OPTIMIZATION AND STATIC ANALYSIS OF INDUSTRIAL GAS TURBINE BLADE

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ABSTRACT

Gas turbine is an crucial functional part of many operations. Blades are considered to be the heart of turbine and all other parts exist for the sake of the blades. Without turbine blading there would be no electricity and the minor fault in blading would mean a reduction in efficiency and costly repairs. Withstanding of gas turbine blades for the elongations is a major consideration in their design because they are subjected to high tangential, axial, centrifugal forces during their funcitioning conditions. infinite methods have been proposed for the better enhancement of the mechanical properties of blades to withstand these intence conditions. This scheme summarizes the layout and analysis of Gas turbine blade, on which Creo-2.0 Software is used for deign of solid model of the turbine blade with the help of the spline and extrude options SOLIDWORKS software is used analysis of F.E. model achieved by meshing of the blade and thereby applying the boundary condition.

I. INTRODUCTION

1.1 Introduction to Gas Turbine

The generally gas turbines are the one of the importance of higher gas temperatures and the means of achieving this is discussed. Gas turbine elements are mechanically and thermally loaded. The modern gas turbine as high temperature levels which are more than the melting point of the turbine elements gas turbine elements can be protected from thermal over loading by two common ways namely internal and external cooling. The internal cooling systems consist of ribbed U-tube which is located inside of a blade. External cooling is done by attaching coolant to injection. Probably a wind mill was the first turbine to produce useful work, wherein there is no pre-compression and no ignition. The peculiarity features of a gas turbine as we think of the name include today a compression process and a heat addition process. The gas turbine represents perhaps the most satisfactory way of producing very large quantities of power in a self contained and firm unit. The gas turbine may have a forthcoming use in conjunction with the oil engine. The various means of producing either coreor power, the gas turbine is one of the most satisfactory. Its main advantages are: remarakableaccuracy, high thrust-to-weight ratio, and relative freedom of pulse. The performance from a gas-turbine machine may be given either as torque in a shaft or as thrust in a jet.

1.2 Problem Statement

New internal heat transfer data is needed to improve current rotor blade cooling performance. And also detailed flow and heat transfer data is necessary to understand the flow physics and to improve the current internal cooling designs. Jet impingement is also used throughout the cross-section of the stator vanes. Pin-fins and dimples can be used in the trailing edge portion of the vanes and blades. These technic have also been merged to further increase the heat transfer from the airfoil walls. A typical cooled turbine vane is shown in figure.As shown in the figure, the vane is hollow, so cooling air can pass through the vane internally. The coolant is extracted from the internal channel for impingement and pin-fin cooling. Jet impingement is a very aggressive cooling technique which very effectively removes heat from the vane wall. However, this technique is not readily applied to the narrow trailing edge. The vane trailing edge is cooled using pin-fins effectively mixing the coolant air to lower the wall temperature of the vanes. After intrude on the walls of the airfoil, the coolant exits the vane and provides a protective film on the vane's outer surface. Similarly, the coolant traveling over the pin-fin array is ejected from the trailing edge of the airfoil

II. INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. CAD define the process of drafting with a system (PC). CADD software, provides the user with input-tools for the purpose of streamlining design process;documentation, and assembling processes. CADD output is always in the electronic form files for print or machine operations. The evolution of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (desinging, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixilated) environments.

2.1 Structural Analysis of Gas Turbine Blade

Aluminium Alloy:

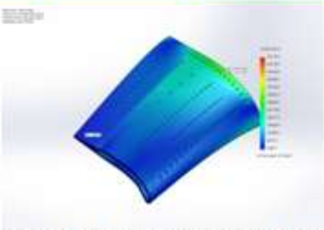
Model name: turbine_blade
Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Imported1 	Solid Body	Mass:0.756762 kg Volume:0.000280282 m^3 Density:2700 kg/m^3 Weight:7.41626 N	

Figure: Meshed Model

Results:

Name	Type	Min	Max
Stress	VON: von Mises Stress	10092.9 N/m^2 Node: 70386	7.37115e +006 N/m^2 Node: 85105

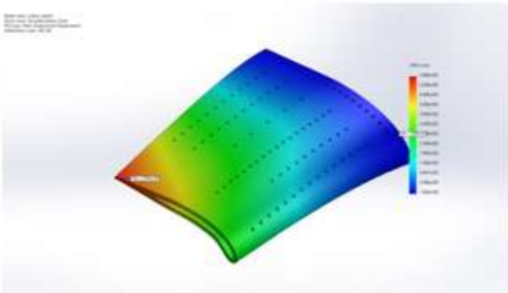


turbine_blade-SimulationXpress Study-Stress-Stress

Figure : Von Misses Stresses

The maximum stress is developed at the gas turbine blade.

