



Design and Analysis of Turbine Blade by Using CATIA and ANSYS

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ABSTRACT

As there is need of power everywhere, there will be a huge usage of machine to generate, store and use the power. Turbines has major role in power generation. As the machine is being used, there will be wear and tear of the machine. So, proper maintenance have to be done for the proper functioning of the turbines, or good material have to be used in the manufacture of the turbines to attain long run of the turbines. The aim of this thought is to bring out a material used in the manufacture of the turbines which is less in cost, gives a long run and can with stand all the properties required in required condition. Here, we took three samples of materials that are used in the manufacture of turbines and performed Static and Thermal analysis on the material in simulation software. All the modeling process is carried out in CATIA Software package, Simulation is done in ANSYS Mechanical Workbench.

Keywords:

Turbine blade
ANSYS
CATIA
Titanium

1. Introduction

Power generation is the major application in now a day. Turbine is major source for the generation of power using either of the external sources as an input [1].

1.1 Types of Turbines

- a) Pelton turbine, a type of impulse water turbine.

- b) Francis turbine, a type of widely used water turbine.
- c) Kaplan turbine, a variation of the Francis Turbine.
- d) Turgo turbine, a modified form of the Pelton wheel.

1.2. Gas Turbines

The outstanding characteristics of gas turbines, which make them eminent of all turbines, are as follows [4]:

- a) It has a very simple mechanism.

- b) It runs at higher speed.
- c) It is very compact engine compared to other requiring less weight and space.
- d) It requires less maintenance cost.
- e) Cheaper liquid fuel can be used, as phenomenon of detonation does not exist.
- f) It is highly situated for peak load and standby power generation and aircraft propulsion.
- g) It works at high operating pressures
- h) It has greater power to weight ration than other engines.
- i) It requires less manpower.

Gas turbines also used in marine application for power generation and propelling.

For these applications the gas turbine has to work under high pressure, temperature and critical forces (tangential force, axial force, centrifugal force) .The main part of the gas turbine is blades which have to withstand these forces.

1.3 Blade Materials

In this paper we are doing analysis on first stages moving rotor blade of marine Gas turbine. Generally gas turbines work under high pressure, forces and temperature. Turbine blade has to withstand these conditions. So we mainly Concentrated on the turbine blade materials we had selected three materials ,Two of them are nickel based super alloys and one them is titanium alloy. Nickel based alloy are used because they have high resisting capacity and strength, titanium, Aluminium is used because it is light weight, more corrosive resistive and have high strength. So by doing analysis on these three materials we have to find out which material is best suited for marine application [2].

For this first we had designed solid blade model in CATIA v5r21 and then we had imported this CATIA file into ANSYS 14 and there we had done fine meshing and then we had applied pressure, centrifugal

forces and calculated structural analysis after we had done thermal analysis by applying temperature and heat flux.

Alloys we used and their composition shown in table 1:

Table 1. NIMONIC 80A

Carbon	0.10 max.
Chromium	18.0-21.0
Silicon	1.0 max
Copper	0.2 max.
Iron	3.0 max.
Manganese	1.0 max.
Titanium	1.8-2.7
Aluminium	1.0-1.8
Cobalt	2.0 max.
Boron	0.008 max.
Zirconium	0.15 max.
Lead	0.0025 max.
Sulphur	0.015 max.
Nickel	Balance

Super Alloy Grade X

Chemical Composition of blade made of super alloy grade is as follows (Table 2):

Table 2. Super Alloy Grade X

Element	C	S	P	Mn	Cr	Mo	W	Fe	Al	C0
Weight	9	4	4	1	9	0	5	8	3	7

Materials Required

- a) Nimonic 80 A
- b) Super alloy grade X
- c) Titanium Aluminium alloy
- d) Structural steel

Table 3. Materials Required

Material Properties	Nimonic 80A	Super Alloy Grade X	Titanium Aluminium alloy	Structural Steel	Cast Iron
Young's Modulus (GPa)	222	160	110	200	180
Density (kg/m3)	8190	9000	4810	5610	7432
Poisson's ratio	0.35	0.3	0.3	0.3	0.3
Thermal Conductivity(w/mk)	24.5	22	8.4	21	20
Thermal expansion(c)	16.2e-6	10e-6	9.4e-6	15.3e-6	13.2e-6

