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DESIGN PROTOTYPE OF CEILING BLADELESS FAN

Sameer Madhukar Gurav[1], Pushkar Madhukar Barve[2], Nikhil Babasaheb Harkal[3], Sujit Anil Shinde[4]

[1-4]UG Students, Sinhgad Institute of Technology, Lonavala, Department of Mechanical Engineering, Sinhgad Technical Education Society's, pune, Maharashtra

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Abstract - *A bladeless fan, also referred to as an air multiplier, is a safe way to cool down your room, since it blows air from a ring. There are no external moving parts that could hurt curious little fingers or paws. In order for your indoor air quality to be comforting and clean, you need to install a ceiling fan in your home. Due to great convenience, bladeless ceiling fans are growing in popularity. These fans come with great versatility as they can also serve as lights and home décor pieces. They are a great investment, especially in the hot season. For you to gain comfort in your workplace or home, buying the best ceiling fan that is bladeless will be a great decision. It may, however, not be easy to spot the best bladeless fan for your ceiling due to the numerous options that customers are presented with.*

The project work aims at design development analysis and testing of a prototype of bladeless ceiling fan. The prototype is developed for a cabin space that is modelled to a working scale and the cabin is made from polyurethane foam and provided with air vents. The 12 volt dc lamp is used as the heat source in the cabin. The fan is mounted on a 12 volt DC motor which carries a fan shaft on which the bladeless fan is mounted.

The parts have been modelled using Unigraphix NX-8 and analysis of parts has been done using Ansys Workbench 16. The fan is manufactured using 3-d printing fused deposition method. Testing was done and results are

Key Words: Air multiplier, Bladeless Ceiling fan, Human comfort, 360^0 Vortex flow, tiny, temperature drop.

1. INTRODUCTION

An air multiplier, sometimes called bladeless fan, is a fan which blows air from a ring with no external blades. Its vanes are hidden in its base and direct the collected airflow through a hollow tube or toroid, blowing a thin high-velocity smooth airflow from holes or a continuous slot across the surface of the tube or toroid.

In the air multiplier fan, there are no visible moving or fast-spinning blades; instead, blades are hidden inside the base. The air is drawn in by a compressor in the base and then directed up into a ring. It comes out of a slit around the ring and passes over a shape like that of aft wing (Coandă effect). This design generates airflow up to 55mph. [3]

The fan contains a brushless electric motor and this motor rotates nine asymmetrical aligned blades that attach with a rotor. Usually, the upper frame of this fan is ring-shaped. The frame is not flat; rather it is manufactured such that the edge can create a curve of a 16-degree angle slope.

The air flows through the channel in the pedestal of the fan when the motor is turned on. After that, the air flows through the hollow tube. Then the air is shot out through 16-mm slits. This air flows smoothly, rather than turbulently as with a traditional fan (fan with blades). The curvature of the inner wall of the fan creates an area of negative pressure like an airplane wing to draw more air into the flow, hence "multiplying" it. This action is called inducement. Further, the air surrounding the edges of the fan also begins to flow with the direction of the breeze or is "entrained" to it. Dyson says that the air-multiplier technology increases the output of the air flowing through the tube by at least 15 times compared to the airflow taken in at the base of the fan [4]

Production catchment. In the warm plains of India, fruits and vegetables are stored in pits or cool dry rooms with proper ventilation on the floor or on bamboo racks. Inside the hut, fruits and vegetables are kept on floor or over racks and covered are with straw or plant leaves to avoid exposure to the atmosphere. By this method fruits and vegetables can be stored for few days without much damage and farmers sell it in local village weekly market according to their financial needs

1.1 Problem Statement

- The high risk of safety by moving fan blades causing injury
- Our project deals with solution for this cooling problems, through effective design of the bladeless fan
- The efficient 360 degree air circulation mechanism ensures that the cold air reaches all sides of the cabin to take care of all over cooling.

Fig -1: Conventional Ceiling Fan

The conventional air coolers give unidirectional air flow which is in effective and cannot manage the cooling requirements for room.

1.2 Methodology

Methodology is a systematic way, in which theoretical analysis of the methods applied to almost every field of study, or it is the theoretical analysis of the body of methods associated with a branch of knowledge. A Methodology is not providing a solution but it is used to solve a problem theoretically.

