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Modeling and Analysis of 2nd Stage HP Stator Blade using FEA

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Abstract:- Advances in materials, cooling technology and design techniques have allowed MS7001 turbines to be operated with higher firing temperatures and airflows, which result in higher turbine output and efficiency. Improvements in combustion technology have also made significantly lower emission levels a reality. Advanced design technology is usually introduced for new unit production and subsequently applied to customer-operated gas turbines by a gas turbine uprate program. Many new uprate programs have been introduced for installed GE-designed heavy duty gas turbines, including the MS7001A, B, C, E, and EA models. Each uprate program provides increased output, improved heat rate and efficiency, improved reliability, reduced maintenance costs, longer inspection intervals, and longer expected parts lives. Additional benefits result because uprates are based on current production components parts that are not specifically unique to older machines and thus readily available. This Project deals with about 2nd Stage HP stator blade. 3D model of blade is done CATIA by taking point data, Meshed in Hyper mesh and Analysis done in ANSYS. Structural analysis is carried on Blade as per given load condition by varying material properties. Study of process making of Blade is studied.

Keywords: -Rotor, Stator.

I. INTRODUCTION

Today's requirements of advanced steam turbine design place special emphasis on the design simplicity, fewer parts, enhanced reliability and maintainability. Such requirements, when coupled with the ever-increasing demand on the higher efficiency level for both existing and new design concepts, offer the most challenging problem to the design engineers. Modern turbine-design entails integrated program system, which accounts for many of the above design requirements from the very beginning of a project and allows the best compromise satisfying the specified constraints to be reached. The principal target is to reduce the design-cycle-time quite drastically, and to enable the designers to perform conceptual studies for any desired ranges of design parameters whilst maintaining the highest level of design quality and reliability. Regarding fine-tuning in the final design stage, hitherto the benefits taken from advances in computational fluid dynamic (CFD) to boost the stage efficiency are quite significant. The improvements were, however, mainly achieved in the standard aerodynamic flow path design to the point where further potential for efficiency improvement on such issues seems to be relatively small. However, as part of continuing technological advance towards the design of new generations of highly efficient turbines, significant efforts have to be concentrated on a number of design details on components placed outside the standard blading flow channel where still some room is left for further efficiency improvement.

II. TYPES OF TURBINES AND DESCRPTION

There are two types of turbines:

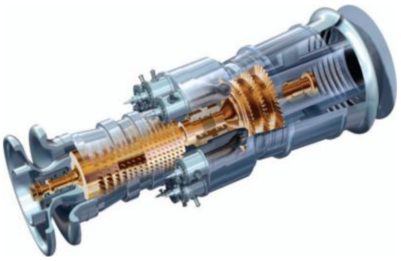
- **HP TURBINE:** The axial flow, two-stage reaction type HP Turbine was designed to deliver high efficiency over a broad power range. It consists of two turbine wheels, first and second stage turbine nozzle assemblies, and turbine casings. Both stages of HPT nozzles are air cooled (convection and film) by compressor discharge air flowing through each vane. Both stages of HPT buckets are cooled by compressor air flowing through the dovetail and shanks into the buckets.

- **LP TURBINE:** The power turbine uses the same general arrangement, materials and mechanical structure as that of the GE Oil & Gas PGT25+ model whose installed fleet consists of over 80 units and more than 500,000 operating hours. The flow-path profile and airfoils were redesigned to allow 20% higher airflow than the PGT25+.

Turbine uprate packages have been introduced because of strong customer interest in extending intervals between maintenance, improving efficiency, and increasing output. The main items that must be considered when evaluating a unit for an advanced technology uprate option are as follows

- Performance Improvements (Output/Heat Rate)
- Maintenance/Inspection Interval Extensions
- Availability/Reliability Improvements
- Emissions Reduction/Regulatory Agencies
- Life Extension

This paper covers new uprates that have been successfully developed using engineered components developed for current new unit production. Uprate benefits are discussed, including turbine performance and maintenance improvements. Each owner of GE heavy-duty gas turbines should evaluate the economics of the various uprates for the specific application. In many cases, the economic evaluation will justify one of the available uprates at the next major overhaul and, in some cases, earlier. When more power generating capacity is required, uprating can provide a cost-effective alternative to purchasing and installing new units. At the same time, the improved parts can provide extended life to the existing turbine.



