Static and Dynamic Response of an Impeller at Varying Effects

Karthik Matta[1], Kode Srividya[2], Inturi Prakash[3]

[1]Student (M.Tech), [2]Assistant Professor Department of Mechanical Engineering, PVPSIT, Vijayawada, India
[3]Projeect Analyst, Data Pro Office, Vizag

Abstract: *An impeller is a rotating component of a centrifugal pump, usually made of iron, steel, bronze, brass, aluminum or plastic, which transfers energy from the motor that drives the pump to the fluid being pumped by accelerating the fluid outwards from the center of rotation. The velocity achieved by the impeller transfers into pressure when the outward movement of the fluid is confined by the pump casing. Impellers are usually short cylinders with an open inlet (called an eye) to accept incoming fluid, vanes to push the fluid radially, and a splined, keyed or threaded bore to accept a drive-shaft.The modeling of the impeller was done by using solid modeling software, CATIA V5 R18. It is proposed to design a blower with composite material, analyze its strength and deformation using FEM software. In order to evaluate the effectiveness of composites and metal blower and impeller using FEA packaged (ANSYS). Modal analysis is performed on both Aluminum and composite centrifugal blower impeller to find out first 5 natural frequencies*
***Keywords:*** *CATIAV5 R18, Study of noise, Vibrations, Impeller, Aluminumand Composite, Blower, Static and Dynamic Response Using FEA.*

I.   Introduction

The impeller made out of cast material in many cases may be called rotor, also. It is cheaper to cast the radial impeller right in the support it is fitted on, which is put in motion by the gearbox from an electric motor, combustion engine or by steam driven turbine. The rotor usually names both the spindle and the impeller when they are mounted by bolts. . [1] JavadAlinejad and FarhadHosseinnejad "Aerodynamic Optimization In The Rotor Of Centrifugal Fan Using Combined Laser Doppler Anemometry And Modelling" World Applied Science Journal 17(10), 2012. The targeted topic in this particular study is the design optimization of a centrifugal fan in order to improve efficiency and rectify the non-uniformity of the flow and to eliminate the vortices that are generated by the existence of inlet distortion. Two types of rotor were used by different geometries in the current study: cylindrical and conical frustum-shaped. Numerical simulation was performed by a 3D turbulent, steady-state, incompressible flow analysis.[2] ShaliniRai, Dr.Prabha Chand "Centrifugal Fan Impeller Design With Optimization Of Blade" International Journal Of Applied Engineering Research, Vol 7, No 11, 2012. In their research redesigning a centrifugal impeller and its inlet duct were considered. The double-discharge volute casing is a structural constraint and is maintained for its shape. To reducing the power required to operate the fan, redesign effort was geared towards meeting the design volute exit pressure.[3] O.P.Singh, Rakesh.Khilwani, T.Sreenivasulu, M.Kannan "Parametric Study Of Centrifugal Fan Performance:Experimental And Numerical Simulation" International Journal Of Advances In Engineering And Technology May 2011. In their research effect of geometric parameters of a centrifugal fan with backward- and forward-curved blades has been investigated.

**Effects performed on the impeller:**
1. Effect of change in blades number
2. Effect of change in blade diameter
3. Effect of change in blade angle
4. Effect of change in speeds
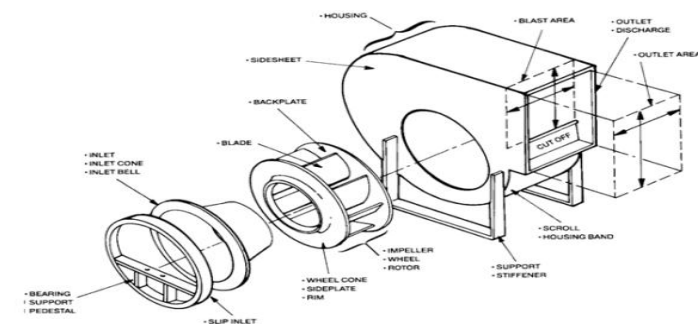
Components of centrifugal blower

