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Investigating Effect of Crack Propagation on a Turbine Blade Structure Using FEA Method

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ABSTRACT

The main aim of this thesis is to investigate the effect of crack growth resulting from thermal mechanical fatigue in turbine blades. In this thesis a turbine blade is designed and modeled in Creo 2.0. The turbine blades are designed using cooling holes. The turbine blade is designed with 3 holes, 5 holes, 9 holes.The present used material for blade is chromium steel. In this thesis, it is replaced with Titanium IMI 834, Nickel alloy 625.Thermal, Static, Fracture and Fatigue analyses are performed on the blades to determine thermal stresses, stress intensity factors, life and damage for different materials Steel, Titanium IMI 834, Nickel alloy 625. Analysis is done in Ansys.

INTRODUCTION TO TURBINE

A turbine is a rotary engine where energy is extracted from flow of fluid and that converted into helpful work.The simplest turbines have a rotor assembly, that is a shaft or drum with blades connectedans a moving part. Fluid movement acts on the blades, or to the flow blades are reacted, in order that they move and rotational energy is imparted to the rotor.Gas, water, and steam turbines sometimes have a casing round the blades that contains and controls the operating fluid.

TURBINE BLADE

A turbine blade is that the individual element that makes up the turbine section of a gas turbine. To extract energy from the high pressure and temperature produced by the combustor the blades are responsible. The gas turbines limiting components are often the turbine blades. They utilize exotic materials like super alloys to survive during this difficult environment, and different ways of cooling, like boundary layer cooling, thermal barrier coatings and internal air channels.

Turbine blade cooling

To improve turbine blades and increasing their in operation temperature, except for better materials, another strategy is to cool down the blades. There are 3 main varieties of cooling employed in turbine blades; convection, film, and transpiration cooling. Whereas all 3 strategies have their variations, all of them work by utilizing cooler air (often bleed from the compressor) to get rid of heat from the turbine blades.

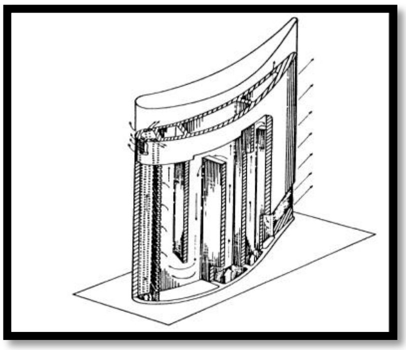

Fig: Film and Convection cooled.

LITERATURE SURVEY

In this paper by OmidAskari[1],Computational analysis employing a commercial code has been done so that performance of EEH for various operating conditions and designs are predicted. The determination of Effectiveness over the blade surface by considering geometric conditions such as: location of EEH on the blade surface, angle between EEH and blade surface, and exit-to-throat area ratio of EEH. Foretold effectiveness distributions agree well with on the market experimental results, confirming quality and advantage of computational approach to optimizeturbine blade

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cooling with EEH.In this paper by R. Becchi [4],to investigate the performance of film covering of different pressure side trailing edge cooling systems for turbine blades an experimental survey was done. In this paper by EhsanKianpour[7],Various film cooling techniques presented in the literature havebeen investigated. Moreover, challenges and future directions of film cooling techniques have beenreviewed and presented in this paper. The aim of this review is to summarize recent development inresearch on film cooling techniques and attempt to identify some challenging issues that need to be solved for future research.

3D MODELS OF GAS TURBINE BLADES

Fig: With 3 Holes

Fig: With 5 Holes

Fig: With 9 Holes

ANALYSIS OF TURBINE BLADE SURFACE WITH HOLES

Boundary Conditions

For Structural and Thermal analysis Input parameters of Pressure and temperature values are taken from the "Film Cooling Effectiveness in a Gas Turbine Engine"