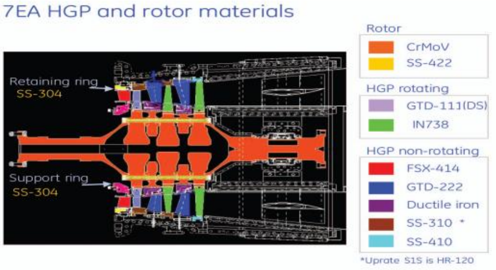


Fig.1 the MS7001EA simple-cycle single-shaft, heavy-duty gas turbine.,**Fig.2** 7EA HGP and rotor materials

Many improvements have been made to the current production 7EA in the above figure that can be utilized in older fielded units. Combustion systems, turbine buckets, nozzles, and compressor components have been redesigned using improved materials that increase component life and reduce repairs. While GE moves forward to address marketplace needs, it will continue to improve its products and serve as a world-class high quality supplier of power generation equipment. As a leader in the gas turbine industry, GE is committed to applying the latest available technology parts to the large installed base of GE-designed gas turbines.

III. THE MAJOR COMPONENTS AND SYSTEMS OF A GAS TURBINE GENERATOR SET INCLUDE

- Gas turbine
- Reduction-drive gear box
- Generator
- Start system
- Fuel system
- Lubricating oil system
- Turbotronic for control system
- On skid electrical wiring
- Skip with drip pads
- Piping and manifolds

IV. PROCEDURE STEPS IN MANUFACTURING OF 2^{ND} STAGE CSB, HPC BLADE

- **Billet:** At this stage stamping of billet as per 104.03TY16 with cold rolled aerofoil. Profile allowance is proportional in all the sections with coefficient deformations. As per the technology additionally equidistant in A1-A1 section on concave by 0.1mm and on convex by 0.4mm with smooth transition up to 0.1mm on concave and convex in the final section.
- **Milling:** It is used to mill the neck and aerofoil tip by maintaining dimensions.
- **Centering:** Centering has to be done on the blade profile by dividing in to sections along vertical and horizontal direction , then carry out the centering of the faces of the part simultaneously by maintaining desired dimensions .
- **Inspection:** Check the aerofoil profile in the device pompkol-4 with block by randomly selection of 10% of parts of the beverage. Displacement of aerofoil profile parallel to x-x axis in section A1 and A2 0.25 mm max in all other sections 0.35mm max. Difference in edges thickness in sections A1 and A2 0.1mm max.
- **Filling:** Here we are using cero band filling by placing the scaling gasket on the neck of the blade. Load the part in the cartridge and fasten it. Carry out the filling of part by alloy ВУД. Cooling of cartridge in air until the hardening of alloy ВУД. Carryout the subsequent cooling in the running waste. Disassemble the cartridge and take out the briquette.
- **Turning:** Turning is used for root preparation; it has to be done on the face of the neck of the blade .Here we have to take in to consider of non-perpendicularity surface relative to surface B 0.03max. Face run-out of surface relative to B0.05mm max. Ensure by machines in one section. Displacement of placement π from the design portions parallel to axis X and Y 0.1mm max and non-perpendicularity of surface π relative to the plane X –Y at the length of 100 mm -0.01mm max. Before starting the centers of fixture and tailstock of machine up to 0.02mm along the mandrel.
- **Smelting:** It has to be done by putting the briquettes in the basket and lower in the tub fill it hot water. After the full removal of ВУДА.. Take out the part and wash the parts in the hot water. Blow off the part by air until full removal of moisture put the blade in the container. Now again milling has to be done on both sides of surfaces of shroud from concave and convex sides flush with aerofoil profile by maintain the dimensions. Projection of machined surfaces relative basic profile should be within the limits of 0.1…0.3mm. Digging is not permitted.
- **Trimming:** It is nothing but removal of unwanted materials of edges and burrs. Check the quality of re-sharpening of cutting surfaces of die. Inspection should be carried out before starting the operation, the contour of aerofoil should be cut incase of quality of surface of parts not matching with inspection etalon i.e. finishing of edges and

excess of burr. Carry out the re-sharpening of cutting surfaces. Radius of indicator E6015-6906. Let at ‘0’ at any section of blade at inlet and outlet edges should not be more than + or – 0.1mm. On the end of face of pair of blades not more than -0.2mm.