II.   Modelling By Using Catia V5 R18

Modeling of the Blower, suction plate, supports and Impellerare done by using CATIA V5 R18. As individual parts and these are assembled as single product, saved as IGES format to import the model in to ANSYS 12.0
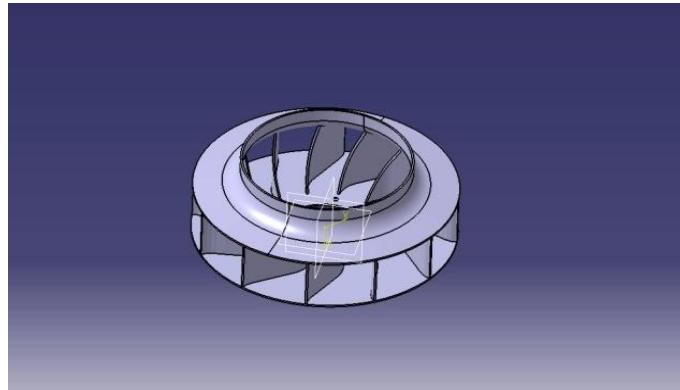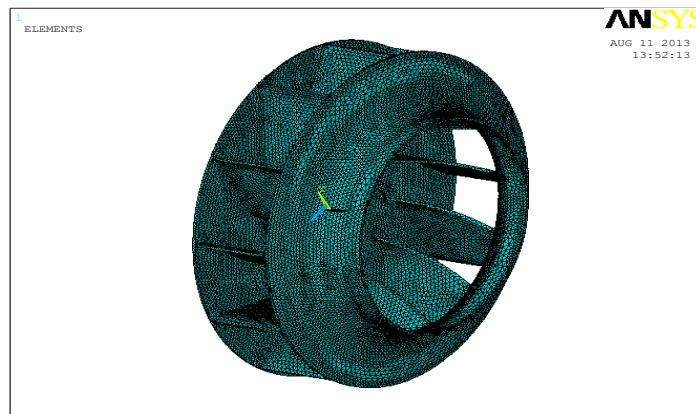
Impeller Solid Model

III.   Finite Element Analysis

The analysis of ship Blower and Impeller has been carried out by using ANSYS 12.0 general purpose FEM software. The following analysis were done on the blower

1) Static analysis
2) Modal analysis
3) Harmonic analysis

Meshed Models ofImpeller

IV.   Case Description

The complete project is aimed at examining the static and dynamic analysis of the impeller and further examining then aluminum impeller results with the composite impeller at varying effects. Also for the purpose of the total deformation and stresses developed static and dynamic analysis is done on metallic blower for present results. More over number of variations are taken for the impeller diameter, speed, blade angle and number of blades was changed for the better performance.

4.1INPUT DATA

Fluid	Air
Operating speeds	283-500 rpm
Pressure	1.20kg/cm^2

4.2MATERIAL PROPERTIES OF THE IMPELLER
The analysis is performed on
(i) Metallicimpeller and (ii) Composite impeller

I.   MATERIAL PROPERTIES OF METALLIC IMPELLER (ALUMINIUM)
     Young's modulus E=70000 MPa
     Poisons ratio NUXY = 0.34
     Mass density = 2700 kg/m^3
     Damping co-efficient = 0.006

