Structural Analysis of Micro Compressor Blades

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Abstract:- A micro turbine used in refrigerator, generator; air drier. A micro turbine – compressor assembly being small in size as compared to large turbine has less weight which reflects on pressure ratio. In our paper we are analyses the compressor shaft and blade of a micro compressor under various loading condition and study the effect of stress distribution over the blade at various speed and shapes. Withstanding of compressor blades of gas turbine for the elongations is a major concern in their design because they are subjected to high axial, tangential, centrifugal forces. There are several projects summarize the design and analysis of gas turbine compressor blade by usingvarious power full finite element software. The present work includes the structural analysis of compressor radial impeller blade designed for small 50kW gas turbine application using solver fluent, Ansys13.0, which is powerful Finite element software. Effect of different material, Titanium, aluminum at the various rotational speed.

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1. INTRODUCTION

The purposes of gas turbine technology are extracting the maximum energy from the working fluid to convert into work with high efficiency at minimum cost. The gas turbine obtains its power by utilizingthe energy of gases and the air which is at high temperature and pressure by expanding in gasturbine. The gas turbine drives the compressor shaft so it is coupled to the turbine shaft. After compression the working fluid expanded in a turbine then the power generated is used for run the compressor and remaining power is used to generate electricity. The energy of burnt gases and the air which is at high temperature and pressure expanded in turbine togenerate high power.

Compressor usually sits at the front of the turbine. There are two main type of compressor the axial andcentrifugal compressor. In both types the of compressor rotates and it is driven by a shaft that attached turbine compressor and generator. Blades may be considered to be the main component of the gas turbine compressor assembly. Without blades there would be no power and small damage causereduction in efficiency and increases maintenance cost.

2. LITERATURE SURVEY

G.Narendranath et.al (1) in 2012 studied on the rotor blade of the gas turbine has been analyzed thermal stresses and structural, modal analysis using ANSYS 9.0carried out which is a powerful finite element method software. For the radial elongation resulting from the axial and tangential forces. The material of the blade was specified as N155 this material is an iron super bases alloy and the geometric model of blade profile is generated with splines and extruded to get solid model in CATIA V5R15 and analytical approach is used to estimate the centrifugal, radial and tangential force.

P.V.Krishnakanthet.al(2) in 2013 is studied on the thermall and structuralanalysis of gas turbine blade. CATIA is used for design of model and ANSYS for analysis of model generated. This paper also includes how the program make effective use of ANSYS to mesh complex turbine blade. Of The principal aim of this paper is to study the effect of various speed on various material of impeller blade and select best material for impeller blade.

Kauthalkaret.al(3) studied the purpose of gas turbine technology is to extract maximum energy form fluid and produce maximum efficiency, minimum cost and also improve efficiency of the turbine. A high pressure of order of order 5 to 10 bar for expansion , a compressor is required. For high speed generally centrifugal compressor is required. The turbine derived the compressor so it coupled the turbine shaft and same shaft connected to the generator.

J.B.Chaudhariet.al(4) in 2015 present work includes work the stress analysis of compressor radial impeller blade for small turbine. Application using solver I-DEAS 10NX. This is powerful finite element software. From study stresses analysis result it was found that for compressor impeller analyzed for different material peak stress are observed at inlet and mid hub section of impeller blade.

V.RagaDeepuet.al(4) Studied on a turbine is a device designed to extract the heat energy of fuel in to useful work such as mechanical power. Compressor blades are most important components in a gas turbine power plant. A blade can be defined as the component for transfer of energy from the gases to the turbine rotor. The turbine blades are mainly

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affected due to static and fatigue loads. Also the temperature has significant effect on the blades. Therefore the coupled analysis of turbine blades is carried out using finite element analysis software .

Dr.R.Rajappan in 2013 present the work on analysis on number of blades of compressor an concluded that Compressor Efficiency mainly depends on the Compressor blades. Therefore, good improvement in the compressor blade is mandatory. To achieve high Compressor efficiency, we made a suggestion of increasing the number of blades in the compressor.

In this paper the gas turbine is created in CATIA V5 R15 Software. This model has been analyzed using ANSYS11.0. The gas forces namely tangential, axial were determined by constructing velocity triangles at inlet and exist of rotor blades. After containing the heat transfer coefficients and gas forces, the rotor blade was then analyzed using ANSYS 11.0 for the couple field stresses.

3. COMPUTATIONAL FLUID DYNAMIC (CFD) ANALYSIS OF COMPRESSOR ROTOR BLADE

The model is created using CREO.2and analyzed using ANSYS. For automatic mesh generation node selection is used. The structural modal modules of ANSYS 13.0 are used for the analysis of the compressor rotor blade. The rotor blade was analyzed for mechanical stresses and radial and tangential elongations.

