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EVALUATION OF STATIC AND DYNAMIC ANALYSIS OF A CENTRIFUGAL BLOWER USING FEA

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Abstract

Centrifugal blowers are used extensively for on-board naval applications have high noise levels. The noise produced by a rotating component is mainly due to random loading force on the blades and periodic iteration of incoming are with the blades of the rotor. The contemporary blades in naval applications are made up of aluminum or steel and generate noise that causes disturbance to the people working near the blower.

The present work aims at examining the choice of composites as an alternative to metal for better vibration control. Composites, known for their superior damping characteristics are more promising in vibration reduction compared to metals. The modeling of the blower was done by using solid modeling software, CATIA V5 R19. The blower is meshed with a three dimensional hex8 mesh is done using HYPERMESH 10.

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 using FEA packaged(ANSYS). modal analysis is performed on both Aluminum and composite blower to find out first 10 natural frequencys .

Keywords: study the noise, vibration, aluminum, composite material(FRP) is chosen for FEA analysis, deformation.

1.0 INTRODUCTION

Blowers are one of the mechanisms used regularly in submarines. They are installed in ventilation and air conditioning systems in almost all submarine compartments. Ventilation systems usually presented by central systems include supply and exhaust fans, serve for ventilation of accommodation and other than accommodation areas with atmospheric air with simultaneous ventilation of storage batteries and for air cooling and purification from harmful and smelling impurities. Air conditioning systems are presented by local, compartment group and single duct systems. These systems are used to provide comfortable conditions in terms of air temperature and humidity for the crew in accommodation areas and other accommodation areas, air purification in galleys, provision rooms, and sanitary areas and also for air mixing in compartments.

All blowers intended for submarine installation differ from industrial ones not only for their high reliability and strength under dynamic impacts but also for low noise and vibration levels. As blower represents a large part of submarine mechanisms, they should naturally meet the following compulsory requirements for all mechanisms:

- Minimum weight-dimensional parameters.
- Reliable operation at submarine motions.
- Vibration and impact resistance.
- Convenience of mountings, repairs and easy access to lubrication points.
- Keeping of service life at transportation and changes in climate.

2.0 FINITE ELEMENT METHOD

Finite element analysis is a computer based numerical technique for calculating the strength and behavior of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It can analyze elastic deformation or “permanently bent out of shape” deformation. The computer is required because of the astronomical number of calculations needed to analyze a large structure. The power and low cost of modern computers has made finite element analysis available to many disciplines and companies.

With the rapid advancement of technology, the complexity of the problem to be dealt by a design engineer is also increasing. This scenario demand speedy, efficient and optimal design from an engineer. To keep pace with the development and ensure better output, the engineer today resorting to numerical methods. For problems involving complex shapes, material properties and complicated boundary conditions, it is difficult and in many cases interactive to obtain analytical solutions. Numerical methods provide approximate but acceptable solutions to such problems.

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Finite element analysis is one of such numerical procedure for analyzing and solving wide range of complex engineering problems (may be structural, heat conduction, flow field which are complicated to be solved satisfactorily by any of the available classical analytical methods.

The computer intervention is the backbone of the procedure since it involves the solution of many simultaneous algebraic equations, which can be solved easily by the computer. Actually Finite Element Method was originated as a method of stress analysis. But today the applications are numerous. Now days, each and every design is developed through Finite Element Analysis. The numerous applications include the fields of Heat transfer, Fluid flow, Lubrication. Electric and Magnetic fields, Seepage and other flow problems. The various areas of applications include design of buildings and bridges, electric motors, heat engines, aircraft structures, spacecrafts etc. With the advances in Interactive CAD systems complex problems can be modeled with relative ease. Several alternative configurations can be tried out on a computer before the prototype is built.

3.0 MODELING AND MESHING OF CENTRIFUGAL BLOWER

The solution procedure of this project work involves the following steps:

1 Modeling by using CATIA V5 R19
2 Meshing by using HyperMesh 10.0
3 Analysis using ANSYS 11.0

3.1 MODELING BY USING CATIA V5 R19

A centrifugal blower with rearwardly curved impeller blades positioned in housing between two housing faces that are spaced apart along the impeller axis. One of the housing faces defines a housing inlet called bell mouth. The housing is substantially closed off with the exception of the inlet and an outlet. Modeling of the Centrifugal blower is done using CATIA V5 R 17. In order to model the centrifugal blower it is necessary to model the parts of the blower which are Spiral Casing, Impeller and the suction plate then it was assembled to get the total component. The solid model of the centrifugal blower is as shown in the figure 5.1.