The Methodology is shown below with the help of flow chart

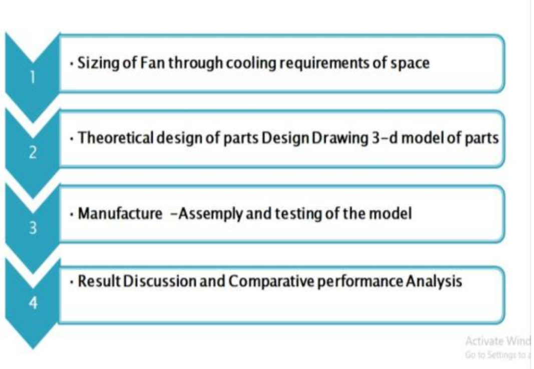

Chart -1: Methodology

2. DESIGN PROCEDURE

2.1 Design Structure

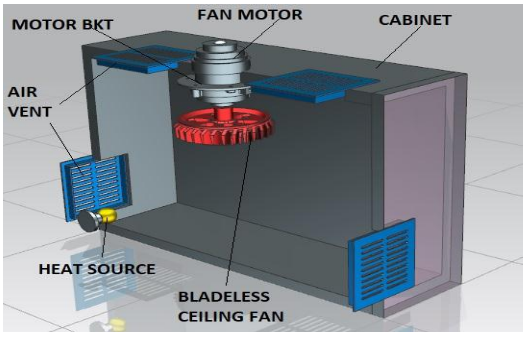

Fig -2: Conventional Ceiling Fan

The figure above shows the complete arrangement of the bladeless fan setup the parts are as follows:

1. Cabin (Polyurethane foam)
2. Air vents
3. 12 volt dc motor
4. Fan shaft
5. Primary fan
6. Secondary fan
7. Heat source
8. Door mechanism.

2.2 Methodology

The fan motor is started and the fan speed can be controlled using voltage control. The movement of the primary and secondary fan pulls the air axially inward and discharges it radially outward. The air discharged out leaves out at high velocity and displaces the surrounding air in the downward direction thereby effecting desired air motion and circulation of air in the cabin,

The heat source is provided to increase the room temperature. Initially the heat source is made on and the temperature of the room is measured, then fan is started and the drop in temperature after every two minutes is recorded.

2.3 Mechanical Design

Mechanical design phase is very important from the view of designer .as whole success of the project depends on the correct deign analysis of the problem. Many preliminary alternatives are eliminated during this phase. Designer should have adequate knowledge above physical properties of material, loads stresses, deformation, and failure. Theories and wear analysis, He should identify the external and internal forces acting on the machine parts

These forces may be classified as;

1. Dead weight forces
2. Friction forces
3. Inertia forces
4. Centrifugal forces
5. Forces generated during power transmission etc.

Designer should estimate these forces very accurately by using design equations .If he does not have sufficient information to estimate them he should make certain practical assumptions based on similar conditions which will almost satisfy the functional needs. Assumptions must always be on the safer side. Selection of factors of safety to find working or design stress is another important step in design of working dimensions of machine elements. The correction in the theoretical stress values are to be made according in the kind of loads, shape of parts & service requirements.

Selection of material should be made according to the condition of loading shapes of products environment conditions & desirable properties of material. Provision should be made to minimize nearly adopting proper lubrications methods

In, mechanical design the components are listed down & stored on the basis of their procurement in two categories

- Design parts
- Parts to be purchased

For design parts a detailed design is done & designation thus obtain are compared to the next highest dimension which is read available in market.

