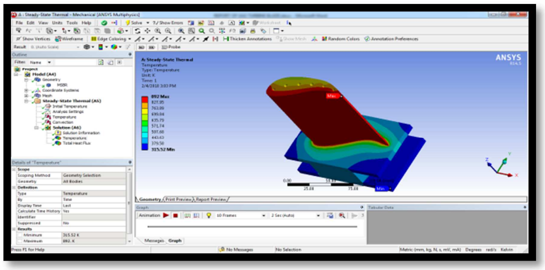


STRESS

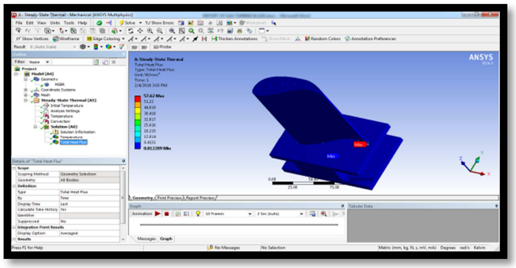


STRAIN

MATERIAL - SILICON CARBIDE



TEMPERATURE DISTRIBUTION



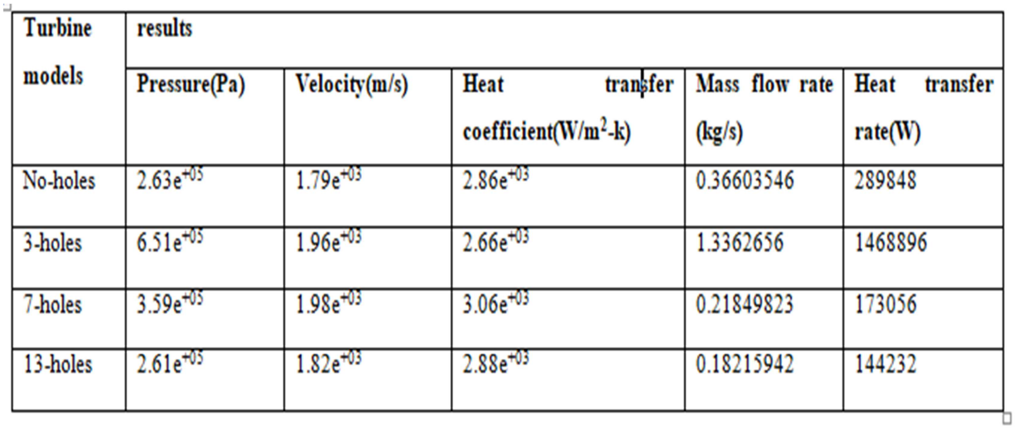
HEAT FLUX

According to the above contour plot, the maximum heat transfer coefficient of the gas turbine blade at surface edges of the turbine blade boundary edges and minimum heat transfer coefficient inside the boundary of turbine blade.

According to the above contour plot, the maximum heat transfer coefficient is 2.88e+03w/m^2-k and minimum heat transfer coefficient is 1.44e+02w/m^2-k.