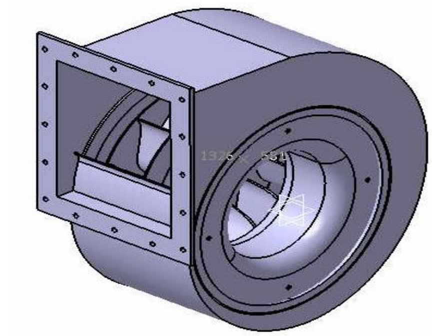

Fig. 3.1.1 Solid model of the centrifugal blower

3.2 MESHING BY USING HYPERMESH 10.0

The solid model is imported to HYPERMESH 9.0 and hexahedral mesh is generated for the same. The meshed model is shown in figure 5.2. The meshing was done by splitting it into different areas and the 2D mapped mesh was done and then it was converted into 3D mesh using the tool linear solid. The number of elements and nodes are 27,388 and 52,412. Quality checks are verified for the meshed model. Jacobian, warpage and aspect ratio are within permissible limits. Then the meshed model is imported into the ANSYS.

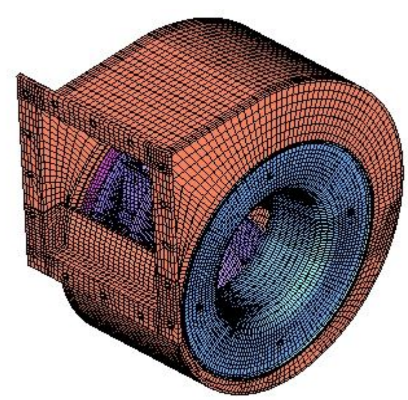

Fig.3.2.1 Centrifugal Blower FE model in Hypermesh 10.0

For meshing the composite blower the solid model is imported in to hyper mesh and the elements are selected for various layup sequences as given by their thickness mentioned in Chapter 3. Then the meshed model is imported into the ANSYS.

4.0 CASE DESCRIPTION

The complete project is divided into two cases and the details of each case is (flow input, boundary condition details, grid details, various plots with results and discussion is presented

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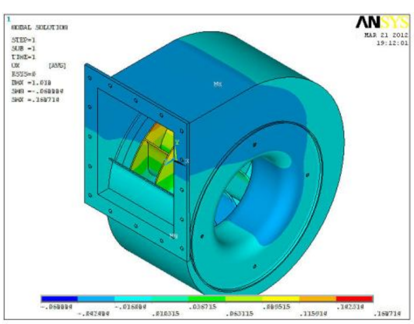
4.1 INPUT DATA

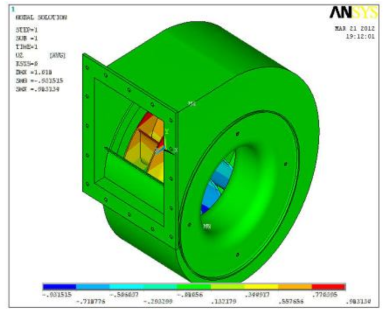
Fluid	Air
Velocity in x-direction	31.0005m/s
Velocity in y-direction	0
Velocity in z-direction	0
Turbulent viscosity	0.001001m^2/s
Temperature	150-200 deg
Pressure	84 MPA

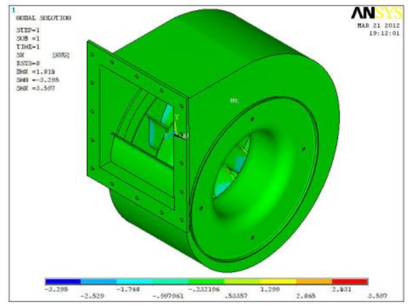
4.2 Results

Aluminum Blower	Results
Deflection in mm	0.0914 mm
Max. Normal stress, N/mm^2	3.483 N/mm^2
1st principal stress, N/mm^2	13.234N/mm^2
2nd principal stress, N/mm^2	1.345N/mm^2
3rd principal stress, N/mm^2	0.9047N/mm^2

Composite blower (27 layers)	Results
Max deflection in mm	1.018mm
Max. normal stress, N/mm^2	4.534N/mm^2
Maximum Inter-laminar shear stress, N/mm^2	8.669N/mm^2
1st principal stress, N/mm^2	15.457 N/mm2
2nd principal stress, N/mm^2	2.795 N/mm2
3rd principal stress, N/mm^2	1.549 N/mm2







4.2.1Displacement of composite blower in x-y-z-direction, mm

4.3 FIRST TEN NATURAL FREQUENIES OF ALUMINIUM BLOWER

Eigen value analysis results show that the first critical speed of Aluminum blower is 128 Hz and next critical speed is 132 Hz and are tabled in table 4.3. The ten mode shapes obtained in modal analysis are shown in figures

No. of modes	Natural frequencies of Aluminum blower in Hz
1	128.11
2.	132.03
3.	132.16
4.	199.67
5.	249.07
6.	281.84
7.	300.39
8.	339.52
9.	366.98
10.	425.50