- **Fatigue test:** This instruction gives the order for the periodic inspection on fatigue for the finally manufactured aerofoil of the compressor blades of the engine AL31FP. This instruction determines the order of test procedure for checking the stability of manufacturing technology of the blades. The technology documentation for conducting the fatigue tests is developed according to the given instruction.

V. MODELLING AND ANALYSIS

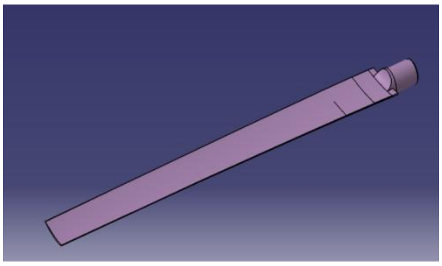
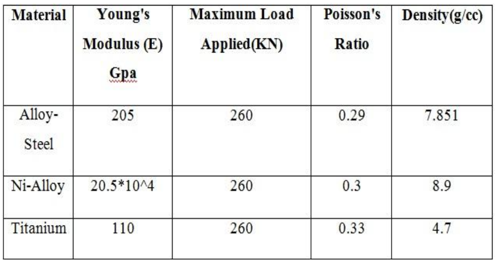


Fig.3 Model of HP stator blade



Material	Young's Modulus (E) Gpa	Maximum Load Applied(KN)	Poisson's Ratio	Density(g/cc)
Alloy-Steel	205	260	0.29	7.851
Ni-Alloy	20.5*10^4	260	0.3	8.9
Titanium	110	260	0.33	4.7

Table.1 Inputs given for the model

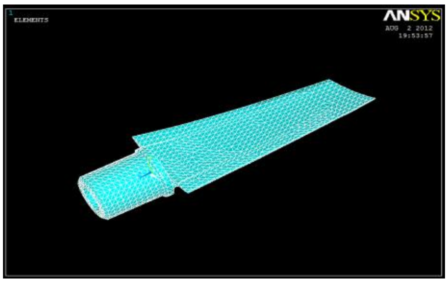


Fig.4 Meshing of model in ANSYS

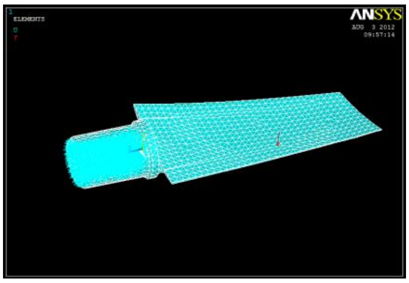
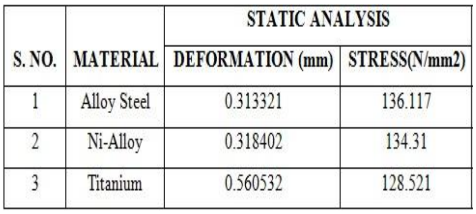


Fig.5 Applying loads in ANSYS

VI. RESULTS AND DISCUSSIONS

- **Static Structural Analysis of blade**



S. NO.	MATERIAL	STATIC ANALYSIS DEFORMATION (mm)	STRESS(N/mm2)
1	Alloy Steel	0.313321	136.117
2	Ni-Alloy	0.318402	134.31
3	Titanium	0.560532	128.521