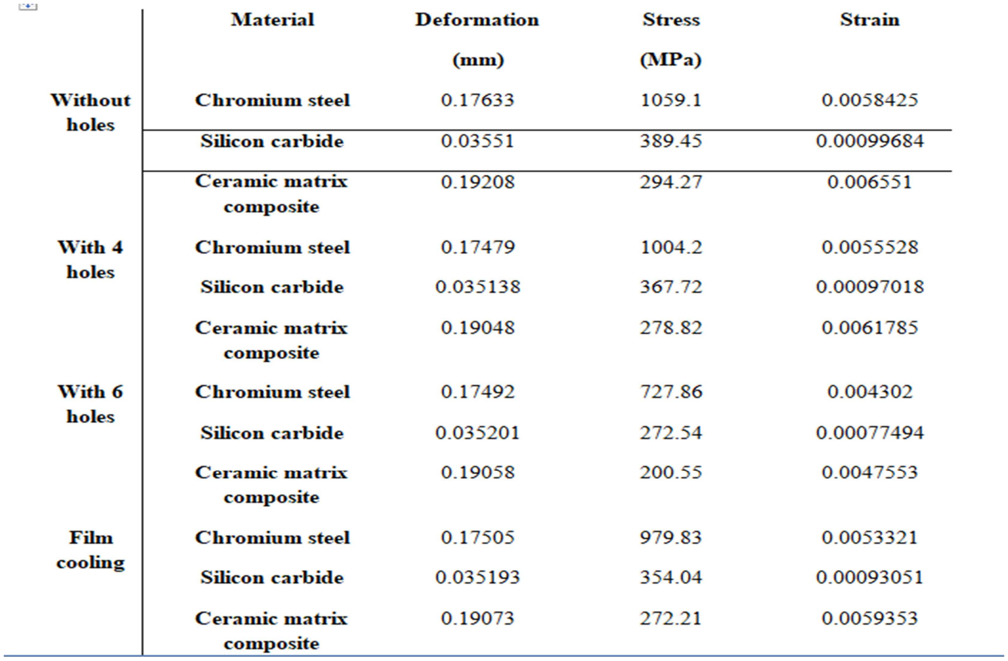
5. RESULTS TABLE

CFD ANALYSIS



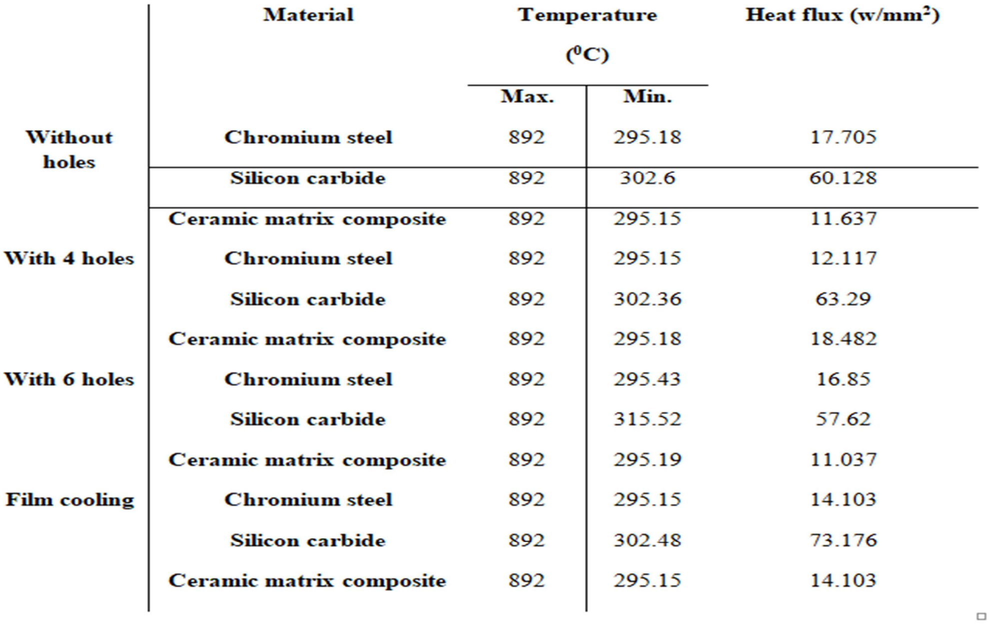
Turbine models	results				
	Pressure(Pa)	Velocity(m/s)	Heat transfer coefficient(W/m^2-k)	Mass flow rate (kg/s)	Heat transfer rate(W)
No-holes	$2.63e^{+05}$	$1.79e^{+03}$	$2.86e^{+03}$	0.36603546	289848
3-holes	$6.51e^{+05}$	$1.96e^{+03}$	$2.66e^{+03}$	1.3362656	1468896
7-holes	$3.59e^{+05}$	$1.98e^{+03}$	$3.06e^{+03}$	0.21849823	173056
13-holes	$2.61e^{+05}$	$1.82e^{+03}$	$2.88e^{+03}$	0.18215942	144232