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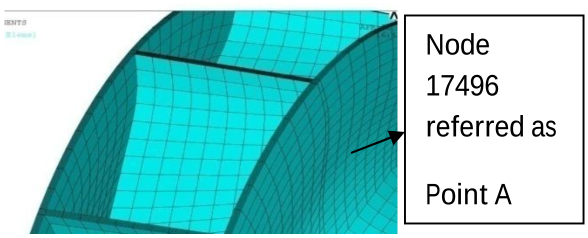
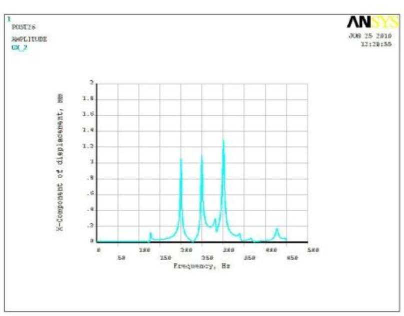
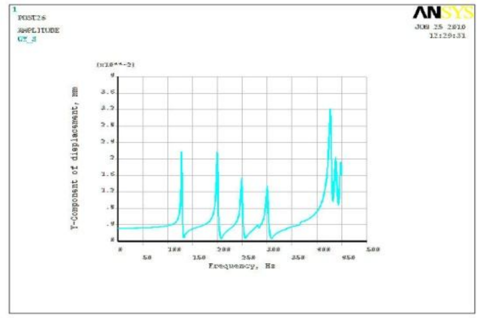
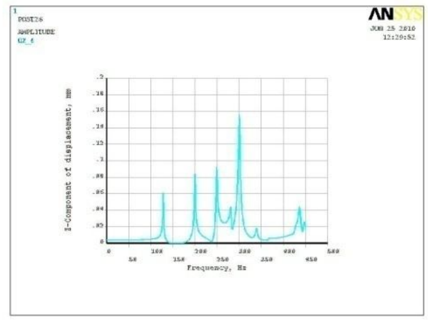
No. of modes	Natural frequencies of Composite blower in Hz
1	94.466
2	94.498
3	102.67
4	106.40
5	132.05
6	149.31
7	158.80
8	179.73
9	191.11
10	222.02



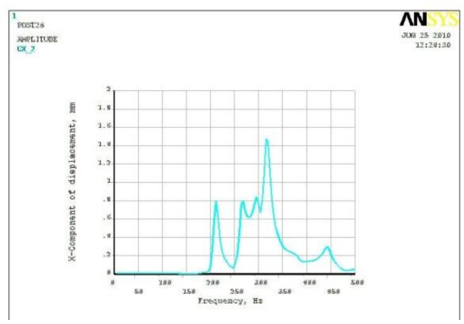
4.3.3Fig.Node17496 referred as point A

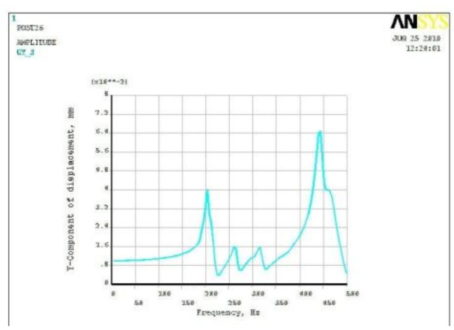






4.3.4 X-Y-Z Component of Displacement versus Frequency response graph of aluminum blower





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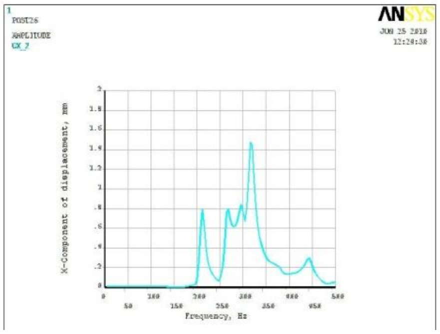

4.3.5 X-Y-Z Component of Displacement versus Frequency response graph of Composite blower

4.4 Maximum and Minimum Displacements of aluminum blower

Displacements of aluminium Blower	Maximum, mm
X-Component	0.6120
Y-Component	0.0087
Z-Component	0.0726

4.5 Maximum and Minimum Displacements of composite blower

Displacements of Composite Blower	Minimum	Maximum
X-Component	-0.6429	0.6521
Y-Component	-0.0224	0.0117
Z-Component	-0.0746	0.0807

5.CONCLUSIONS & FUTURE SCOPE OF WORK

5.1 CONCLUSIONS

The following conclusions are drawn from the present work

1. The stresses of composite blower obtained in static analysis 4.534 N/mm^2 are within the allowable stress limits.
2. The natural frequency of composite blower is reduced because of high stiffness and the lay up sequence in the blower.
3. The weight of the Composite blower is 15 kg which is less than the aluminum blower with a weight of 20 kg.
4. From the results of harmonic analysis, damping effect is more in composite blower which controls the vibration levels.

5.2 FUTURE SCOPE OF WORK

In present work the harmonic analysis is carried out for both aluminum and composite blower and response is compared. The aerofoil blade profile may be used for impeller blade and further solution is required.

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