

## Static Analysis of Centrifugal Blower Using Composite Material

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### -----ABSTRACT-----

*This paper is static and model analysis of centrifugal blowers using composite materials Centrifugal blowers are used in naval applications and motors which have high noise levels. The noise generated by a rotating component is mainly due to random loading force on the blades and periodic iteration of incoming air 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 observing the choice of E-Glass as an alternative to metal for better vibration control. E-Glass, known for their superior damping characteristics are more promising in vibration reduction compared to metals. The modeling of the blower was done by solidworks2014. The blower is meshed with a three dimensional hex8 mesh is done using. It is proposed to design blower with Epoxy glass, analyze its strength and deformation using FEM technique. In order to evaluate the effectiveness of E-Glass and metal blower using FEA packaged (ANSYS). Modal analysis is performed on both Aluminium and E-Glass blower to find out first five natural frequencies.*

**Keywords:** solidwork2014, ANSYS

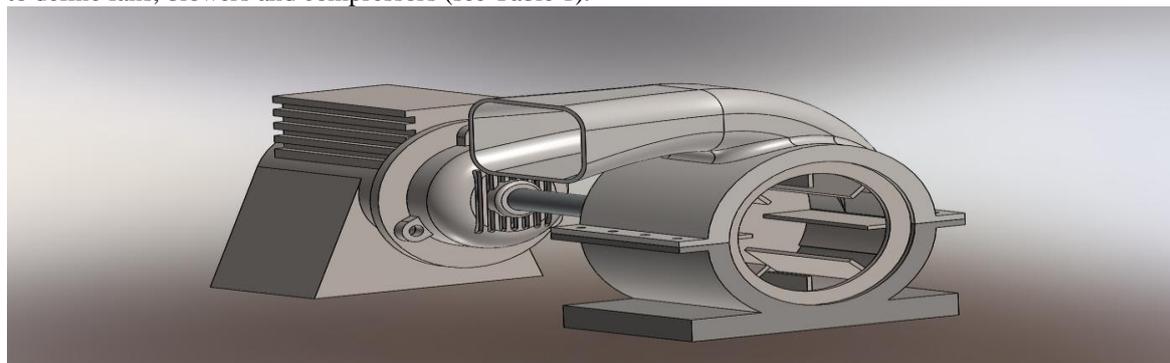
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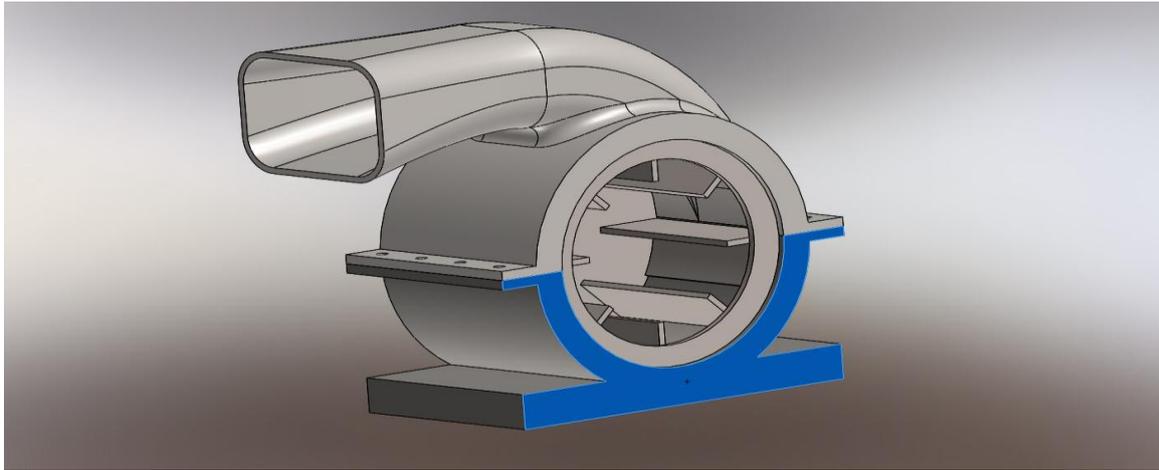
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### I. INTRODUCTION