Pressure and Thermal Conditions

Generally gas turbines operate under the pressure of 4bar to 10bar

Temperature is range

Inlet temperature =839.22

Exit temperature =659.22

Heat transfer coefficient =230w/m²k

Heat flux =230*(839.22-659.22)

=41400 w/m²

2. CATIA V5

CATIA (Computer Aided Three Dimensional Interactive Application) is good CAD software packages provided by Dassault Systems which is leading solution for product design and innovation. The abilities of this software now days are growing and supported company trying to add more features and making it more powerful in the area of engineering. Some of the abilities can be mention as design virtual, manufacture to simulation, analysis, assembly etc [3].

CATIA V5 is a multiple form CAD/CAM/CAE commercial software suite developed by French company Dassault systems. The software was created in late 1970s to develop Dassault's Mirage fighter jet, but was subsequently adapted in aerospace, automotive ship building, and other industries side rails, body components because CATIA is very good in surface creation and computer representation of surfaces part in the part design workbench; the change will be reflected in the assembly design and the drawing workbenches. Similarly, if you modify the dimensions of a part in the drawing views generated in the Drawing workbench, the changes will be reflected in the part design Assembly design workbenches [6].

3. Designing of Turbine Blade

3.1. CATIA Model

Creating Turbine Blade using key points shown in Fig 1.

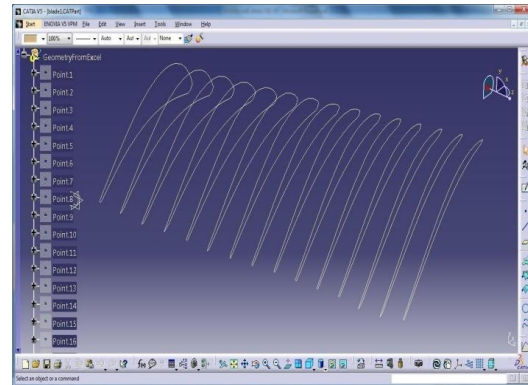


Fig 1. Creating Turbine Blade using key points

4. Analysis of Turbine Blade on Ansys

4.1 Ansys Work Bench Analyses

The ANSYS Work bench platform is the frame work upon the industry's broadcast and deepest suite of advanced engineering simulation technology is built. A latest project schematic view ties together the entire simulation process, guiding the user through even complex metaphysics analyses with drag and drop simplicity. With bidirectional CAD connectivity, powerful highly automated meshing, a project level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Work bench platform delivers unprecedented productivity, enabling simulation [5].

The Work bench environment allows you to solve much more complex analyses, including (as of ANSYS 8.0):

- a) Multi-part assemblies.
- b) 3-D solid elements, shell elements, and shell solid assemblies.
- c) Nonlinear contact with or without friction.
- d) Small displacement and large displacement static analyses.
- e) Modal, harmonic, and Eigen value buckling analyses.

- f) Steady state thermal analysis, including temperature Dependent material properties and thermal contact.

4.2 Step by Step Procedure Analysis in Ansys Work Bench

- (i) Open ANSYS work bench analysis version 13.0
- (ii) ANSYS work bench environment will be seen. Then assembled part in CATIA is imported in (iges) format to ANSYS by going through this step.
- (iii) Static structural geometry import
- (iv) ANSYS work bench environment will be seen like this.
- (v) Select the static structural analysis type from top menu bar by clicking new analysis tab as shown below.
- (vi) The next step will be assignment of material properties to the solid model. Default material will be structural steel in ANSYS.
- (vii) At the left side of the page, click MODEL EDIT then mechanical window will open. Select mesh on left side of the screen and select sizing at the bottom of the page then you can select the relevance center of mesh you are desired.
- (viii) Right click to static structural on left side of the page and then click to INSERT option and provide then click FORCE and these forces are provided in all 3 directions.
- (ix) Select the points where forces are to be applied and its magnitude with its direction.
- (x) Click to apply on bottom left portion of the page.
- (xi) Similarly click STATIC STRUCTURAL INSERT fixed supports (constraints)
- (xii) Select the points where constraints are to be applied.
- (xiii) Right click to solution option on top left portion of the page and then select and find out present project of the page and then select required outputs
- (xiv) Project we required Deformation and Equivalent Stress (Von-misses)
- (xv) Click on SOLVE icon on Top menu as shown below

- (xvi) ANSYS reports are generated.
- (xvii) Click to report preview and print preview.
- (xviii) You can get the reports in the word format by using the SEND TO button on the pallet.