Pressure = 0.32364Pa

Temperature = 1500 ^{0}C

NO OF HOLES – 3

Material –Titanium IMI 834

STATIC STRUCTURAL ANALYSIS

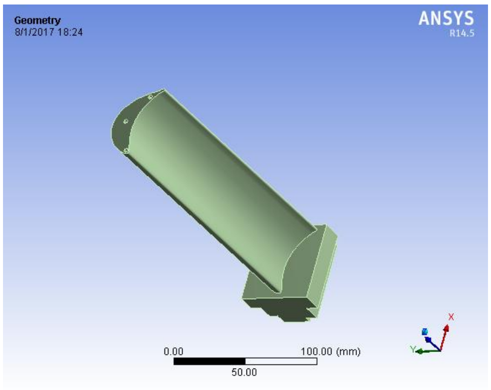

Fig – Imported model from Creo 2.0

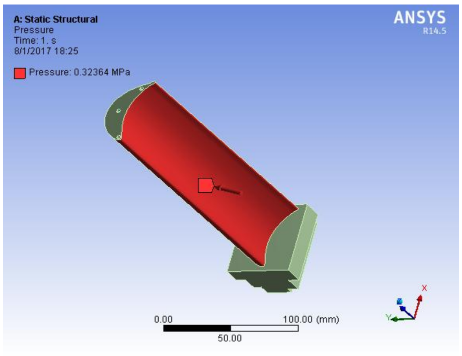

Fig –Pressure

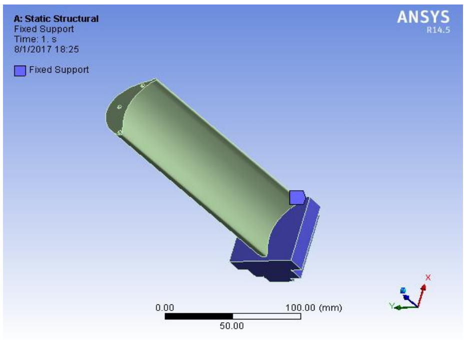

Fig – Fixed support is applied at inside the shaft

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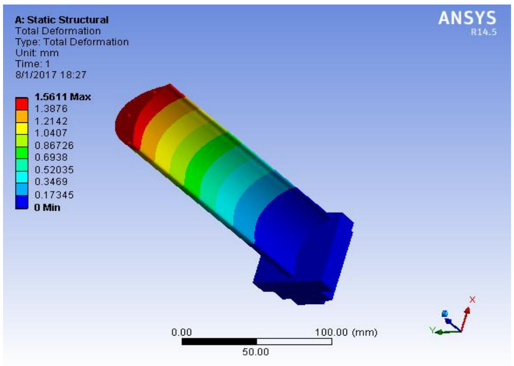