Table.2 static analysis of blade

- **CASE 1: For Alloy-Steel**

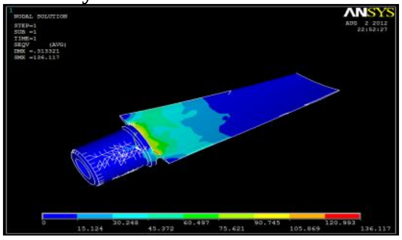


Fig.6 Stress values

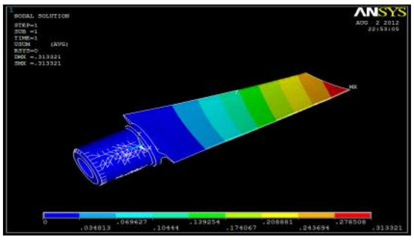
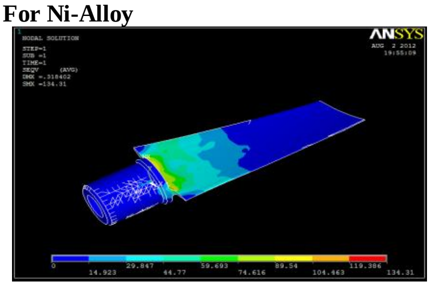


Fig.7 Deformation values

- **CASE 2: For Ni-Alloy**



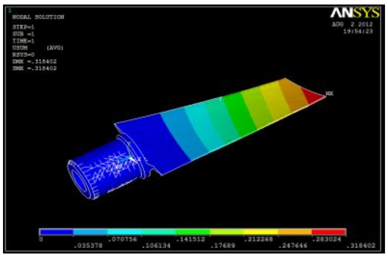


Fig.8 Stress values **Fig.9 Deformation values**

- **CASE 3: For Titanium**

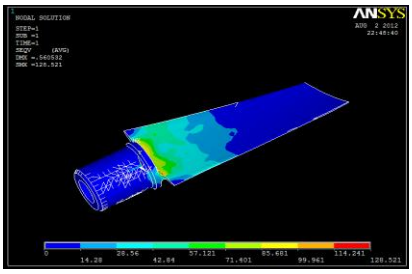


Fig.10 Stress values

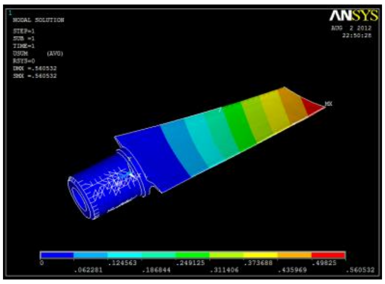


Fig.11 Deformation values

- **Harmonic Analysis of blade**

S. NO.	MATERIAL	AT MAX AMPLITUDE	
		DEFORMATION(mm)	STRESS(N/mm2)
1	Alloy Steel	3.42	976.601
2	Ni-Alloy	1.51	447.107
3	Titanium	0.977522	162.269