4.3 Nimonic 80A Inputs

- Density 8190 kg/m³
- Young's modulus 222Gpa
- Poisson ratio 0.3
- Thermal conductivity 24.5 w/mk
- Coefficient of thermal expansion 16.2e-6

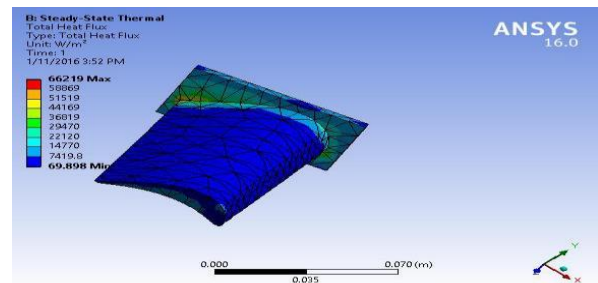


Fig 2. Nimonic 80A Inputs

4.4. Super Alloy Grade X Inputs

- Density 9000 kg/m³
- Young's modulus 160Gpa
- Poisson ratio 0.3
- Thermal conductivity 22 w/mk
- Coefficient of thermal expansion 10e-6

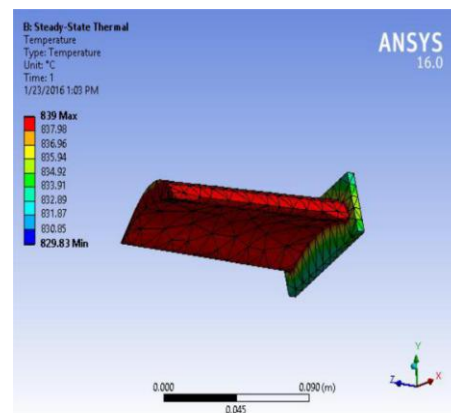


Fig 3a. Super Alloy Grade X Inputs

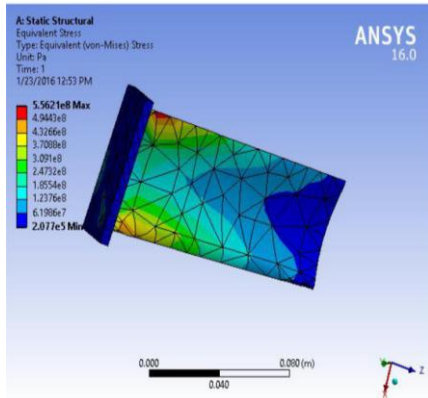


Fig 3b. Super Alloy Grade X Inputs

4.5. Titanium Aluminium

- Density 4810 kg/m³
- Young's modulus 110Gpa
- Poisson ratio 0.3
- Thermal conductivity 8.4w/mk
- Coefficient of thermal expansion 9.4e-6

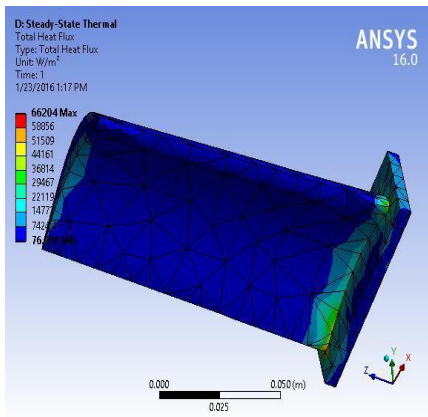


Fig 4. Titanium Aluminium Inputs

4.6. Structural Steel

- Density 4810 kg/m³
- Young's modulus 110Gpa
- Poisson ratio 0.3
- Thermal conductivity 8.4w/mk
- Coefficient of thermal expansion 9.4e-6