Fig – Total Deformation for Titanium IMI 834

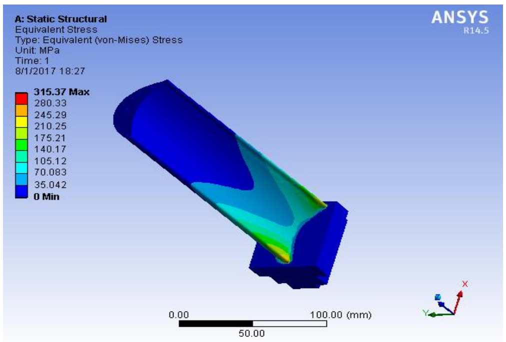


Fig – Equivalent Stress for Titanium IMI 834

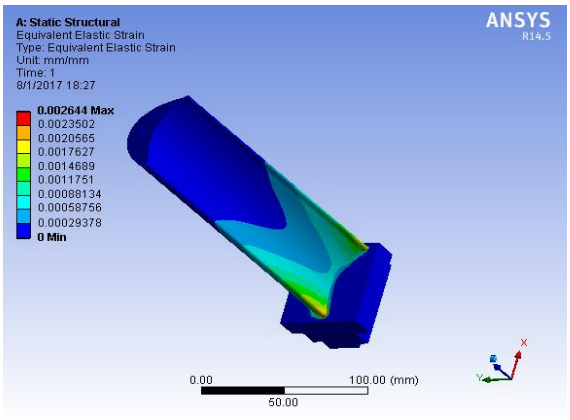


Fig – Equivalent Elastic Strain for Titanium IMI 834

THERMAL ANALYSIS

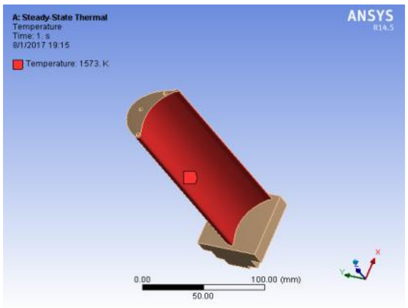


Fig: Temperature

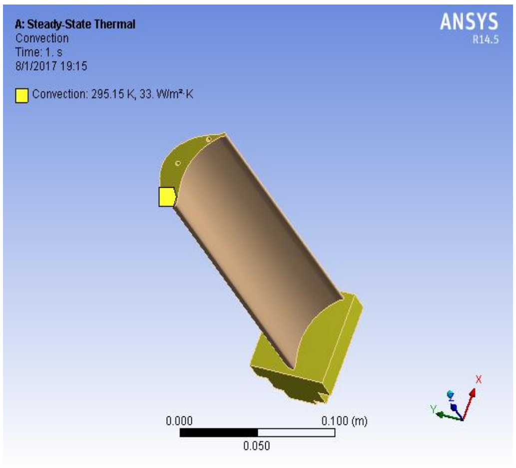


Fig: Convection

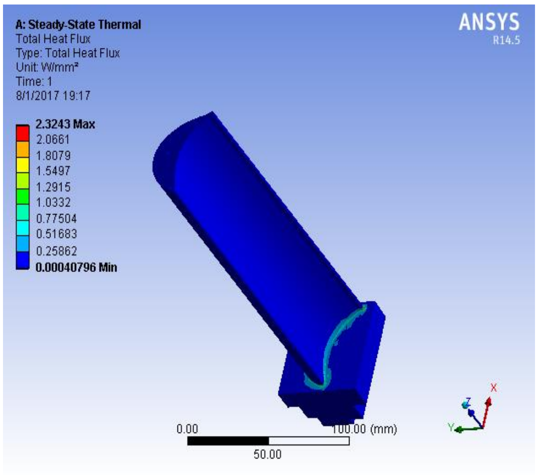


Fig: Heat flux

FATIGUE ANALYSIS

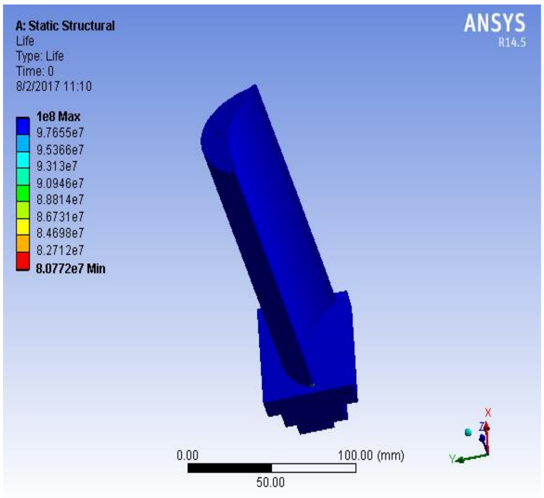


Fig: Life

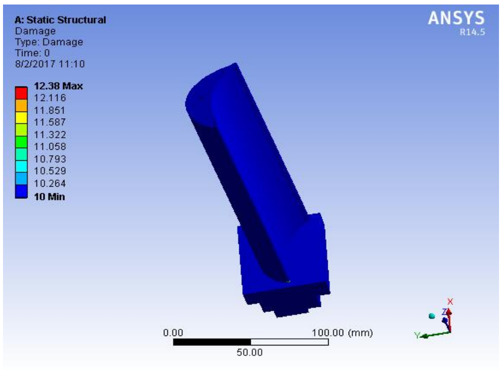


Fig: Damage

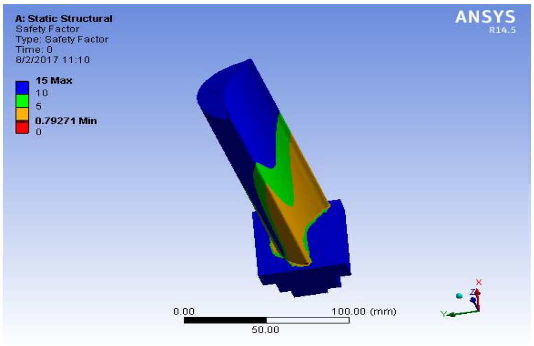
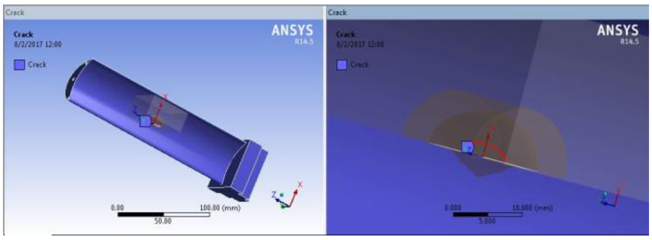


Fig: Safety Factor

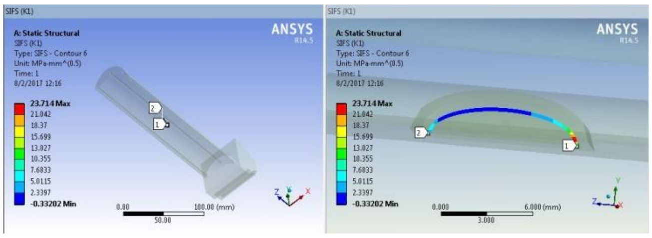
FRACTURE ANALYSIS

FRACTURE CREATED AT THE MIDDLE OF THE BLADE

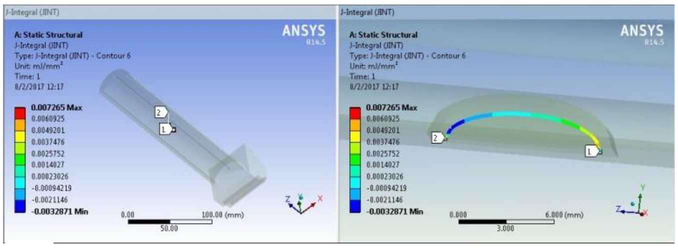
Select Crack Shape – Semi Elliptical
Enter major radius →5 mm
Enter minor radius→2 mm
Enter Fracture affected zone Height – 13.55mm
Enter largest contour radius – 5 mm



Crack on blade



Stress Intensity Factor



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RESULT & DISCUSSIONS

STATIC STRUCTURAL ANALYSIS