STATIC ANALYSIS RESULT



	Material	Deformation (mm)	Stress (MPa)	Strain
Without holes	**Chromium steel**	0.17633	1059.1	0.0058425
	Silicon carbide	0.03551	389.45	0.00099684
	Ceramic matrix composite	0.19208	294.27	0.006551
With 4 holes	**Chromium steel**	0.17479	1004.2	0.0055528
	Silicon carbide	0.035138	367.72	0.00097018
	Ceramic matrix composite	0.19048	278.82	0.0061785
With 6 holes	**Chromium steel**	0.17492	727.86	0.004302
	Silicon carbide	0.035201	272.54	0.00077494
	Ceramic matrix composite	0.19058	200.55	0.0047553
Film cooling	**Chromium steel**	0.17505	979.83	0.0053321
	Silicon carbide	0.035193	354.04	0.00093051
	Ceramic matrix composite	0.19073	272.21	0.0059353

THERMAL RESULT



	Material	Temperature (⁰C) Max.	Temperature (⁰C) Min.	Heat flux (w/mm²)
Without holes	Chromium steel	892	295.18	17.705
	Silicon carbide	892	302.6	60.128
	Ceramic matrix composite	892	295.15	11.637
With 4 holes	Chromium steel	892	295.15	12.117
	Silicon carbide	892	302.36	63.29
	Ceramic matrix composite	892	295.18	18.482
With 6 holes	Chromium steel	892	295.43	16.85
	Silicon carbide	892	315.52	57.62
	Ceramic matrix composite	892	295.19	11.037
Film cooling	Chromium steel	892	295.15	14.103
	Silicon carbide	892	302.48	73.176
	Ceramic matrix composite	892	295.15	14.103

6. CONCLUSION

This turbine blade is designed and designed in the Pro / Engineer program. The turbine blades are designed using cooling holes. The blade of the turbine is designed without holes, 3 holes, 7 holes, 13 holes. The current material used for the blade is chromed steel. In this thesis, it is replaced by a nickel mixture. Thermal analysis and CFD are performed to determine the heat transfer rates and the heat transfer coefficients for the blade. When observing the results of the CFD analysis, the pressure is greater than the sheet with 3 code holes with 7 and 13 holes. Due to the high pressure gradient, the heat transfer coefficient and the heat transfer rate are more for the three-hole sheet. When observing the results of the thermal analysis, the heat flow is almost similar to that of nickel alloy 617 and chromium steel. Therefore, the heat transfer rate will be higher when nickel alloy 617 and chromed steel. But the strength of 617 nickel alloys is more than the chromium alloy, so it is better to use 617 nickel alloys. When comparing the results of the models, the use of 7 holes has a heat transfer rate. Therefore, from the previous analysis it can be concluded that 3 holes are provided for a better alloy 617.

REFERENCES

[1].Design and Analysis of Gas Turbine Blade by Theju V, Uday P S, PLV Gopinath Reddy, C.J.Manjunath

[2].Heat Transfer Analysis of Gas Turbine Blade through Cooling Holes by K Hari Bahamian, M.Lava Kumar

[3].The design and analysis of gas turbine blade by pedaprolu venkata vinod

[4].Effect of Temperature Distribution In 10c4/60c50 Gas Turbine Blade Model Using Finite Element Analysis by V.Veeraragavan

[5].Film Cooling on a Gas Turbine Rotor Blade by K. Takeishi, S. Aoki, T. Sato and K. Tsukagoshi

[6].Film Cooling of the Gas Turbine Endwall by Discrete-Hole Injection by M. Y. Jabbari, K. C. Marston, E. R. G. Eckert and R. J. Goldstein