

DESIGN AND ANALYSIS OF COMPRESSOR BLADE BY USING COMPOSITE MATERIALS

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Abstract— Compressor stall and choked flow condition is the two main parameters that affecting the compressors performance. These two parameters can also damage the aircraft and engine. In this project these two parameters optimized by the means of high temperature and composite materials. Changing the compressor blade material into high temperature material as well as composite material it will increase its properties like temperature, load, wear and corrosion. It's also reducing the FOD problem. Here axial compressor chosen for the project because of its high efficiency and performance. And we made the blade design in Blade gen, meshing in Gambit, flow analysis in Fluent and structural analysis in Ansys work bench. In this project compressor blade is designed and analyzed by modern engineering and advanced methods, materials, and compressor system and their integration into aircraft manufactures. This compressor gives more path ways to increase the pressure by reducing the negative factors.

I. INTRODUCTION

Compressor Blades are small airfoils and are subject to the same aerodynamic principles that apply to any airfoil. A compressor blade has an angle velocity. In other words, the relationship between the air pressure passing across the blade passing through the engine and the air pressure that is due to the rotation of the blade. These two forces combine to form a vector, which defines the airfoil's actual angle of attack to the approaching inlet air. By changing the compressor blade material the strength and temperature load will increase. For the change of blade we used high temperature and alloy material. For this project we have chosen axial flow compressor that working in aircrafts. In axial flow compressor there is no major Deviation in airflow, and the overall CPR also high. First we have modeled a blade with two different angles and thickness. Then we have done flow analysis in fluent software.

II. DESIGN SPECIFICATIONS

The different input parameters, used in design Process are:

- (i) Main specification
- (ii) Detailed specification
- (iii) Inlet specification

A. SPECIFICATIONS OF AXIAL FLOW COMPRESSOR

- The main specification of the axial flow compressor is based on the following parameters,
 1. Types of compressor
 2. Mass flow
 3. Number of stages
 4. Pressure ratio of each stage
 5. Rotational speed
 6. Stage reaction
- The Inlet specification of the axial flow compressor is based on the

Following parameters,

1. Inlet flow angle,
2. Stage flow coefficient
3. Hub tip ratio, r_{hub}/r_{tip}

B. BLADE DESIGN SPECIFICATIONS:

Inlet relative velocity Mach number = 0.7 to 1.1

Pressure ratio	= 1.15 to 1.6
Efficiency	= 80 % to 85%
Types of compressor	= Axial flow
Mass flow rate	= 1 kg/s
Number of stages	= 1
Rotation speed	= 36000 rpm
Density	= 1.225 kg / m ³
Inlet flow angle	= 45° and 60°

• **BLADE DETAILED SPECIFICATIONS:**

At 60° angle,

Thickness (t) = 2.5 mm

Chord length (c) = 414.125 mm

Thickness chord ratio = 6.036x10⁻³

Inlet pressure = 1.03x10⁹ Pa

Inlet temperature = 300 K

Velocity = 1.45x10⁴ m s

Pitch chord ratio (s/c) = 0.524

Area =
= 1 (1.225x1.45x10⁴xss2.5)
= 2.25193x10⁻⁵ m²
= 22.5193 mm²

r_{tip} =
= 22.5193 { [1 + (r_{tip}/r_{hub})²]}
= 9.5574 mm²

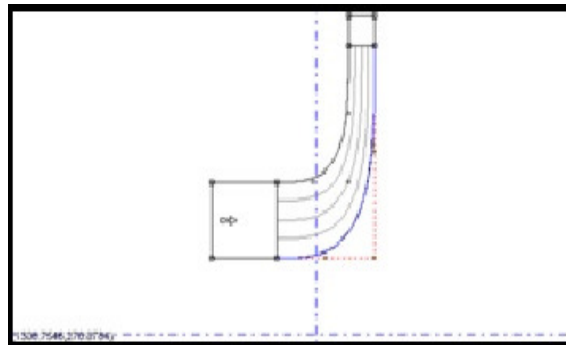
r_{rms} = [(r_{hub}² + r_{tip}²) / 0.5]^{0.5}
= 39.5284 mm²

U_{mean} = U_{rms}
= (2 x 39.5284 x 36000 / 60)
= 149.0185 m s

III. BLADE GEN – MODELING

Blade Modeler provides the essential link between blade design and advanced simulation including computational fluid dynamics and stress analyses. Blade Modeler contains a rich set of tools and functions for designing a turbo machinery blade from scratch, using industry-specific tools, workflow, and langu