Centrifugal blowers look more like centrifugal pumps than fans. The impeller is typically gear-driven and rotates as fast as 15,000 rpm. In multi-stage blowers, air is accelerated as it passes through each impeller. In single-stage blower, air does not take many turns, and hence it is more efficient. Centrifugal blowers typically operate against pressures of 0.35 to 0.70 kg/cm<sup>2</sup>, but can achieve higher pressures. One characteristic is that airflow tends to drop drastically as system pressure increases, which can be a disadvantage in material conveying systems that depend on a steady air volume. Because of this, they are most often used in applications that are not prone to clogging. Most manufacturing plants use fans and blowers for ventilation and for industrial processes that need an air flow. Fan systems are essential to keep manufacturing processes working, and consist of a fan, an electric motor, a drive system, ducts or piping, flow control devices, and air conditioning equipment (filters, cooling coils, heat exchangers, etc.). An example system is illustrated in Figure 1. The US Department of Energy estimates that 15 percent of electricity in the US manufacturing industry is used by motors. Similarly, in the commercial sector, electricity needed to operate fan motors composes a large portion of the energy costs for space conditioning (US DOE, 1989). Fans, blowers and compressors are differentiated by the method used to move the air, and by the system pressure they must operate against. The American Society of Mechanical Engineers (ASME) uses the specific ratio, which is the ratio of the discharge pressure over the suction pressure, to define fans, blowers and compressors (see Table 1).



Assembly of centrifugal blower and motor



Centrifugal blower

## II. REASONS OF NOISE GENERATION IN CENTRIFUGAL BLOWER

Vibration due to motor fan static and dynamic unbalanced rotating masses, resonant vibration of motor fan casings, motor fan mounting and misalignment, etc. Due to Electro magnetically produced noise caused by changing of electromagnetic field in the electric motor. Whole noise is due to rotational frequency and fan Blade passing frequency (BPF) and their harmonics. These are usually dominant noise source. Broadband aerodynamic noise generated by airflow at the inlet and outlet of the cooling fan. Mechanical noise caused by friction in bearings and seals,

## III. NOISE CONTROL METHODS

Environmental noise usually does not affect directly from the energy source rather, it transmitted along mechanical or liquid streams before it finally radiates from some vibrating surface into the surrounding environment. The approaches to treating pump noise generally include in the following: 1. Modify the basic design or operating condition to minimize the generation of acoustic energy.

Prevent sources from generating airborne noise by interrupting the stream between the energy source and the listener. This approach may range from isolation mounts at the source physically removing the listener. Role of epoxy glass in noise generation control, E-Glass material is a system that is created by the synthetic assembly of two or materials. The material consists of fiber of high strength and modulus embedded in a resin with distinct interfaces between them. They produce a combination of properties that cannot be achieved with either of the constituents acting alone. E-Glass materials have high strength, modulus. The most common form in which reinforced composites are used in structural application is called a laminate and it is obtained by stacking a number of thin layers of fibers and matrix and consolidating them into the desired thickness. Fiber orientation in each layer and stacking sequence of various layers can be controlled to obtain a wide range of physical and mechanical properties for the composite laminate. These materials are found to have high damping coefficient. The damping property of a material represents its capacity to reduce transmission of vibration caused by mechanical disturbances to a structure. The measure of damping of a material is its damping factor. Increasing the value of efficiency is desirable for reducing the resonance amplitude of vibration in a structure. Damping factor value depends on a number of factors, including fiber orientation angle, and stacking sequence. Principle of Centrifugal Blower Operating principle is a combination of two effects: Centrifugal force which produces more static pressure and again deflection of the air flow by the blades, but here the deflection is from a radial outward direction in to a spiral flow pattern. In case of forward curved blades the air deflections have a strong influence on the flow pattern on the performance.

## IV. PROBLEM DEFINITION

In the present work, metal blower is used for air conditioning and ventilation purpose in naval defense applications causes vibration and noise during its operation which causes mental imbalance to the people working near the blower on ship. Therefore reducing vibration from a source is very important and critical task. Hence the objective of this project is to reduce the vibration level produced by metal air blower. It can be effectively reduced by the modifying the shape of blades.