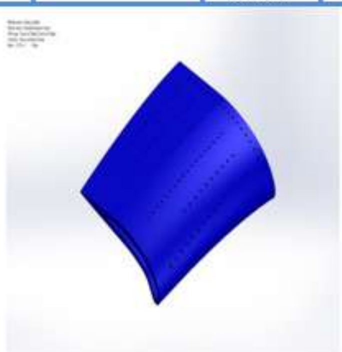
Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 1613	0.059979 9 mm Node: 3163



turbine_blade-SimulationXpress Study-Displacement-Displacement

Figure: Resultant Displacemen

Name	Type	Min	Max
Factor of Safety	Max von Mises Stress	3.74083 Node: 85105	2732.03 Node: 70386



turbine_blade2-SimulationXpress Study-Factor of Safety-Factor of Safety

Figure :Areas below FOS

A factor of safety less than 1 at a location indicates that the material at that location has failed. A factor of safety of 1 at a location indicates that the material at that location has just started to fail. A factor of safety greater than 1 at a location indicates that the material at that location is safe.

Regions with FOS value less than 1 are shown in red (unsafe region).Blue region indicates the safe region.

Titanium alloy:

Model Information

Model name: turbine_blade
Current Configuration: Default

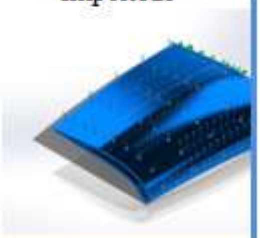
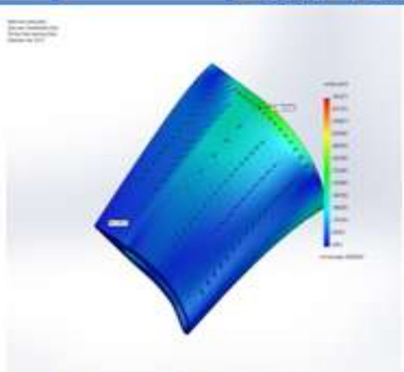
Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Imported1 	Solid Body	Mass:1.26407 kg Volume:0.000280282 m^3 Density:4510 kg/m^3 Weight:12.3879 N	

Figure: Meshed Model

Study Results

Name	Type	Min	Max
Stress	VON: von Mises Stress	9664.97 N/m^2 Node: 70386	7.43623e+006 N/m^2 Node: 86225

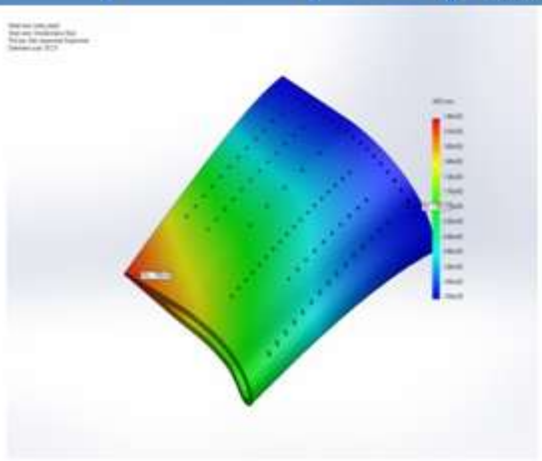


turbine_blade-SimulationXpress Study-Stress-Stress

Figure : Von Misses Stresses

The maximum stress is developed at the gas Turbine blade.

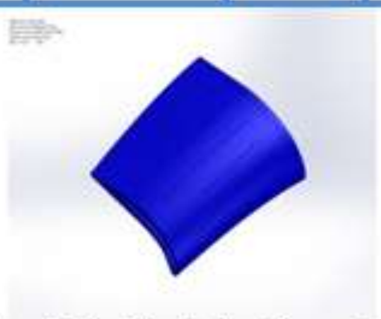
Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 1613	0.019800 6 mm Node: 3163



turbine_blade-SimulationXpress Study-Displacement-Displacement

Figure: Resultant Displacement

Name	Type	Min	Max
Factor of Safety	Max von Mises Stress	39.2672 Node: 86225	30212.2 Node: 70386



turbine_blade-SimulationXpress Study-Factor of Safety-Factor of Safety

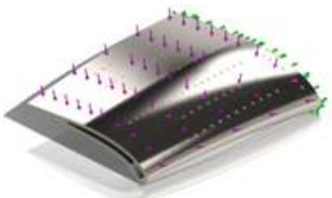
Figure :Areas below FOS

A factor of safety less than 1 at a location indicates that the material at that location has failed.A factor of safety of 1 at a location indicates that the material at that location has just started to fail. A factor of safety greater than 1 at a location indicates that the material at that location is safe.

Regions with FOS value less than 1 are shown in red (unsafe region).Blue region indicates the safe region.