A. FIRST MODEL WITH THICKNESS 2.5MM WITH ANGLE OF 60°



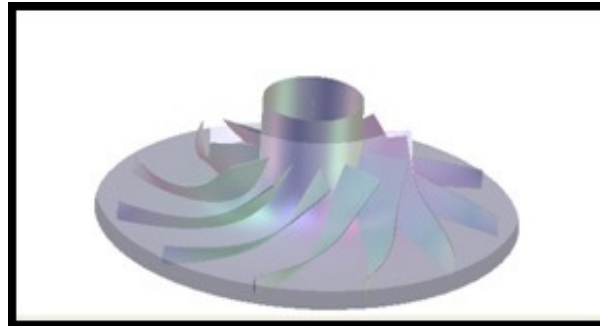


Fig 1: Initialblade design

IV. FLUENT – FLOW ANALYSIS

A. FIRST MODEL COMPRESSOR BLADE WITH INLET PRESSURE $1.03e^9$ Pa

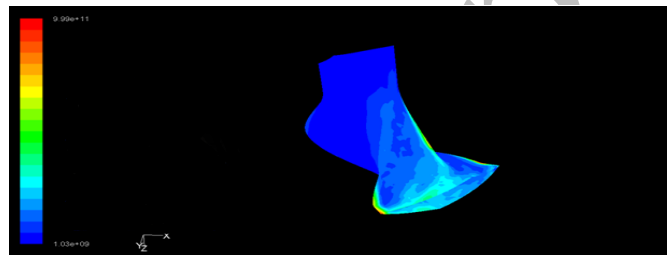


Fig 2: Flow analysis in first model of compressor blade

In above flow analysis the inlet pressure is 1034214 Pa applied in the first model of the compressor blade and the maximum pressure the blade can withstand is 9.99×10^9 Pa.

• SECOND MODEL COMPRESSOR BLADE NI BASED ALLOY MATERIAL WITH PRESSURE $1.71e^9$ Pa

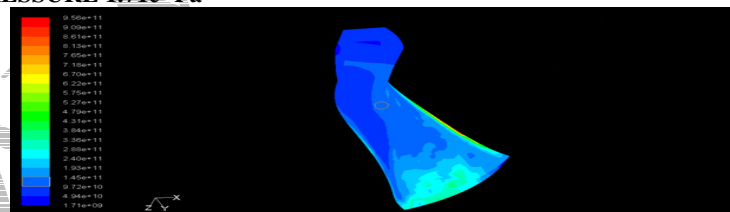


Fig 3: Flow analysis in second model of compressor blade

In above flow analysis the inlet pressure is 1713214 Pa applied in the first model of the compressor blade and the maximum pressure the blade can withstand is 9.56×10^9 Pa.