**V. MODELING BY USING SOLID WORKS**

With some models, where you should start is not obvious. You may find it very tempting to start building your sweep by drawing the sweep profile first. It is best practice, however, to create the path and guide curves first so that the profile appears at the right point in history to apply Pierce e relations to make the sweep work. This can present some difficulties because it is often helpful to use the profile to help build the path and guide curves. If you find that you must build the profile first and use it to construct the path and guide curves, you can copy the original profile to a new sketch which is driven by the path and guide curves. In this part, the overall shape is a flat spiral, but the cross section of the involute shape changes in two directions as the sweep progresses. Making the profile grow taller around the sweep will mean that we use a spiral for the path and a spiral of a slightly larger pitch for the first guide curve. Making the sweep grow in width will be the work of a helix

**VI. ANALYSIS OF CENTRIFUGAL BLOWER**

The analysis of centrifugal blower has been carried out by using ANSYS14.5 general purpose FEM software. The following analysis was done on the blower.

➤ Static analysis

Procedure for Static analysis in ANSYS14.5 Build the FE model as shown fig Define the material properties such as young’s modulus and density etc., Apply boundary condition and pressures as given. Solve the problem using current LS command from the tool bar.

Procedure for modal analysis in ANSYS14.5 Build the FE model explained in fig Define the material properties such as young’s modulus and density etc., Apply boundary condition as given. Enter the ANSYS14.5 solution processor in which analysis type is taken as modal analysis, and „by taking mode extraction method, by defining number of modes to be extracted. Solution method is chosen as Block lanczos method. Solve the problem using LS command tool bar.

Procedure for harmonic analysis in ANSYS Build the FE model explained in fig. Material properties such as Young’s modulus and density are defined. Apply the constraints and pressure as explained as given. Enter the ANSYS solution processor in which new analysis is chosen as harmonic response and solution method. For this analysis the solution technique used is frontal solver. By defining the frequency range as 0-500 HZ with 150 sub-steps. Solve the problem using current LS command tool bar and obtain the results.

**VII. SPECIFICATIONS OF THE CENTRIFUGAL BLOWER**

**MATERIAL PROPERTIES OF THE BLOWER**

- Metallic blower and
- Composite blower

i) Material properties of metallic blower :(aluminum)

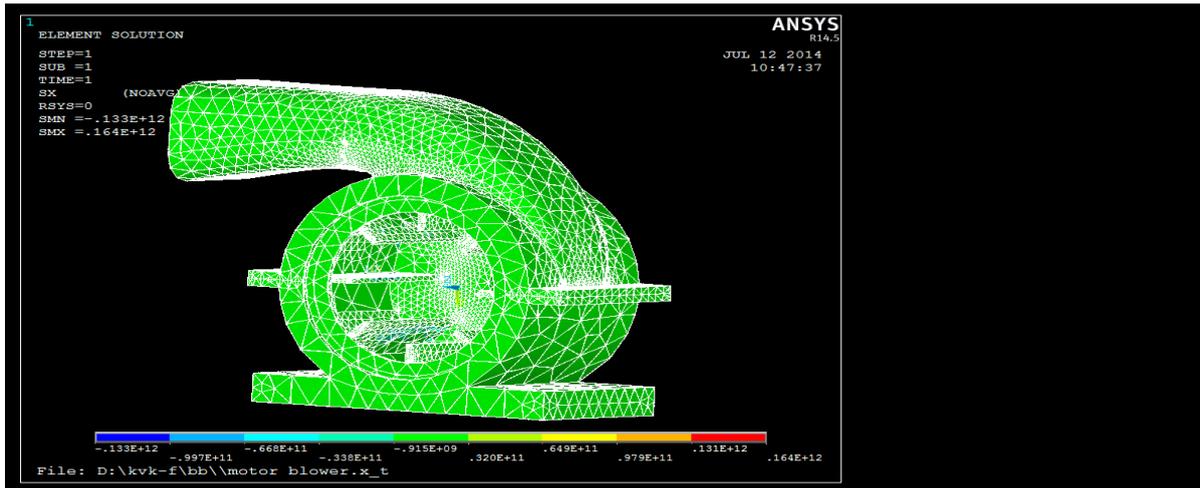
| property             | Value     |
|----------------------|-----------|
| Young's modulus E    | 70 GPa    |
| Poisson's ratio NUXY | 0.34      |
| Mass density         | 2700kg/m3 |
| Damping co-efficient | 0.006     |

ii) Material properties of composite blower : (E-Glass/Epoxy)

