Product design of a fran blade

1. Manufacturing Concepts

1. 1 Product Design Specification of fan blade

To effectively develop a Product Design Specification for the Fan Blade, we need to firstly define the basic functions of the Fan blade. The basic function of a fan is to cause effective air flow in a room and this should be accomplished for a long usage of several years at varying rotations per minute.

The quality of fans is rated by their performance in moving the air effectively and quietly. This is monitored by such factors as the pitch, length, and number of ceiling fan blades, and their revolutions per minute (rpms). The angular edges of the ceiling fan blades are termed as the pitches which are particularly important for the effective movement of the air. The shape enables the blade to apply pressure to the air in front of it and thus the air is forced downwards.

Thus the important specifications required for our component would be:

- Effective Air Flow
- Low Noise levels
- No Wobbling
- Durability
- Light weight for low power consumption
- Should not get rusted.
- Aesthetics
- Low cost

The higher the pitch the more is the replacement of air. Good quality ceiling fan blades have a pitch of 12-14 degrees. Blade pitches as low as 8 or 10 degrees leads to poorer performance and thus lower Air flow and higher noise levels. While the short ceiling fan blades with minimum pitches can swirl at high speeds, they do not make for much air circulation and they are noisier than the types of fans with longer blades and higher pitch though they rotate more slowly.

One of the issues people sometimes find with their ceiling fans is wobbling. While many people may think that the wobbling is caused by the motor, this is usually not the case. The wobbling of the fan is usually caused by blades that are out of weight alignment. This is due to the use of warped, bent, or unmatched blades. Another reason for wobbling is that the blades may not have been screwed into the brackets straight.

Aesthetics are very important in the design of a ceiling fan as the color and design need to live up to the looks of the place of installment. Different materials like solid wood, cross-laminated veneer and less-expensive veneered constant-density boards are used to render the ceiling fan blades a smart and contemporary look. This also may include a metal finish, or a wooden looks. Contrast or reversible ceiling fan blades are another innovative addition to the whole range of ceiling fan blade designing.

Ceiling fans usually are not replaced for many a years at a stretch. Thus they are expected to be durable to withstand long usage at varying speeds. Though some designs of fan blades may consume low power at the cost of low air flow, a better design would include the use of a low weight material

for the fan blade. Rusting of metallic fan blades can cause unevenness in the balancing of the fan blades because of change in weight and it also will affect the durability. Thus the blades need to be coated effectively with paint to prevent oxidation of the fan blades.

1. 2 Wooden and Plastic blades in comparison with Aluminum blades

The most widely used materials for making ceiling fan blades are Wood, Plastic and Metal. We have decided on using an aluminum blade for our fan, but let us also consider the other materials too.

Wood had been traditionally used as it is a light weight material that is easily available. It also can be carved elegantly to add beauty to the aesthetics of a home. It is known that the conventional blade of a ceiling fan is made of plywood or solid wood. In the manufacturing procedure, such a blade needs to go through many processing steps such as cutting, planing, multi polishing, finishing, painting and printing or covering with printed paper, etc. Moreover, each blade must finally be weighed and three or four blades of the same weight must be selected as a set for the packing operation. Therefore, the whole processing procedure for a wooden blade is quite labor-intensive and time-consuming, and therefore very expensive. The wooden blades are made of longitudinal strips of wood that have their sides laminated together. Due to the thermal cycling and operational stress, the laminated wooden blades may crack along the length of the blade. Under such impact the blade could separate into one or more pieces and send harmful missiles about a room.