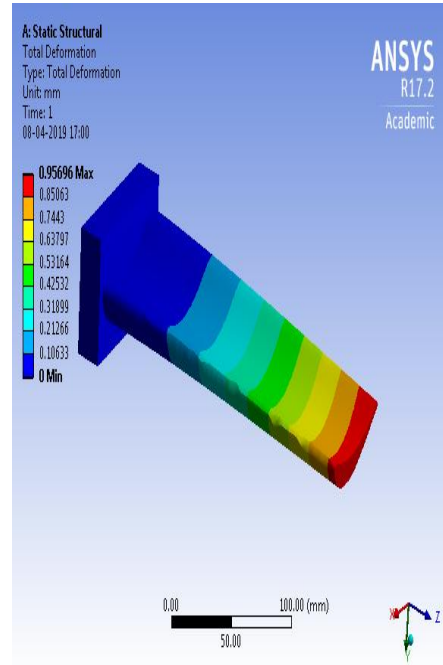


Fig 5. Structural Steel components

4.7. Cast Iron

- Density 4810 kg/m³
- Young's modulus 110Gpa
- Poisson ratio 0.3
- Thermal conductivity 8.4w/mk

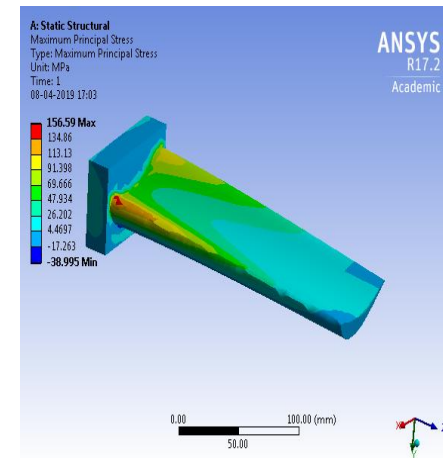


Fig 6. Cast Iron Inputs-1

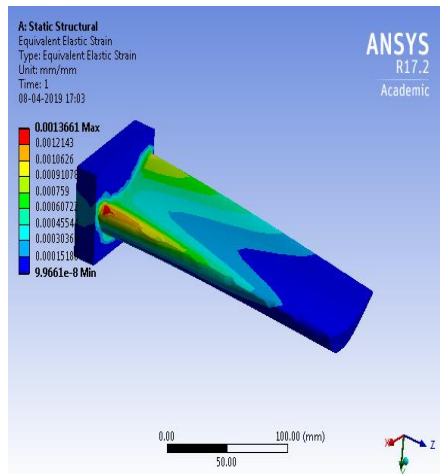


Fig 7. Cast Iron Inputs-2

5. Results

The results of stress (Table 4.), temperature (Table 5.) and Total deformation (Table 6.) are obtained by the implementation of this work.

Table 4. Results of Stress

Material	Max. Value	Min. Value
Nimonic 80A	1.0249E9	3.625E5
Super Alloy Grade X	5.5621E8	2.077E5
Titanium Aluminium	4.99E8	1.545E5
Structural Steel	1.494E8	1.24E5
Cast Iron	2.243E8	1.45E5

Table 5. Results of Temperature

Material	Max. Value	Min. Value
Nimonic 80 A	839.22	830.05
Super Alloy Grade X	839	829.83
Titanium Aluminium	839	829.83
Structural Steel	839	829.65
Cast Iron	839.10	830

Table 6. Results of Total deformation

Material	Max. Value	Min. Value
Nimonic 80 A	0.0019863	0.0002207
Super Alloy Grade X	0.0016833	0.000187
Titanium Aluminium	0.0016341	0.00018157
Structural Steel	0.095696	0.00126
Cast Iron	0.0017425	0.00134

6. Conclusion

Here, we took three samples of materials that are used in the manufacture of turbines and performed Static and Thermal analysis on the material in simulation software. All the modeling process is carried out in CATIA Software package, Simulation is done in ANSYS Mechanical Workbench.

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