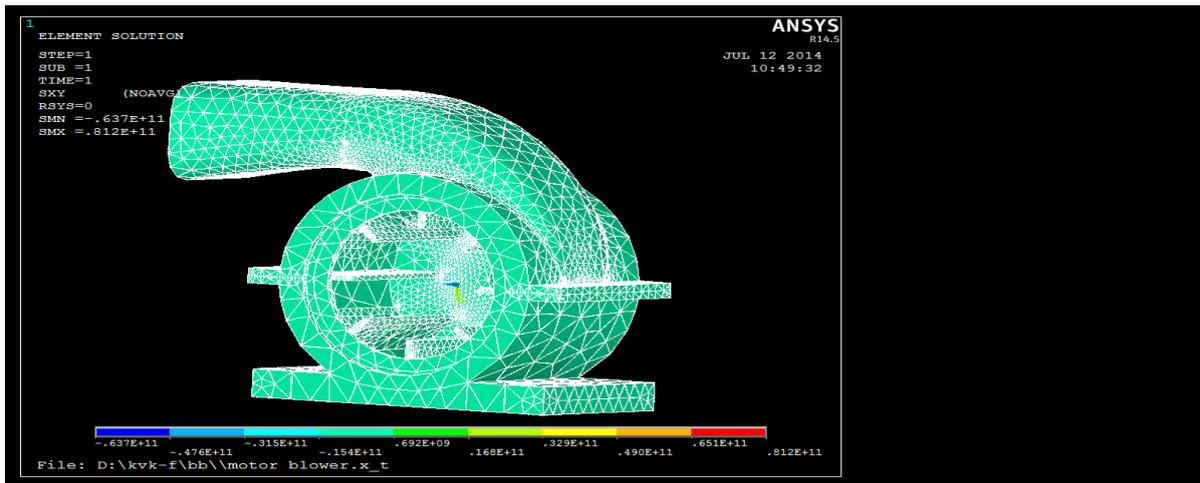
| property             | Value      |           |
|----------------------|------------|-----------|
| Young's modulus E    | EX         | 14000 MPa |
|                      | EY         |           |
|                      | EZ         | 8800 MPa  |
| Poisson's ratio      | NUXY       | 0.13      |
|                      | NUYZ       | 0.39      |
|                      | NUZX       |           |
| Mass density         | 1750 kg/m3 |           |
| Damping co-efficient | 0.02       |           |