2.4 Motor Selection

Fan Motor: Brushless dc motor

Speed	3000 rpm
Wattage	15 watt
Voltage control	6 volt to 12 volt
Weight:	220 gm

Table -1: motor specification

3. DETAILED DESIGN AND ANALYSIS

3.1.1 Design of Mount Bracket

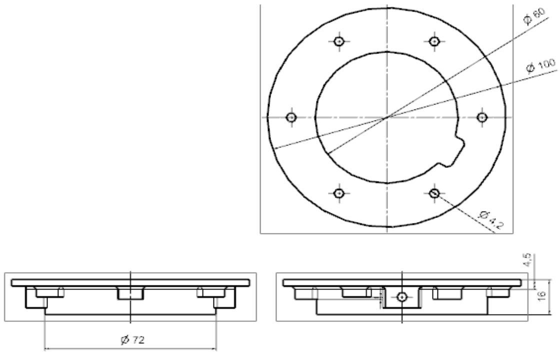

Fig -3: Mount Bracket

DESIGNATION	ULTIMATE TENSILE STRENGTH (Mpa)	YEILD STRENGTH (Mpa)
EN24	800	680

Table -2 Strength of mount bracket

3.1.2 Analysis of Mount Bracket

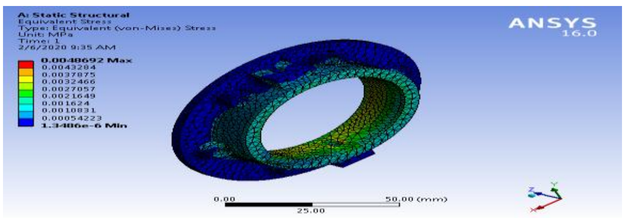

Fig -4: von-mises stress of mount bracket

As the maximum stress induced in material is 0.0049 Mpa which is less than the allowable stress of 32 Mpa motor mounting bracket is safe.

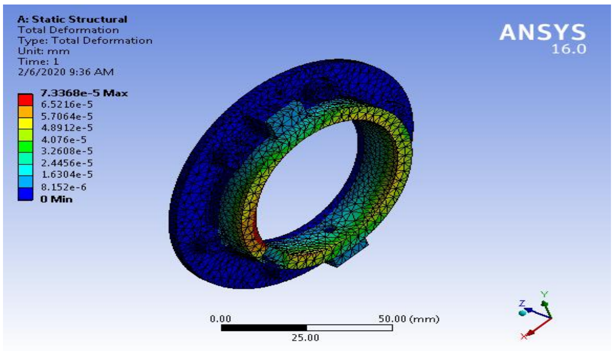

Fig -5: Total deformation of mount bracket

As the maximum deformation induced is very negligible the motor mounting bracket is safe

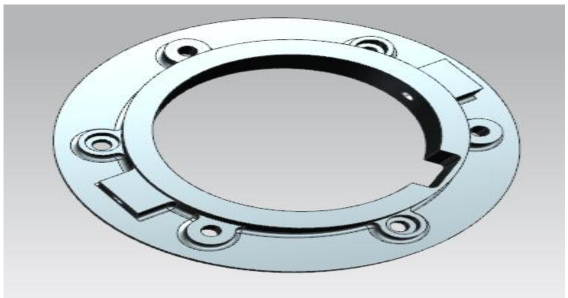

Fig -6: mount bracket

3.2.1 Design of Fan shaft

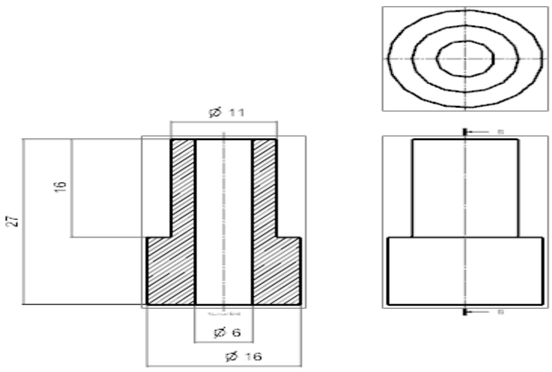

Fig -7 design of fan shaft

SELECTION: -Ref: - PSG (1.10 & 1.24)

As per ASME code $fs_{allowable}$= 104 Mpa

Check for torsional shear failure of shaft

Te= 60 x 15/ 2x 3.142x3000 = 0.05 N-m

Te = $\Pi fs\ d^3$

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$fs_{ac} = 0.042\ N/mm^2$

As; $fs_{act} < fs_{all}$

The fan shaft is safe under torsional load.

3.2.2Analysis of fan shaft

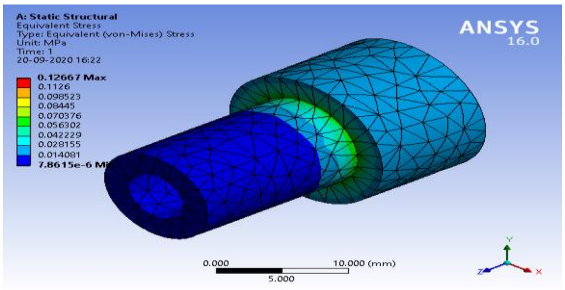


Fig -8: von-mises stress of fan shaft

The maximum stress induced in the fan shaft is .126 Mpa which is far below the allowable stress hence the shaft is safe