B. STRUCTURAL ANALYSIS

• FIRST MODEL COMPRESSOR BLADE NI BASED ALLOY MATERIAL WITH PRESSURE $1.03e^9$ Pa

- **TOTAL DEFORMATION IN THE FIRST MODEL NI BASED ALLOY MATERIAL WAS 23436 mm**

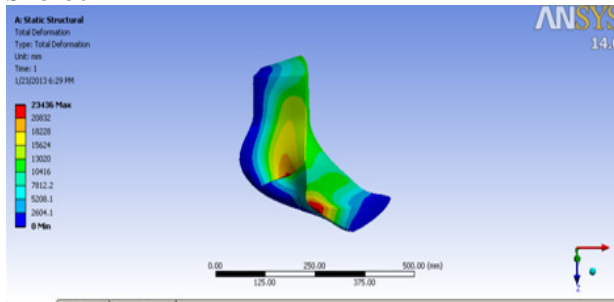


Fig4: Total deformation in first model blade with Ni based alloy

- **NORMAL STRESS IN THE FIRST MODEL NI BASED ALLOY MATERIAL WAS 2.703×10^7 MPa**

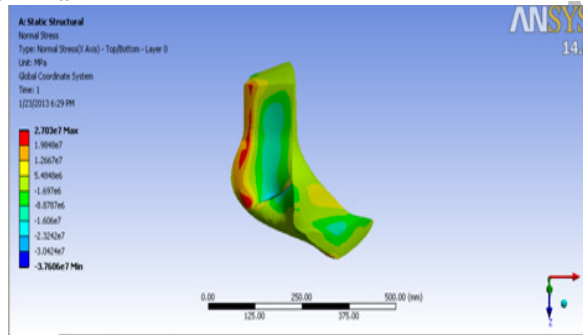


Fig 5: Normal stress in first model blade with ni based alloy

- **NORMAL STRAIN IN THE FIRST MODEL NI BASED ALLOY MATERIAL WAS 74.376**

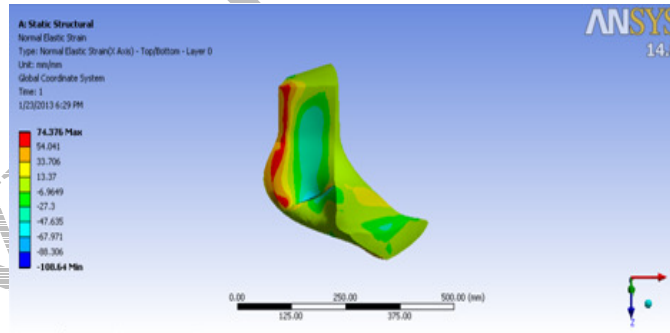


Fig6: Normal strain in first model blade with ni based alloy

- **FIRST MODEL COMPRESSOR BLADE IN TITANIUM PRESSURE 9.97×10^5 Pa**

4.2.6 TOTAL DEFORMATION IN THE FIRST MODEL TI MATERIAL WAS 23436 mm

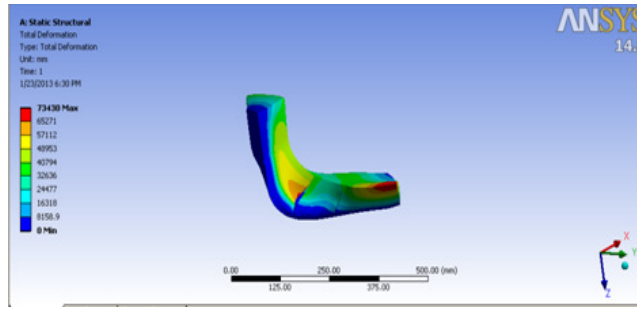


Fig 7: Total deformation in first model blade with Ti

- **NORMAL STRAIN IN THE FIRST MODEL TI MATERIAL WAS 226.28**

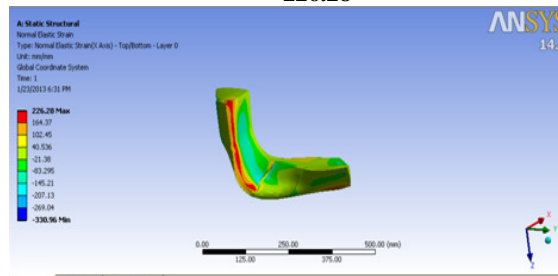


Fig 8: Normal strain in first model blade with Ti

- **NORMAL STRESS IN THE FIRST MODEL TI MATERIAL WAS 2.8036×10^7 Mpa**

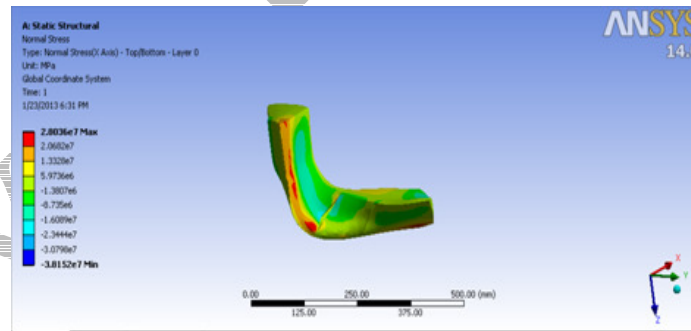


Fig 9: Normal stress in first model blade with Ti

C. SECOND MODEL COMPRESSOR BLADE NI BASED ALLOY MATERIAL WITH PRESSURE $9.54e^9$ MPa

- **TOTAL DEFORMATION IN THE SECOND MODEL BLADE WITH NI BASED ALLOY WAS 8.3352×10^6 MPa**

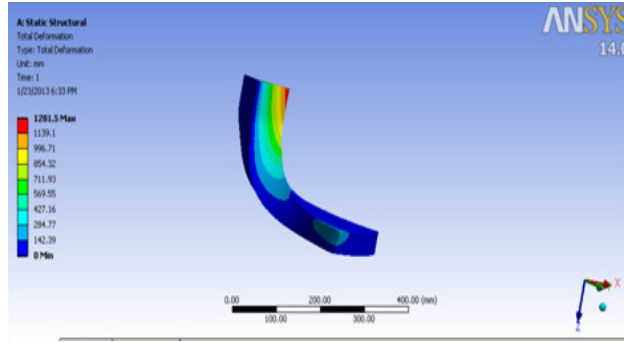


Fig 10: Total deformation in second model blade with Ni based alloy

- NORMAL STRAIN IN THE SECOND MODEL BLADE WITH NI BASED ALLOY WAS 26.896

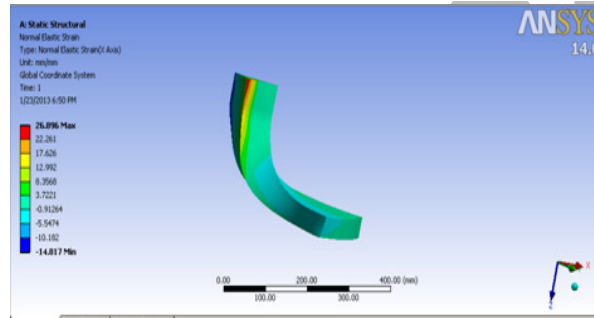


Fig 10: Normal strain in second model blade with Ni based alloy

- NORMAL STRESS IN THE SECOND MODEL BLADE WITH NI BASED ALLOY WAS 8.3352×10^6 MPa

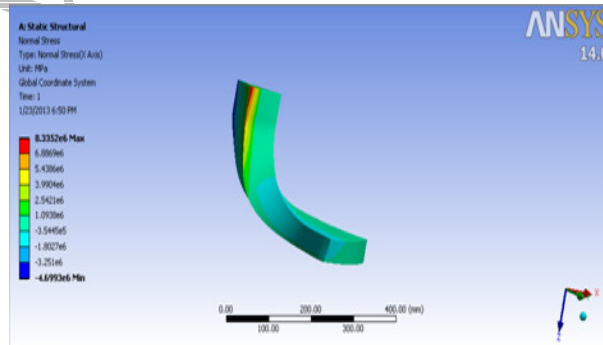


Fig11: Normal stress in second model blade with Ni based alloy

- SECOND MODEL COMPRESSOR BLADE TITANIUM WITH PRESSURE 9.54e5 MPa