**VII. RESULTS**

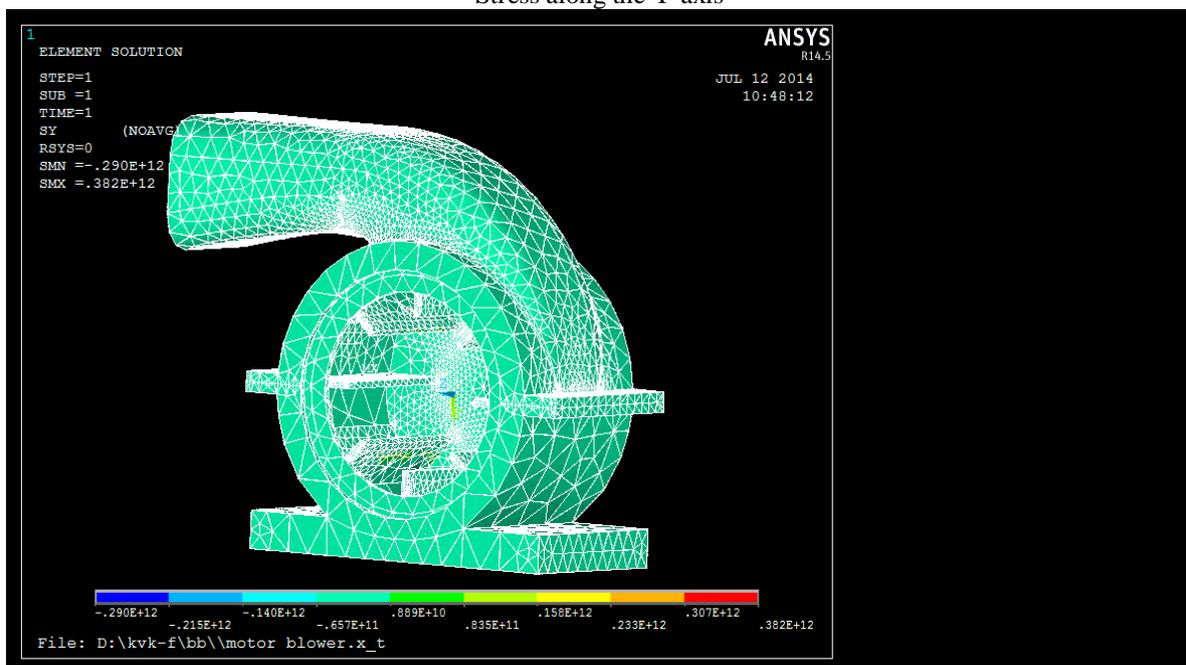
Static analysis of aluminum blower the deformation of aluminum blower is shown in below figure and the maximum deflection was found as 0.0056mm. The maximum normal stress obtained is 1.33N/mm<sup>2</sup>. The stress and displacements are shown in below figures