The plastic blade comprises a blade frame made by injection molding or die casting a commercially available tensionable plastic or fabric. This method of making fan blades greatly reduces manufacturing time and expense. The assembled blade also has a controllable weight error falling within a tolerable range so that the weighing and selecting procedures performed before packing can be greatly simplified. The blade frame is mass produced by plastic injection molding. The blade plate can be pre-printed with various colors and designs, and then mass cut by a cutter, whereby the production speed is greatly increased. Moreover, the blade frame and blade plate can be assembled by means of a specific assembling machine in a factory or assembled outside a factory by contract so that production can be greatly increased with less labor. Thus the manufacturing cost is greatly reduced. The blade has a total weight which is 40-50% that of a conventional wooden blade. Therefore, the power of the blade-driving motor can be reduced according to the reduced weight. Therefore, the cost of the motor as well as of the blade is lowered.

Blades for conventional ceiling fans have been manufactured from numerous materials in a variety of shapes and sizes. Generally, the environment in which the ceiling fan is intended to operate is a significant factor in accompanying drawings, the selection of the material for the blade composition. Rigid materials such as wood or plastic are commonly used on fans intended solely for indoor use, but are prone to warping when subjected to long-term outdoor use due to the extreme fluctuations in temperature and humidity. Thus aluminum blades which are made from aluminum casting seem ideal for outdoor usage.

1. 3 Suitable manufacturing process

The wooden blades are made from a number of materials and are given a wide variety of finishes. The natural wood and painted blades are made from solid wood, cross-laminated veneer (plywood), and less-expensive veneered constant-density board.

The finishes include natural, appliance white, cherry wood, oak, walnut, burled camphor, bleached oak, white, faux granite, rosewood, black, high luster, colors, and many more.

Many processing steps are involved such as cutting, planing, multi polishing, finishing, painting and printing or covering with printed paper, etc. Thus the making of a wooden blade seems more laborious and time consuming. From our Product design specification, the wooden blades satisfy the conditions of being light weight, rust proof and having high aesthetic value. But it is not durable as wood might absorb moisture, and this may cause unevenness in the balancing of the blades.

Using a plastic blade is considered safer then using a metal or wooden one, this way you don’t need a shroud over the blade. Unlike wooden blades, a plastic blade is made by Injection molding process and its production is not laborious and time consuming. The whole plastic blade can be made of one piece, unlike a wooden blade which is mostly an assembly of wooden pieces glued together.

Due to the lower material and manufacturing costs and the ease with which they can be mass produced, one-piece molded plastic fans of both the impeller and centrifugal or blower types are being used as air circulating

means in numerous appliances such as hair dryers, automobile heaters, refrigerators. Even though such fans are relatively small and light, it is nevertheless desirable that they be dynamically balanced to within accurate limits.

The method used for obtaining dynamic balance has involved the molding of a test fan in each mold cavity, testing these molded fans for dynamic balance and thereafter machining away material from selected areas of the mold surfaces thereby to increase the weight of the portions of the fan formed by these areas to obtain a balanced weight distribution.

The plastic blade is quite useful as it satisfies most of the Product design specifications. But it cannot be said to be durable as the plastic may warp due to higher temperatures thus affecting the balance of the blades.

Thus we see that a metal blade made from aluminum is ideal as it is durable and can be placed outdoors to without being rusted.

2. Mechanical Principles

The design proporsal is as follows. The Aluminum blades are supported on a strong plastic plate at the bottom. They are fixed together by two tightly fixed screws one behind the other. The plastic plate is in turn connected to the hub of the fan by two screws. The weight of the Aluminum blade is supported on the plastic plate. They are a total of four blades fixed symmetrically to the hub.

2. 1 Mechanical principles relating to the Aluminum Blade

Our design of the Ceiling fan with four aluminum plates would have the following mechanical principles acting on it.

- Force acting downwards due to weight of aluminum blade.
- Radial force when the fan is in rotating.
- Normal force of the plastic plate acting upwards
- Normal force of pushing air down acting up wards.
- Tangential normal force from the bolts to the Aluminum blade, which causes rotation
- Torque acting on the bolts due to the weight of the Aluminum blades.

2. 2 Analysis

For an aluminum plate of dimensions 14cm Ã- 2. 5cm the area of the plate is approximately 35cm. The thickness of the plate is around 0. 1 cm.