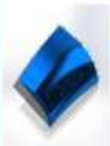
Stainless steel:

Model Information:



Model name: turbine_blade

Current Configuration: Default

Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Imported1 	Solid Body	Mass:2.20302 kg Volume:0.000280282 m^3 Density:7860 kg/m^3 Weight:21.5896 N	

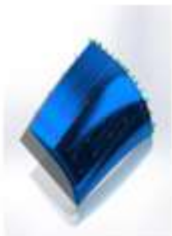
Model Reference	Properties		Components
	Name:	**Stainless Steel (SS)**	**Solid Body 1(Imported1)(turbine blade)**
	Model type:	**Linear Elastic Isotropic**	
	Default failure criterion:	**Unknown**	
	Yield strength:	**2.92e+008 N/m^2**	
	Tensile strength:	**6.85e+008 N/m^2**	

Table: addition of Stainless steel material

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 1 face(s) **Type:** Fixed Geometry

Table: Fixed Geometry

Load name	Load Image	Load Details
Force -1		**Entities:** 2 face(s) **Type:** Apply normal force **Value:** 100 N

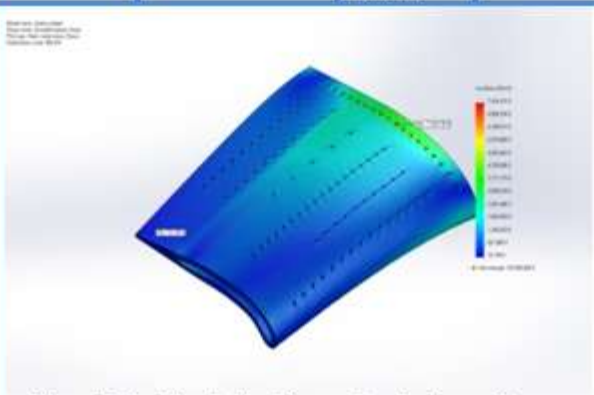
Table: Apply normal force on the gas turbine blade

Mesh Information:

Total Nodes	90737
Total Elements	51212
Maximum Aspect Ratio	2519.8
% of elements with Aspect Ratio < 3	80.7
% of elements with Aspect Ratio > 10	0.154
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:23
Computer name:	SYS-26
	

Figure: Meshed Model

Name	Type	Min	Max
Stress	VON: von Mises Stress	10149 N/m^2 Node: 70386	7.42419e+006 N/m^2 Node: 85105

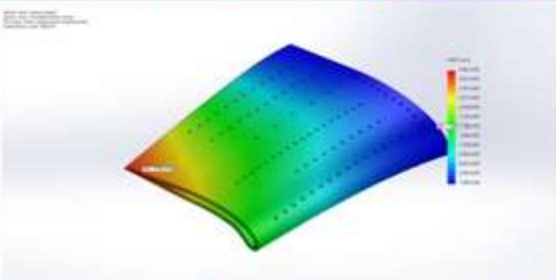


turbine_blade-SimulationXpress Study-Stress-Stress

Figure : Von Misses Stresses

The maximum stress is developed at the gas turbine blade

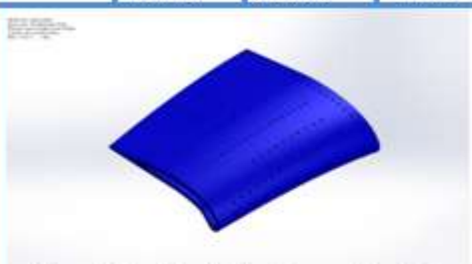
Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 1613	0.039607 mm Node: 3163



turbine_blade-SimulationXpress Study-Displacement-Displacement

Figure : Resultant Displacement

Name	Type	Min	Max
Factor of Safety	Max von Mises Stress	49.8371 Node: 85105	36456.7 Node: 70386



turbine_blade-SimulationXpress Study-Factor of Safety-Factor of Safety

Figure :Areas below FOS

A factor of safety less than 1 at a location indicates that the material at that location has failed. A factor of safety of 1 at a location indicates that the material at that location has just started to fail. A factor of safety greater than 1 at a location indicates that the material at that location is safe.

Regions with FOS value less than 1 are shown in red (unsafe region).Blue region indicates the safe region.

Results:

Structural analysis			
	Aluminium alloy	Titanium alloy	Stainless steel
Stress	7.37115e+006 N/m^2	7.43623e+006 N/m^2	7.42419e+006 N/m^2
Displacement	0.0599799 m	0.0198006 mm	0.039607 mm

III. CONCLUSION

In this project, 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.

The turbine blades and are subjected to high mechanical stresses, elevated temperatures and are operated in aggressive environments. To survive in this difficult environment, turbine blades often made from exotic materials. Three materials such as Aluminium alloy, stainless steel and titanium used for manufacture of turbine blades of a gas turbine blade.

From the above results, titanium alloy has been selected for the performance analysis because of its low stresses and displacement. The turbine blade data was obtained using Coordinate Measuring Machine (CMM) and its model profile is generated by using CREO-2.0 software. The turbine blade is analyzed for its structural performance due to the loading condition.

REFERENCES

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[5] L.W. Florschuetz, R.A. Berry, and D.E. Metzger, “Periodic Streamwise Variations of Heat Transfer Coefficients for Inline and Staggered Arrays of Circular Jets with Crossflow of Spent Air,” ASME Journal of Heat Transfer 102 (1980): 132-137; R.N. Koopman and E.M. Sparrow, “Local and Average Transfer Coefficients Due to an Impinging Row of Jets,” International Journal of Heat and Mass Transfer 92 (1976): 73-82.

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