NO. OF HOLES	MATERIAL	Deformation (mm)	Stress (MPa)	Strain
3	Chromium Steel	0.93587	313.94	0.00158
	Titanium IMI 834	1.5611	315.37	0.002644
	Nickel Alloy 625	0.91394	315.66	0.001549
5	Chromium Steel	0.93916	305.5	0.0015519
	Titanium IMI 834	1.5665	306.26	0.0025898
	Nickel Alloy 625	0.91715	306.42	0.0015164
9	Chromium Steel	0.95591	288.64	0.0014938
	Titanium IMI 834	1.5944	289	0.0025139
	Nickel Alloy 625	0.93347	289.08	0.0014743

THERMAL ANALYSIS

NO. OF HOLES	MATERIAL	Temperature (K)	Heat Flux (W/mm^2)
3	Chromium Steel	1573	1.1732
	Titanium IMI 834	1573	2.3243
	Nickel Alloy 625	1573	2.6478
5	Chromium Steel	1573	1.2113
	Titanium IMI 834	1573	2.3992
	Nickel Alloy 625	1573	2.7337
9	Chromium Steel	1573	1.2721
	Titanium IMI 834	1573	2.5368
	Nickel Alloy 625	1573	2.8954

FATIGUE ANALYSIS

NO. OF HOLES	MATERIAL	Life	Damage	Safety Factor
3	Chromium Steel	$1e^8$	34.958	15
	Titanium IMI 834	$1e^8$	12.38	15
	Nickel Alloy 625	$1e^8$	13.566	15
5	Chromium Steel	$1e^8$	33.956	15
	Titanium IMI 834	$1e^8$	11.983	15
	Nickel Alloy 625	$1e^8$	13.19	15
9	Chromium Steel	$1e^8$	32.117	15
	Titanium IMI 834	$1e^8$	11.296	15
	Nickel Alloy 625	$1e^8$	12.538	15