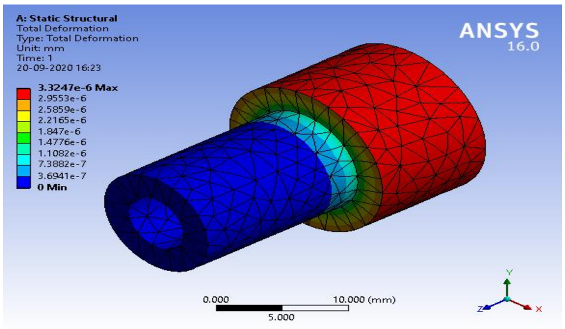


Fig -9: Total deformation of Fan shaft

The maximum deformation is negligible hence the shaft is safe.

3.3.1 Design of Primary Fan

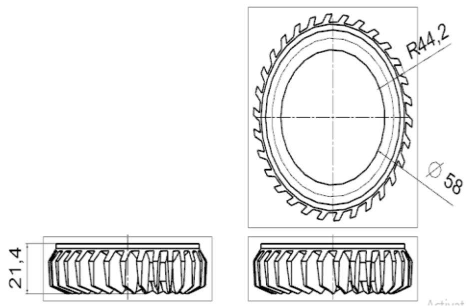


Fig -10: Design of Primary Fan

MATERIAL SELECTION: -Ref: - PSG (1.10 & 1.18)

As per ASME code $fs_{allowable} = 30$ Mpa

Check for torsional shear failure of shaft

$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4)/D$

$fs_{act} = 0.00146$Mpa

As; $fs_{act} < fs_{all}$

Primary fan is safe under torsional load

MATERIAL SELECTION: -Ref: - PSG (1.10 & 1.18)

DESIGNATION	ULTIMATE TENSILE STRENGTH (MPa)	YEILD STRENGTH (MPa)
ABS POLYMER	60	42

Table -3 Strength of Primary fan

3.3.2 Analysis of Primary Fan

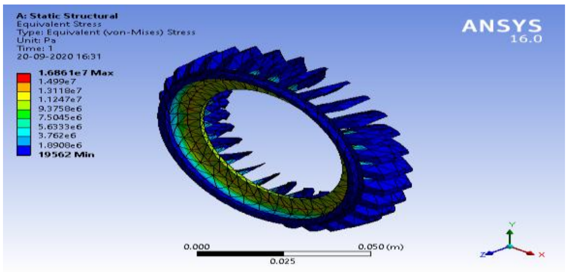


Fig -11: von-mises stress of primary fan

The maximum stress induced is far below allowable value hence fan is safe

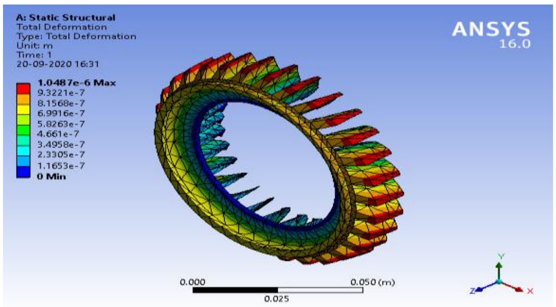


Fig -12: Total deformation of primary Fan

The deformation is negligible hence the fan is safe.

3.4.1Design of Secondary Fan

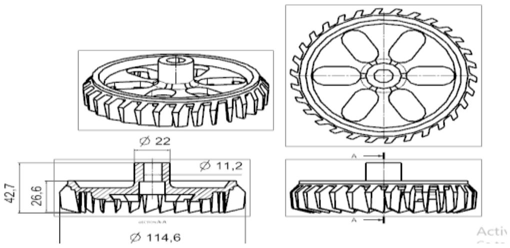


Fig -13: Design of Secondary Fan

MATERIAL SELECTION: -Ref: - PSG (1.10 & 1.18)