Therefore the volume of the Aluminum blade would be 3. 5cm^3.

The density of Aluminum is 2. 7 gm/cc.

Therefore the weight of each Aluminum blade is 9. 45gm

The RPM at which fans are usually expected to rotate is around 80-220 rpm or 8. 37-23 radians per second

The radial forces acting on the aluminum blade is F = m? 2r where m is the mass of the aluminum blade, ? is the angular velocity and r is the radial distance of the center of mass of aluminum blade from the vertex. The radial distance of the center of mass of the aluminum blade to the center point of the hub = Hub radius + ½ length of blade

= 6cm +7cm = 13cm

Thus the maximum radial force for 23 radians per second = 0. 65 N

The weight of the aluminum plate is = 0. 092 N

The Aluminum plate is connected to the plastic plate by 2 bolts.

Suppose we use a M2 bolt made of low or medium carbon steel, fully or partially annealed. The Ultimate tensile strength is 1176N

The Ultimate shear strength can be approximated by

Therefore the Ultimate shear strength is = 882 N

The Shear stress acting in the radial direction t = F/[dÃ-(t1+t2)]

= 162500 N/

For calculating the Shear stress acting in the tangential direction, we write the moment equation for the bolt.

Therefore the Shear stress on the bolt acting in the tangential direction is =

= 26750 N/

Now to check for the effect of fatigue on the bolt, we check the S-N curve for Carbon steel. It is to be noted that after = 560N

The tensile strength acting on the bolt is much lesser and thus there is no problem of the bolt breaking due to fatigue.

2. 3 Effects of Analysis on Design procedure

We thus see that the radial force acting on our blades is much more than the weight of the aluminum blade acting downward. It is also more than the tangential stress acting on the bolt. It is also observed that due to the small

size of our fan, even one bolt can support each blade. But for balance sake we shall change the design to place the bolts symmetrically across the radial center line from the hub to the blade. Thus a three bolt joint would help create better stability and would prevent wobbling conditions. Since we are using Aluminum blades over plastic blades, we can try to reduce cost by including three blades instead of four. The effect of adding an extra blade does not increase the air flow much, so the fourth blade can be avoided.

2. 4 Effect of Final design on Manufacturing/Material

Since we have decided on using a 3 bolt joint to fix the blade to the plastic plate, the position of the plastic plate can be shifted on above the aluminum blade for better aesthetic values.

It is also clear from our analysis that bigger fan blades can be used for better performance without compromising on the fear of fracture.

We could make the baldes from plastic, as it would reduce the cost and make the manufacturing process easier, but it would risk deformation.

Since we are looking for using durable blades that can be used in outdoor conditions too, we shall neglect the use of wood and stick to using aluminum as our blade material.

3. References

1. Thomas Cartwright (2005), “ Fan Blade”, Publication number: US 2004/0047735 A1.
2. Norton, Robert L (2006), “ Machine Design-An Integrated Approach”, Pearson Prentice Hall.

3. Leigh A. Junkin (1992), “ Fan Blade”, US Patent 5, 110, 261, Google patents.
4. Kuo-Neng Chien (1994), “ Ceiling Fan Blade”, US Patent 5, 338, 156, Google patents.
5. GarrettD. Euler (2002), “ Standard Metric and USA Bolt Shank Dimensions”, available at [26th April]
6. Dane Roger, Patricia (2001), “ Eye on Design”, Washington post.
7. Roy Beardmore (2010), “ Bolted Joint Design”, available at [25thApril]
8. H. W. Hayden, W. G. Moatt, and J. Wulff (1965), “ Structure and Properties of Materials” John Wiley & Sons.
9. Robert B Gelbard, (1964), “ Mold for molding dynamically”, US Patent 3, 136, 001, 1964 – Google Patents.
10. Brydson, J (1999), “ Plastics Materials”, Butterworths 9th Ed.

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