The blade is then analyzed with structural analysis. The model is discretized using quiderateral element

4. DETAILS OF COMPRESSOR BLADE:

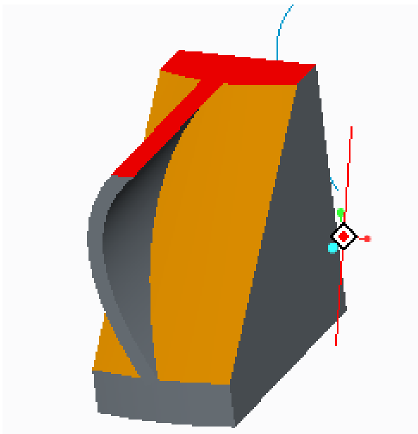
ITEMS	PARAMETER	VALUE
Shaft Diameter	D (mm)	16
Impeller Inner Diameter	d1	50
Impeller Outer Diameter	d2	100
Impeller Thickness to Shaft	h (mm)	32
Impeller Outflow thickness	b (mm)	5.61
Blade/Splitter Degree	β (degree)	32
Blade/Splitter Number	#	10

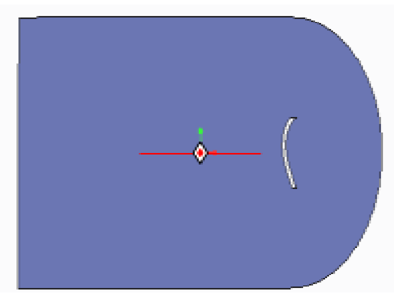
4.1 PROPERTIES OF MATERIAL :

propertie s	Units	Ti-6Al-4v	Aluminum
E	Pa	$1.14\text{x}10^{11}$	$7.1\text{x}10^{10}$
P	Kg/cu	4430	2800
poission ratio	---	0.34	0.33
Yield stress	MPa	$4.25\text{x}10^{10}$	$2.7\text{x}10^{10}$

4.2 MODELLING AND MESHING:

The impeller design is 3-dimensionally modelled then meshed properly to divide it into elements and nodes. Finite element model was generated using Quadrilateral due to their flexibility in curved and complex shapes, for your analysis the slice of blade is taken into account and convert into 2-D model for analysis.





5. RESULTS & DISCUSSIONS

ANALYSIS UNDER VARIOUS ROTATIONAL SPEED:

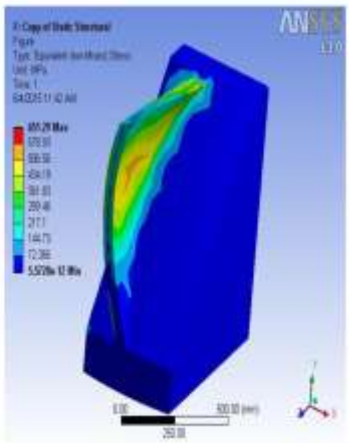
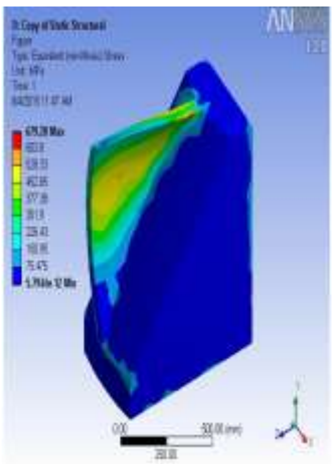
The variation of rotational speed is as a representation of a various operating conditions, depending on the required output. For this purpose analyses were carried out at rotational speeds of 60000 rpm, 50000 rpm and the maximum stresses were compared with the yield strength of every item.

1) Rotational Speed of 60000 rpm

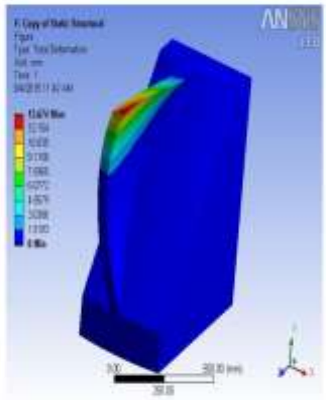
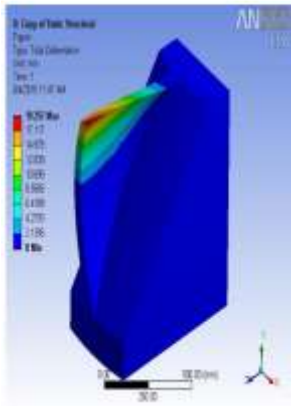
At rotational speed of 60000 rpm the total pressure counter get by CFD analysis in fluent is 4.11×10^8Pascal.