Table.3 Harmonic analysis of blade

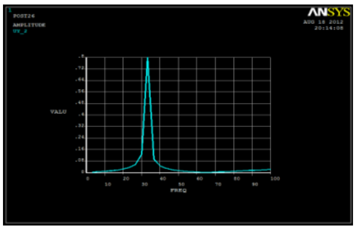


Fig.12 CASE 1: For Alloy-Steel

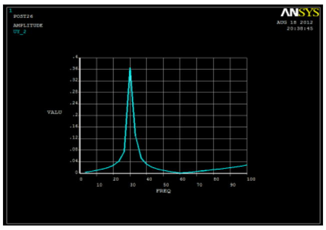


Fig.13 CASE 2: For Ni-Alloy

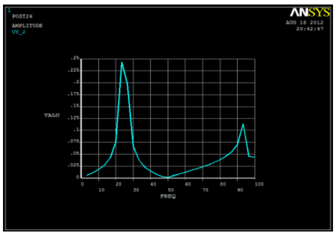


Fig.14 CASE 3: For Titanium

- ➢ **Modal Analysis of the blade**
- **Case 1: For Alloy Steel**

S.NO.	NATURAL FREQUENCY
1	32.878
2	128.37
3	168.67
4	391.36
5	426.19
6	565.9
7	655.72
8	687
9	85
10	758.95

Table.4 Natural frequencies of Alloy steel blade

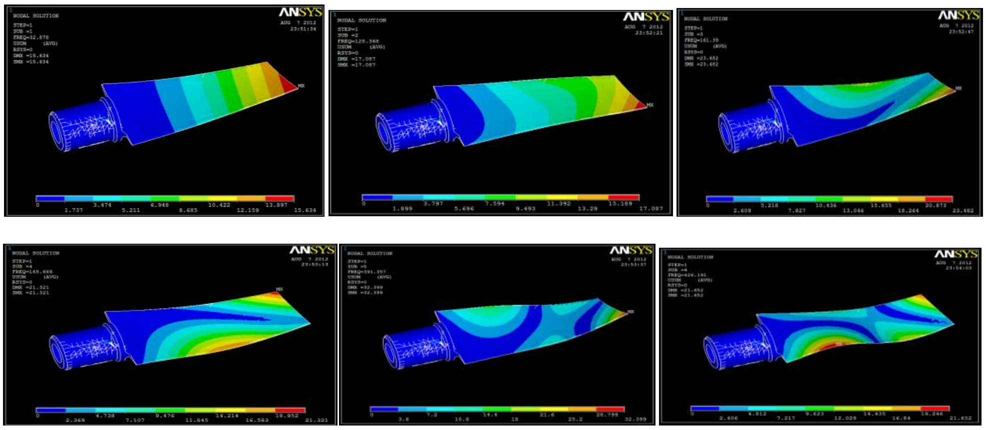


Fig.15, 16, 17, 18, 19&20 Different mode shapes of the Alloy steel blade

- **Case 2: For Ni-Alloy**

S.NO.	NATURAL FREQUENCY
1	30.879
2	120.57
3	151.58
4	158.41
5	367.57
6	400.29
7	531.51
8	615.86
9	646.05
10	712.82

Table.5 Natural frequencies of Ni-Alloy blade

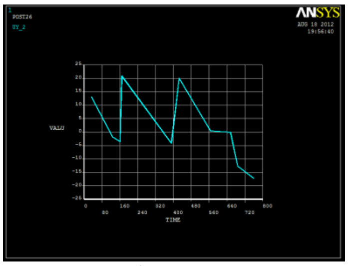


Fig.21 Graph for modal analysis

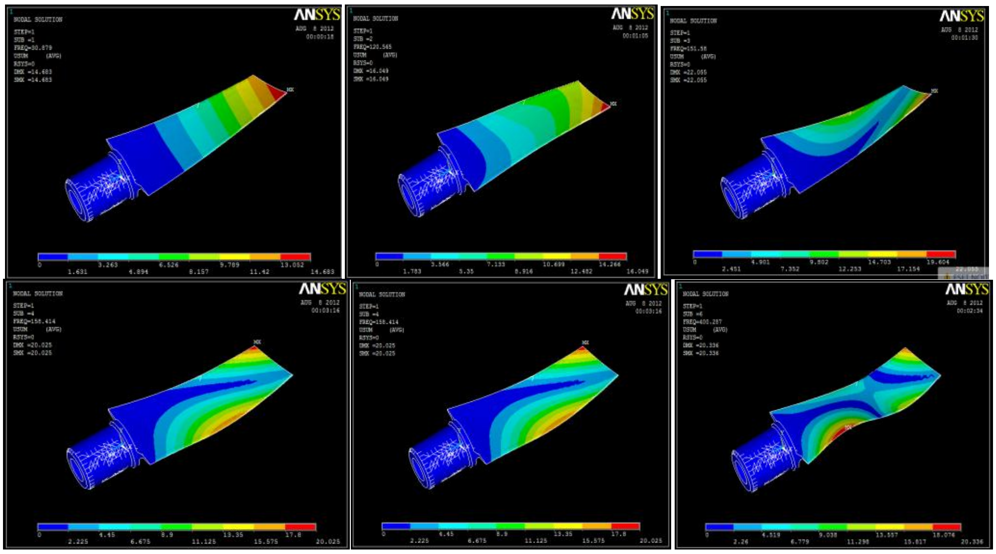


Fig.22, 23, 24, 25, 26&27 Different mode shapes of the Ni-Alloy blade

- **Case 3: For Titanium**

S.NO	NATURAL FREQUENCY
1	24.844
2	95.459
3	120.35
4	126.11
5	293.63
6	318.29
7	418.66
8	486.19
9	513.61
10	567.62