- TOTAL DEFORMATION IN THE SECOND MODEL BLADE WITH

TITANIUM WAS 4068.9 mm

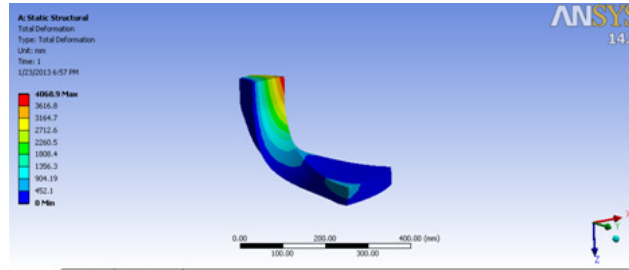


Fig 12: Total deformation in second model blade with Ti

- NORMAL STRAIN IN THE SECOND MODEL BLADE WITH TITANIUM WAS 62.914

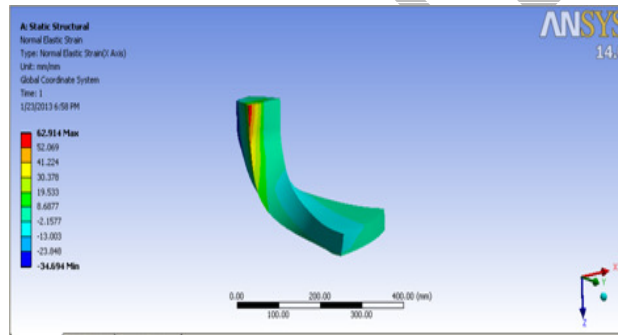


Fig 13: Normal strain in the second model blade Ti

- NORMAL STRESS IN THE SECOND MODEL BLADE WITH TITANIUM WAS 8.1585×10^6 MPa

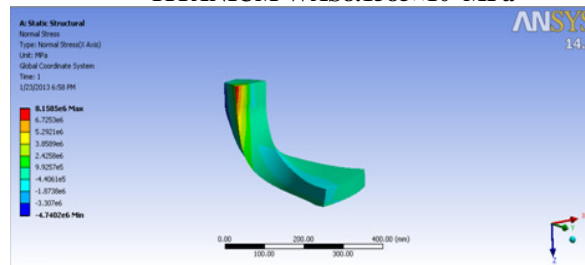


Fig 14: Normal stress in second model blade with Ti

V. RESULT

MODEL ONE AT 60° ANGLE & 2.5 mm THICKNESS	MODEL TWO AT 45° ANGLE & 2 mm THICKNESS
Flow analysis (pressure)	
9.99×10^3 Mpa	9.56×10^3 Mpa
Structural analysis	
Nickel base alloy	
23436 mm deformation	1281.5 mm deformation
2.703×10^7 MPa stress	8.3352×10^6 MPa stress
74.376 strain	26.896 strain
Titanium	
73438 mm deformation	4068.9 mm deformation
2.8036×10^7 MPa stress	8.1585×10^6 MPa stress
226.28 strain	62.914 strain

Table 1: comparison of two blades

VI. CONCLUSION

In this project we aimed to design a compressor blade with high strength and high temperature by adding composite materials and high temperature materials. For this we designed a blade with two different angles and we did flow analysis and structural analysis in that design. Finally we analysed four blades, each angle of blade has two different materials. And we compared the values of the results and we got a best result in one blade, by this blade we can optimize the compressor.

In designing analyzing this compressor we earned wide knowledge about the giant field aeronautics and its circumstances to designing a compressor blades, the world has sky as its end but the field aeronautics is initiated in that extreme, so as aeronautical engineers we too made an initial step in the sky by completing this project in a successful path.

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