FRACTURE ANALYSIS

NO. OF HOLES	MATERIAL	SIFS K1 (MPa.mm^0.5)	SIFS K2 (MPa.mm^0.5)	SIFS K3 (MPa.mm^0.5)	JINT (mj/mm^2)
3	Chromium Steel	23.711	17.576	19.478	0.0043697
	Titanium IMI 834	23.714	17.413	19.611	0.007265
	Nickel Alloy 625	23.714	17.381	19.638	0.0042506
5	Chromium Steel	23.566	17.31	19.662	0.0044309
	Titanium IMI 834	23.57	17.151	19.797	0.0073644
	Nickel Alloy 625	23.571	17.12	19.824	0.0043091
9	Chromium Steel	24.362	17.691	20.237	0.0045231
	Titanium IMI 834	24.368	17.53	20.377	0.0075178
	Nickel Alloy 625	24.369	17.498	20.405	0.0043985

CONCLUSION

By observing static structural analysis results, stresses are decreasing when turbine blade with 5holes and 9 holes is used when compared with that of 3 holes. When compared with 3 holes, for Chromium Steel the stresses are decreasing by 2.6%, for Titanium IMI 834 the stresses are decreasing by 2.8%, for Nickel alloy 625 the stresses are decreasing by 2.9% for turbine blades with 5 holes. When compared with 3 holes, for Chromium Steel the stresses are decreasing by 8.05%, for Titanium IMI 834 the stresses are decreasing by 8.36%, for Nickel alloy 625 the stresses are decreasing by 8.4% for turbine blades with 9 holes.By observing fracture analysis results, stress intensity factors are decreasing when turbine blade with 5holes is used but increasing for 9 holes blade when compared with that of 3 holes. When compared with 3 holes, the SIF is decreasing by about 0.6%, SIF is decreasing by 2.8% for all materials for turbine blades with 5 holes. When compared with 3 holes, for Chromium Steel the SIF is increasing by about 2.8 for all materials for turbine blades with 9 holes.By observing thermal analysis results, heat flux is increasing when turbine blade with 5holes and 9 holes is used when compared with that of 3 holes. When compared with 3 holes, for Chromium Steel the heat flux is increasing by 3.14%, for Titanium IMI 834 the heat flux is increasing by 3.12%, for Nickel alloy 625 the heat flux is increasing by 3.1% for turbine blades with 5 holes. When compared with 3 holes, for Chromium Steel the heat flux is increasing by 7.7%, for Titanium IMI 834 the heat flux is increasing by 8.3%, for Nickel alloy 625 the heat flux is increasing by 8.55% for turbine blades with 9 holes.By observing fatigue analysis results, the damage factor is decreasing when increasing the number of holes. Decreasing the damage factor, decreases the life of the blade.

REFERENCES

1. By OmidAskari,Cooling of Turbine Blade Surface With Extended Exit Holes.
2. By R. Becchi,Film cooling adiabatic effectiveness measurements of pressure side trailing edge cooling configurations.
3. Prakhar Jindal, Computational study of turbine blade cooling with various is blowing ratios.
4. By W. Colban, Experimental and ComputationalComparisons of Fan-ShapedFilm Cooling on a Turbine VaneSurface.
5. Design and Analysis of Gas Turbine Blade by Theju V, Uday P S , PLV Gopinath Reddy, C.J.Manjunath
6. Heat Transfer Analysis of Gas Turbine Blade Through Cooling Holes by K HariBrahmaiah , M.Lava Kumar
7. The design and analysis of gas turbine blade by PedaproluVenkataVinod
8. Effect Of Temperature Distribution In 10c4/60c50 Gas Turbine Blade Model Using Finite Element Analysis by V.Veeraragavan
9. Film Cooling on a Gas Turbine Rotor Blade by K. Takeishi, S. Aoki, T. Sato and K. Tsukagoshi
10. 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