Table.6 Natural frequencies of Titanium-Alloy blade

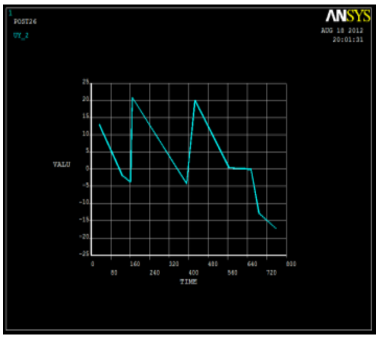
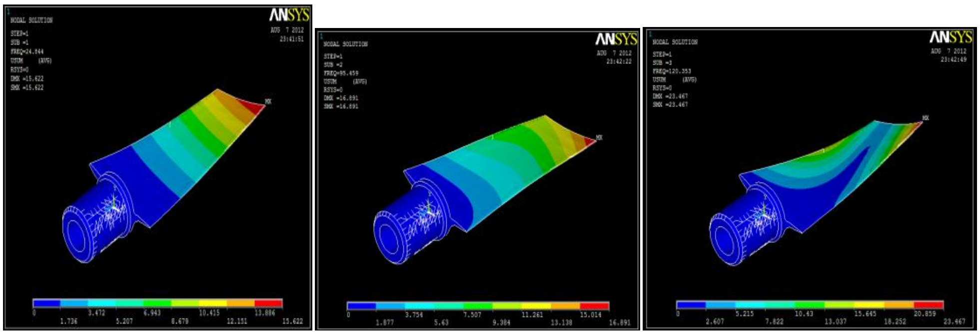


Fig.28 Graph for modal analysis



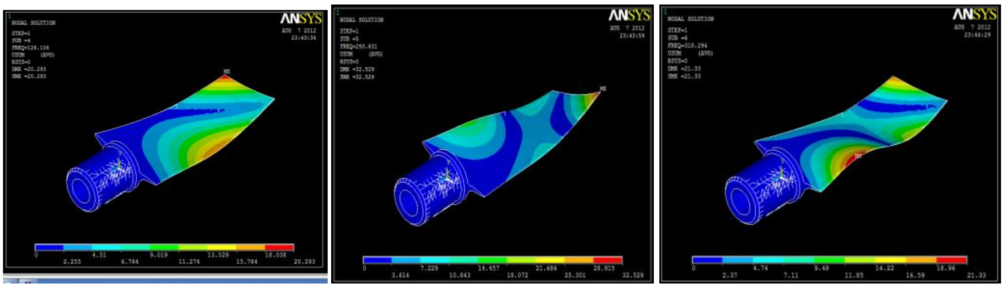
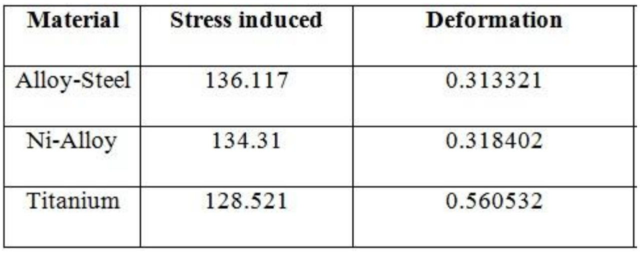


Fig.29, 30, 31, 32, 33&34 Different mode shapes of the Titanium-Alloy blade

- **Results obtained**



Material	Stress induced	Deformation
Alloy-Steel	136.117	0.313321
Ni-Alloy	134.31	0.318402
Titanium	128.521	0.560532

Table.7 Obtained results

VII. CONCLUSION

By doing the analysis of 2nd stage hp stator blade with different materials we can observe that the stress induced is more in Alloy-Steel compared to other two materials of Ni-Alloy & Titanium by considering the cost and availability of materials Alloy-steel is more preferable than Titanium or we may use Ni-Alloy instead of Alloy-Steel. And the deformation is observed more in Titanium compared to Alloy-Steel & Ni-Alloy so by seeing the results after analysis Alloy-Steel is best material for 2nd stage hp stator blade and further we may use Ni-Alloy instead of it.

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