II. MATERIALS PROPERTIES OF COMPOSITE IMPELLER(GLASS/EPOXY)
     Young's modulus $E_X = E_Y = 14GPa$, $E_Z = 8.8GPa$
     Poisson's ratio NUXY = 0.13, NUYZ = NUZX = 0.39
     Shear modulus $G_{XY}=4.7GPa$, $G_{YZ} = G_{ZX} = 4.2GPa$
     Mass density = 1750kg/m^3
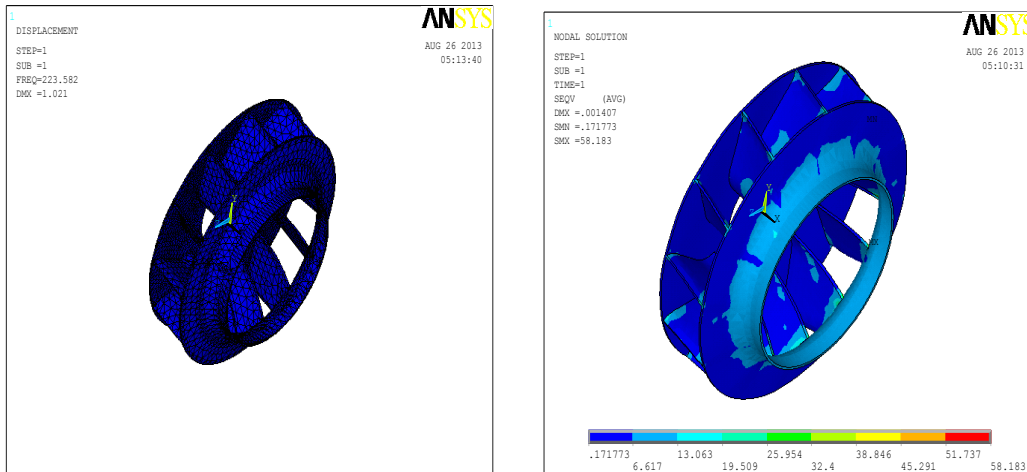   Damping co-efficient = 0.02
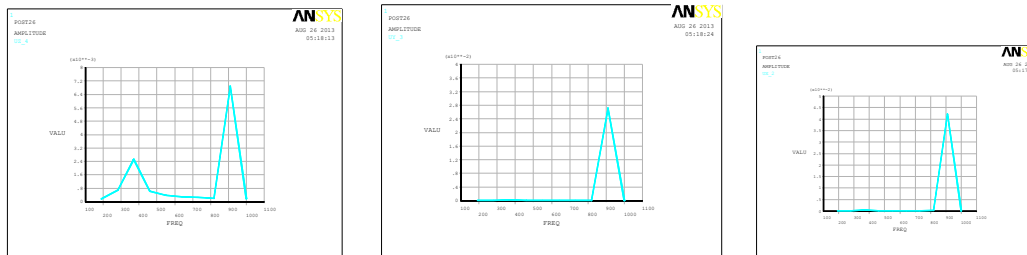
V.   Results And Discussions

Aluminum Impeller:
DEFORMATION MAX= 0.001407
STRESS MAX=58.18
STRESS MIN=0.1717

MODEL ANALSYS:

MODE SHAPE	FREQUENCY(Hz)
1	223.58
2	227.26
3	346.45
4	885.59
5	902.30

Static and dynamic analysis of aluminium impeller

Harmonic analysis of aluminium impeller

Composite Impeller:
DEFORMATION MAX=0.05968
STRESS MAX=12.59
STRESS MIN=0.079
MODEL ANALYSIS:

MODE SHAPE	FREQUENCY(Hz)
1	57.05
2	57.63
3	67.57
4	77.89
5	87.67

VI. Comparison Results:

6.1.1Blades variations of composite impeller: glass epoxy

Number of blades	Deformation max mm	Stress max(N/mm^2)	Stress min(N/mm^2)
8	0.052	12.13	0.04
10	0.065	13.10	0.06
12	0.065	13.59	0.07
14	0.065	13.72	0.08
16	0.085	15.08	0.08

6.1.2 Diameter variation of composite impeller: glass epoxy

Diameter of blade	Deformation max mm	Stress max(N/mm^2)	Stress min(N/mm^2)
325	0.043	11.40	0.043
350	0.046	12.07	0.047
375	0.066	12.73	0.097
398	0.069	12.79	0.099

6.1.3 Blade angle variation of impeller: both aluminum and glass epoxy

Blade material	Angle of blade	Deformation (max)	Stress (max)
Aluminum	48°	0.001407	58.18
Aluminum	52°	0.123131	28.485
Glass epoxy	48°	0.05968	12.59
Glass epoxy	52°	0.03353	3.948