DESIGNATION	ULTIMATE TENSILE STRENGTH (MPa)	YEILD STRENGTH (MPa)
ABS POLYMER	60	42

Table -3: strength of secondary fan

As per ASME code $fs_{allowable} = 30$ Mpa

Check for torsional shear failure of shaft

$Td = \Pi/16 \times fs_{act} x(D^4 - d^4) /D$

fs_{act} = 0.0.08Mpa

As; $fs_{act} < fs_{all}$

Secondary fan is safe under torsional load

Fig -14: secondary fan

4. EXPERIMENT WORK AND TRIAL

1. Start Fan motor
2. Note air speed m/sec
3. Note air flow rate m3/min
4. Note the drop in temperature

3.4.2Analysis of Secondary Fan

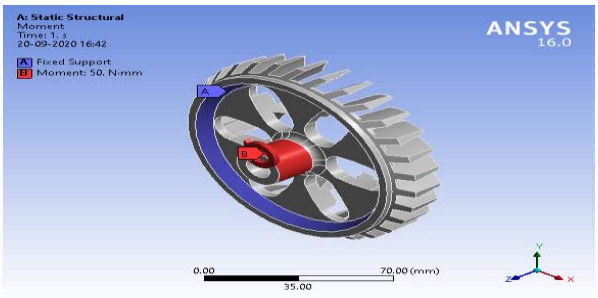


Fig -15: von-mises stress of Secondary Fan

The maximum stress induced is far below allowable value hence fan is safe

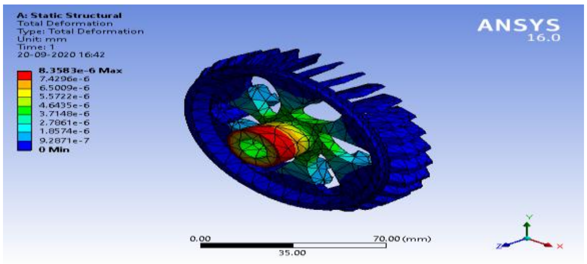


Fig -16: Total deformation of secondary Fan

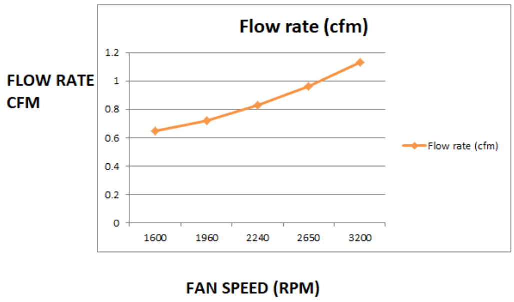
Sr No.	Time	Initial Temp	Initial Temp	Temp drop
1	3	32	31.6	0.4
2	6	32	31.1	0.9
3	9	32	30.7	1.3
4	12	32	30	2
5	15	29.6	29.2	2.8

The deformation is negligible hence the fan is safe.

Fig-17 Testing using wind anemometer

The test and trial of the 360 degree evaporative cooler shows following results:

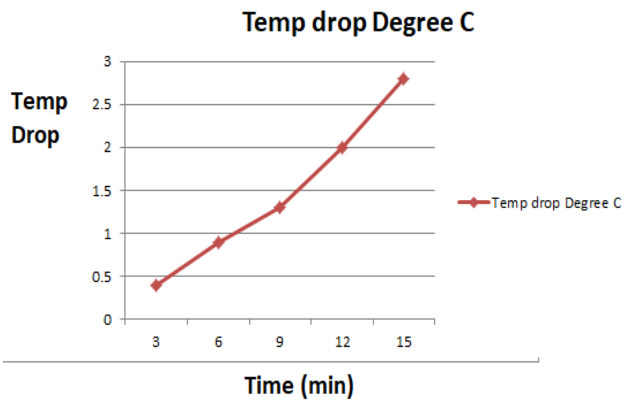
1. Air speed = 4.5 m/sec
2. Airflow = 1.64 cfm



Graph-1 flow rate vs. fan speed

The flow rate increases with increase in fan speed

Table-4 Temp reading



Graph-2 Temp drop vs. time

Temperature drop = 2.8 degree Celsius in 16 minutes

The cabin temperature drops with increase in time indicating cooling effect of fan

5. Acknowledement

We would like to thank Mr. Sagar Wasunde sir And our project teacher Mr. T.S,Jagtap Sir for their valuable guidance

6. CONCLUSIONS

The sizing, design analysis critical components of BLADELESS CEILING FAN is successfully done and the dimensions of the components have being determined. Estimation of the maximum stress induced in the components of the unit have being determined by both theoretical method as well as using Ansys Work bench and the results indicate that the maximum stress values are well below the permissible limit hence the parts are safe under given system of loads. As the maximum load > design load so the designed unit works to optimal design.

The designed device gives air flow in all directions and with maximum reach.

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