For that maximum pressure the von stresses and deformation as fallow:

a) Von stresses

Material	Stress Contour
Ti-6Al-4V	
l 7075	

b) Deformation:

Material	Deformation Contour
Ti 6Al-4V	
Al 7075	

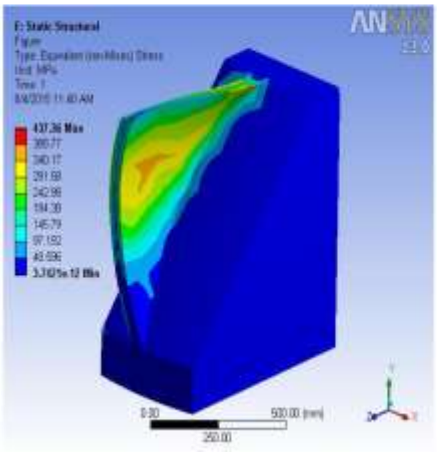
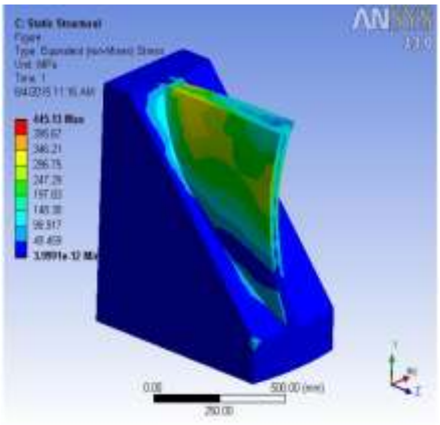
Result obtain from the above observation at 60000 rpm for both alloy as fallow:

Items	Ti-6Al-4V	Al 7075
Fluid Load (Pascal)	4.11×10^8	
Maximum Stress (Pascal)	6.51×10^8	6.79×10^8
Maximum Deformation (mm)	13.074	19.257

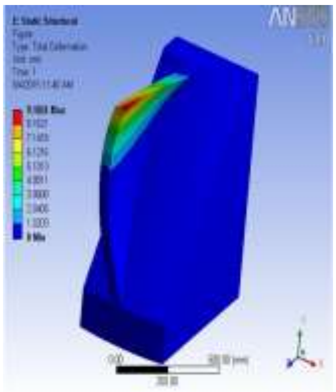
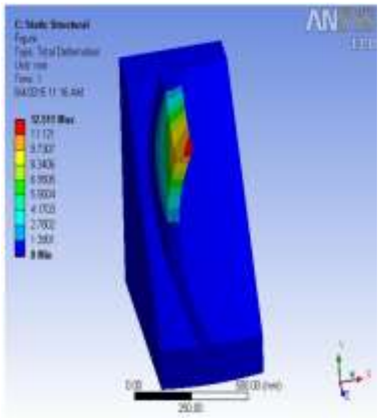
2) Rotational Speed of 50000 rpm

At rotational speed of 50000 rpm the total pressure counter get by CFD analysis in fluent is 2.76×10^8Pascal.

a) **For that maximum pressure the von stresses and deformation as fallow.**

Material	Stress Contour
Ti-6Al-4V	
Al 7075	

b) **Deformation:**

Material	Deformation Contour
Ti-6Al-4V	
Al 7075	

Result obtain from the above observation at 50000 rpm for both alloy as fallow:

Items	Ti-6Al-4V	Al 7075
Fluid Load (Pascal)	$2.76 x 10^{8}$	
Maximum Stress (Pascal)	$4.37 x 10^{8}$	$4.45 x 10^{8}$
Maximum Deformation (mm)	9.182	12.511

From the study of stress analysis it was found that for radial compressor analyzed for different materials, peak stress in high speed rotor vanes are reduced for materials Titanium which possess high yield strength to density ratio than steel alloy

From the above result it is concluded that for our designated output power of 50 kW, the compressor has to rotate at 60000 rpm. Thus for this purpose, titanium alloy, with a much higher ultimate tensile strength, is thus the safe material to be used. Aluminum alloy would not be suitable for this case as it would fail

6. CONCLUSION

Compressor blades may be backward curved, straight, or forward curved; the most common being the backward curved. This analysis showed that the backward curved blade gives better safety factors.

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The simulation showed that the stresses are concentrated on the blade tip at the mid. And maximum deformation at the outer edge of the blade

Another point observed is that a higher rotational speed will result in greater stresses to be borne by the structure.

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