Introduction

Fans and Blowers
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.

![Figure 1: Typical Fan/Blower system components.](image)

Blowers are regularly used 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, air purification in galleys, provision rooms, and sanitary areas and also for air mixing in compartments (Itha V. and Rao T. B. S. 2012).

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 (Table 1) (UNEP 2006)

<table>
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<tr>
<th>Equipment</th>
<th>Specific Ratio</th>
<th>Pressure Rise (mmWg)</th>
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<tr>
<td>Fans</td>
<td>Up to 1.11</td>
<td>1136</td>
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<tr>
<td>Blowers</td>
<td>1.11 to 1.20</td>
<td>1136 - 2066</td>
</tr>
<tr>
<td>Compressors</td>
<td>More than 1.20</td>
<td>-</td>
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Operating Principles:
Figure 2 shows a typical centrifugal blower wheel with backward inclined blades. Figure 3 shows the same blower wheel in a scroll housing. The airflow enters the unit axially, but then spread outs in a funnel shaped pattern, turning $90^\circ$ into various radially outward directions before meeting the blades. The blades then deflect these individual air streams into a spiral pattern to an almost circumferential direction. All these air streams are finally collected by scroll housing and are reunited into a single air stream that leaves the unit at a right angle to the axis (Bleier F. P., 1997).

The operating principle of the axial-flow fans is simply deflection of the airflow by the fan blades from an axial direction into a helical flow pattern. In centrifugal blowers, the operating principle is a combination of two effects:
- Centrifugal force (this is why they are called centrifugal blowers) and
- Deflection of the airflow by the blades

But here the deflection is from a radially outward direction into a spiral flow pattern as can be seen from figure 2 and 3. As the fan wheel rotates, the air located between the blades and rotating along with them is subject to centrifugal force, and this is the main cause for the outward flow of the air.

Figure 2. Centrifugal blower wheels with backward-inclined (BI) blades welded to back plate and shroud.
Types of Blowers

Blowers can achieve much higher pressures than fans, as high as 1.2 kg/cm$^2$. They are also used to produce negative pressure for industrial vacuum systems. There are two types of blowers:

- Centrifugal blowers and
- Positive displacement blowers.

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/cm2, 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.
Positive displacement blowers have rotors, which "trap" air and push it through housing. These blowers provide a constant volume of air even if the system pressure varies. They are especially suitable for applications prone to clogging, since they can produce enough pressure (typically up to 1.25 kg/cm²) to blow clogged materials free. They turn much slower than centrifugal blowers (e.g. 3,600 rpm) and are often belt driven to facilitate speed changes (UNEP, 2006).

**Composite Materials and its importance in Noise Control**

Choice of composites is an alternative for better noise and vibration control. A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibers, etc. Examples include wood, where the lignin matrix is reinforced with cellulose fibers and bones in which the bone-salt plates made of calcium and phosphate ions reinforce soft collagen (Kaw A. K., 2005).

**CATIA**

The modeling of the blower will be done by using solid modeling software CATIA. CATIA is a robust application that enables us to create rich and complex designs. CATIA s a mechanical design software with a feature-based, parametric, solid modeling design tool that takes advantage of easy-to-learn windows graphical user interface. We can create fully associative 3D solid models, with or without constraints, while using automatic or user-defined relations to capture the design intent. CATIA allows us to:

- **Consolidate end-to-end industry process** coverage for plastic part design and enables new terrain modeling in context process.
- **Enables in-context composite design** for optimizing the definition of large composites parts.
• **Accelerates long lasting productivity tools** for the design of plastic part and tooling design review process.

• **Adds a global collaboration environment** tailored to CATIA designers.

**Application of Finite Element Analysis**

The strength and deformation of the composite material used to design the blower will be analyzed using Finite Element Analysis (FEA) technique. FEA is a computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed. It is called analysis, but in the product development process, it is used to predict what is going to happen when the product is used.

FEA works by breaking down a real object into a large number (thousands to hundreds of thousands) of finite elements, such as little cubes. Mathematical equations help predict the behaviour of each element. A computer then adds up all the individual behaviours to predict the behaviour of the actual object.

Finite element analysis helps predict the behaviour of products affected by many physical effects, including:

• Mechanical stress
• Mechanical vibration
• Fatigue
• Motion
• Heat transfer
• Fluid flow
• Electrostatics
• Plastic injection moulding
ANSYS
The model prepared by CATIA will be imported to HYPERMESH for quality checks. Then it will be exported to FEA package software ANSYS to evaluate the effectiveness of composites and metal blower.

ANSYS is a general purpose finite element modeling package for numerically solving a wide variety of mechanical problems. These problems include: static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid problems, as well as acoustic and electromagnetic problems.

In general, a finite element solution may be broken into the following three stages. This is a general guideline that can be used for setting up any finite element analysis.

1. **Preprocessing: defining the problem**: the major steps in preprocessing are given below:
   - Define keypoints/lines/areas/volumes
   - Define element type and material/geometric properties
   - Mesh lines/areas/volumes as required

   The amount of detail required will depend on the dimensionality of the analysis (i.e. 1D, 2D, axi-symmetric, 3D).

2. **Solution: assigning loads, constraints and solving**: here we specify the loads (point or pressure), constraints (translational and rotational) and finally solve the resulting set of equations.

3. **Postprocessing: further processing and viewing of the results**: in this stage one may wish to see:
   - Lists of nodal displacements
   - Element forces and moments
   - Deflection plots
   - Stress contour diagrams