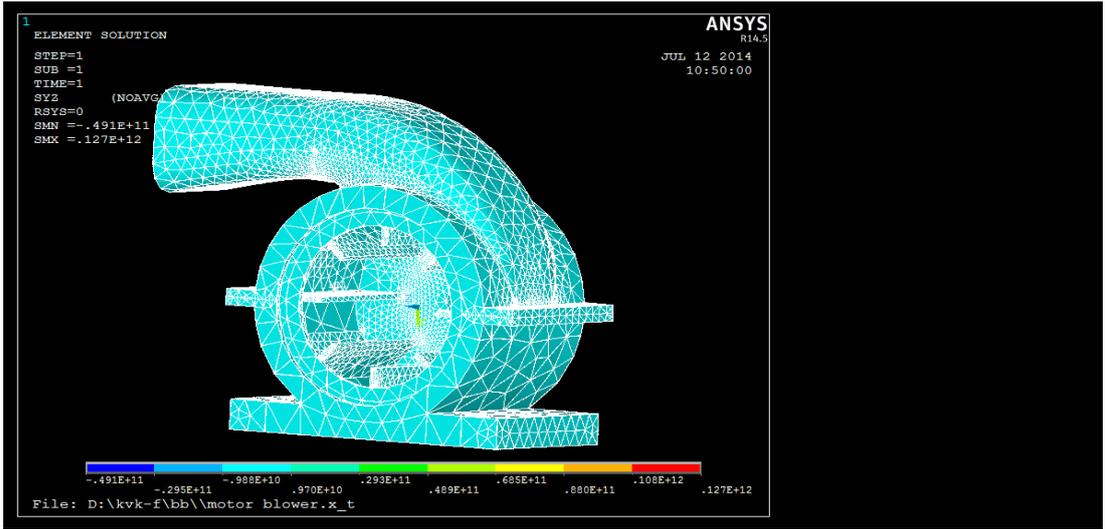
Stress along the X-axis



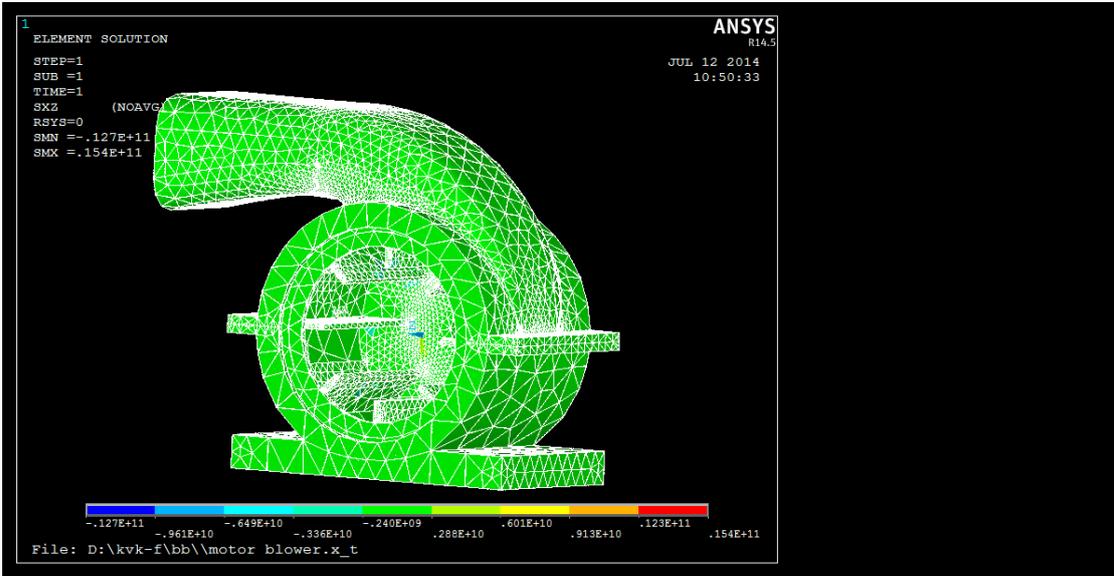
Stress along the Y-axis



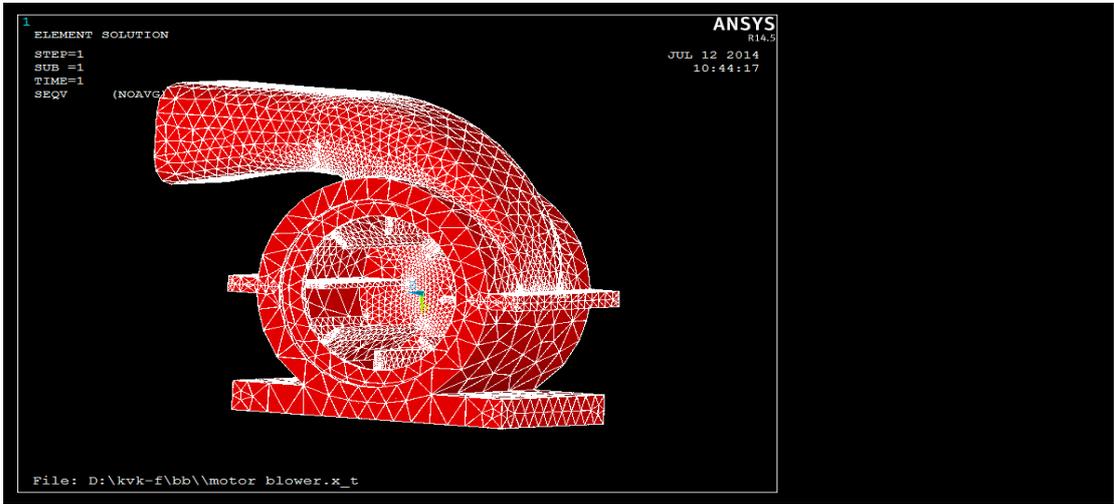
Stress along the Z-axis



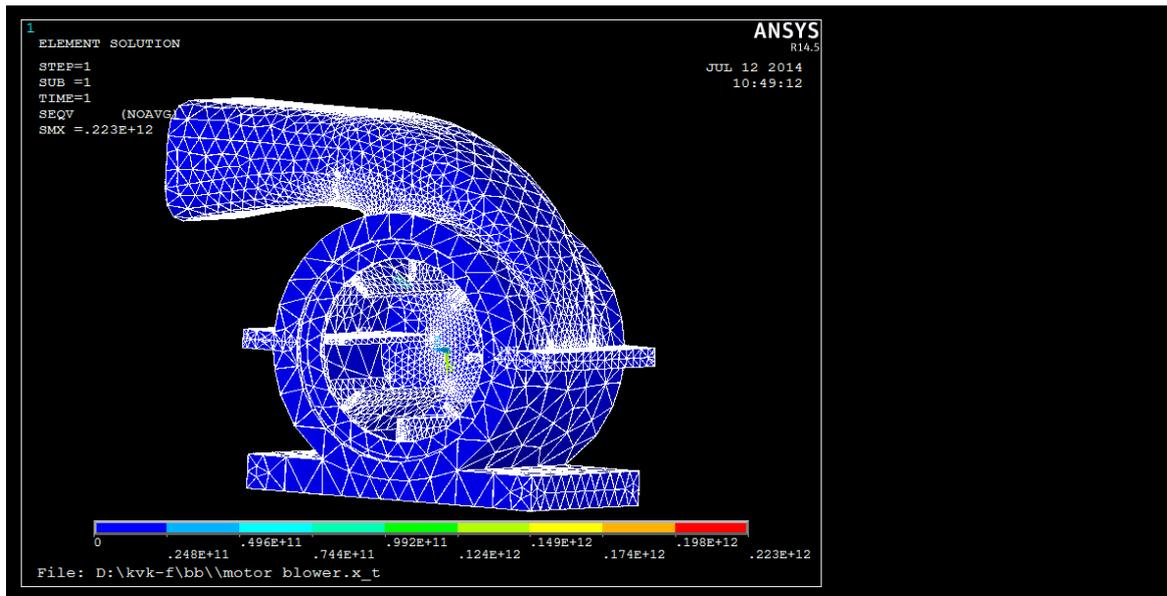
Shear stress along the xy-axis



Shear stress along the yz-axis



Shear stress along the ZX-axis



Von miss stress

Static analysis results of Aluminium blower Aluminium Blower Results Deflection in mm 0.22 mm Max. Normal stress, N/mm<sup>2</sup> 2.88 N/mm<sup>2</sup> 1st principal stress, N/mm<sup>2</sup> 1.33 N/mm<sup>2</sup> 2nd principal stress, N/mm<sup>2</sup> 0.985 N/mm<sup>2</sup> 3rd principal stress, N/mm<sup>2</sup> 0.854N/mm<sup>2</sup> the maximum deflection induced in metallic blower is 0.0814 mm, which is in safe limits. Hence based on rigidity the design is safe. The maximum induced stress 12000KPa which is less than the allowable stress (140000KPa). Hence the design is based on strength.

**FACTOR OF SAFTY**

|          | Minimum Stress(Mpa) | Maximum Stress(Mpa) | Young's modules(Gpa) | Ultimate strength (MPa) | Factory of safty |
|----------|---------------------|---------------------|----------------------|-------------------------|------------------|
| x        | 1.33                | 16.64               | 70                   | 40-50                   | 2.8125           |
| y        | 6.3                 | 8.1                 |                      |                         | 4.93             |
| z        | 2.9                 | 3.8                 |                      |                         | 10.526           |
| xy       | 4.9                 | 12.7                |                      |                         | 3.149            |
| yz       | 12.3                | 16.4                |                      |                         | 2.439            |
| zx       | 12.7                | 16.4                |                      |                         | 2.439            |
| von miss | 2.48                | 22.3                |                      |                         | 1.793            |

**Results of composite blower**

| Composite blower                   | (17 layers)       | Results |
|------------------------------------|-------------------|---------|
| Max deflection in                  | mm                | 0.987   |
| Max. normal stress                 | N/mm <sup>2</sup> | 16.6    |
| Maximum Inter-laminar shear stress | N/mm <sup>2</sup> | 16.4    |

**VIII. CONCLUSION**

The Stresses of E-Glass/Epoxy blower obtained in static analysis are within the allowable stress limits. The natural frequency of E-Glass blower is reduced by 16.6% to 27.7% because of high stiffness and the lay-up sequence in the blower. The weight of the E-Glass blower is 15 kg which is less than the Aluminium blower with a weight of 19 kg. From the results of harmonic analysis, damping effect is more in E-Glass blower which controls the vibration levels. From the above results we can conclude that E-Glass blower is preferable than Aluminium blower and based up on frequency values can be reduced.

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