6.1.4 Variation In Speed: both aluminum and glass epoxy

Speed(rpm)	Stress(max) AL	Stress(max) COMPOSITE	Deformation(max) AL	Deformation(max) COMPOSITE
283	127.88	57.986	0.386774	0.45373
380	234.07	103.089	0.601948	0.798462
450	330.286	143.97	0.806327	1.111
500	408.551	177.253	0.975323	1.365
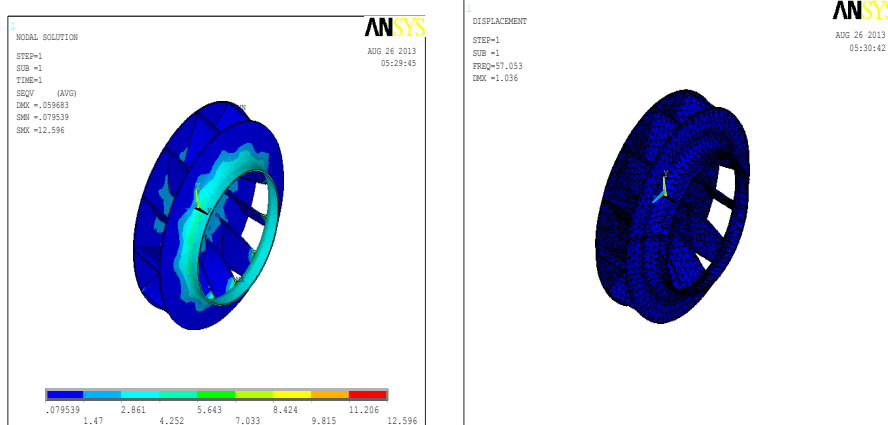
Static and dynamic analysis of composite impeller
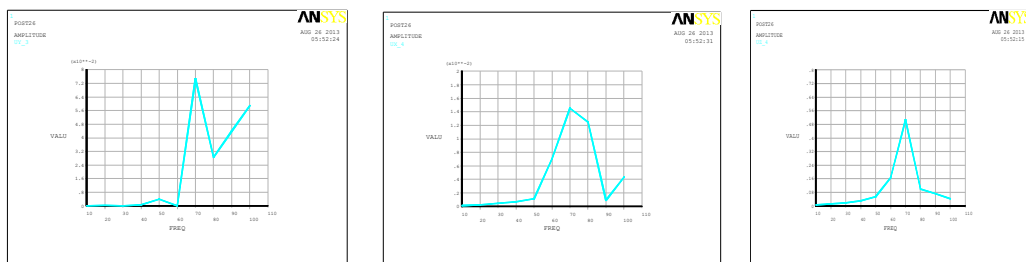
`   **Harmonic analysis of composite impeller**

VII.   Conclusion

The following conclusions are estimated from the above analysis.

1. Different types of effects are performed on the impellers with varying sizes, number of blades, varying blade angle and varying speeds. Impeller is modelled in design software CATIA V5 R18; these are used to run the analysis.
2. Three types of analysis are performed using aluminium and glass epoxy materials.
3. If number of blades, angle of the blade and outer diameter increases stresses and deformations also increases all are in allowable limit and we can increases the pressure of exhaust air. In case of varying the speeds the stresses of the composite are within the limits and are less when compared with aluminium, where the deformations are less for aluminium compared to glass epoxy.
4. Model analysis are performed to find out the natural frequencies of the impeller blade using harmonic analysis we have found that were resonance occur.
5. Total analysis results compares and found that composite materials are having less deformation and stresses.
6. All the above analysis results are in allowable limits and design is in safe conditions.

VIII.   Future Scope Of The Work

1. Dynamic analysis can be performed for entire blower using composite materials.
2. We can check the lifetime of the impeller with changing various thickness of the blade FEM.
3. By changing the different lay-upsequences angles of particular composite materials we can run the analysis and find out optimum model.

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