Abstract—This Analysis have been conducted to analyse the different blade angle by Computational Fluid Dynamics (CFD) in ANSYS software to finding the maximum air delivery. By finding maximum air delivery with their blade angle the optimum design is carried out by comparison of energy consumption i.e. power with different number of blades of ceiling fan. The experiments were conducted based on three different number of blades, have different blade angles, with constant speed and blade length and mathematical model was developed. Based on this analysis optimum design is achieved.

Keywords—Ceiling Fan, Blade Angle, Air delivery, CFD.

I. INTRODUCTION

The coefficient of performance (COP) of a ceiling fan which describes the fan efficiency will be expected to in-crease by changing the blade angle and enhancing the pro-file of the blades. Thus, this research aims to conduct a comparative Analysis on the use of a newly designed ceiling fan which incorporates special aerodynamic profile and more efficient set of blades in comparison to the conventional blades. By changing the angle of blade, the power needed for operating the ceiling fan will be decreased and they will be produce high velocity of airflow. [7] Further, by adding an aerodynamic feature to the existing at profile, the fan air delivery can be increased to provide better performance.

For Analysis purpose we are changing the blade angle and number of blades. ANSYS Software is used to obtain graphical representation of result. It saves time and Optimise the design.[2]

II. DESIGN OF CEILING FAN BLADE

Blades are key elements of Ceiling Fan. These blades are found to be very efficient at low speed, but at high speed it becomes necessary to study the flow effects which affects the speed and efficiency of Ceiling Fan.

A simple model of fan blade which is obtained by modelling using SolidEDGE Software.[4] which is Shown in Fig.1 In This model we take different Cross-Sections area of the blade 10%,50% and 90%.[9]

III. AIR FLOW ANALYSIS OF CEILING FAN BLADE

Analysis of designed fan blade which taken in ANSYS CFD Software with different blade angles and number of blades.[7]

For CFD Analysis we take constant velocity of air = 11.07 m/s take place.

For CFD Analysis we take three cross section 10%, 50% & 90% of blade and

- 10% c/s of Blade
- 50% c/s of Blade
90% c/s of Blade

The results air velocities of 8°, 10°, 11°, 12°, and 13° of Blade angle in three C/s of Blade is Shown in Following Figures.

Analysis of 8 Degree 10% cs of Fan Blade which is shown in figure.3

Analysis of 8 Degree 50% cs of Fan Blade which is shown in figure.4

Analysis of 8 Degree 90% cs of Fan Blade which is shown in figure.5

Analysis of 10 Degree 10% cs of Fan Blade which is shown in figure.6

Analysis of 10 Degree 50% cs of Fan Blade which is shown in figure.7

Analysis of 10 Degree 90% cs of Fan Blade which is shown in figure.8

Similarly, analysis for 11°, 12°, & 13° blade angle take place.
IV. VELOCITY CALCULATIONS FROM ANALYSIS FIGURES

A) For finding optimum blade angle

1) 8 Degree
   a) 10% c/s area = 5.588e+000 = 5.588
   b) 50% c/s area = 1.116e+001 = 11.16
   c) 90% c/s area = 1.550e+001 = 15.50
   Average Velocity = 10.74 m/s

2) 10 Degree
   a) 10% c/s area = 5.500e+000 = 5.50
   b) 50% c/s area = 1.104e+001 = 11.40
   c) 90% c/s area = 1.667e+001 = 16.67
   Average Velocity = 11.07 m/s

3) 11 Degree
   a) 10% c/s area = 5.288e+000 = 5.288
   b) 50% c/s area = 1.093e+001 = 10.93
   c) 90% c/s area = 1.658e+001 = 16.58
   Average Velocity = 10.93 m/s

4) 12 Degree
   a) 10% c/s area = 5.353e+000 = 5.353
   b) 50% c/s area = 1.076e+001 = 10.76
   c) 90% c/s area = 1.626e+001 = 16.26
   Average Velocity = 10.79 m/s

5) 13 Degree
   a) 10% c/s area = 5.186e+000 = 5.186
   b) 50% c/s area = 1.078e+001 = 10.78
   c) 90% c/s area = 1.621e+001 = 16.21
   Average Velocity = 10.73 m/s

B) For finding optimum design at 10 degree blade angle

θ = Blade angle = 10°
V = Velocity of air = 11.07 m/s
N = Revolution = 200 rpm
R = Radius of circumference = 0.5 m

Angular velocity

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 200}{60} = 20.94 \text{ m/s}$$

According to kinematics equation.

$$\alpha = \alpha_0 + 2a\alpha$$

$$\frac{(v/r)^2}{(11.07/0.5)^2} = 2 + 2\alpha \times 20.94$$

$$\alpha = 11.70 \text{ rad/sec}$$

C) For 2 blade ceiling fan

$$Force = F = ma$$

$$F = \left(\frac{2.75}{9.81}\right) \times 11.70$$

$$F = 3.279 N$$

$$Power = P = \frac{2\pi N(T)}{60} = \frac{2\pi \times 200}{60} \times 3.279 \times 0.5$$

$$P = 34.34 \text{ watt}$$

C) For 3 blade ceiling fan

$$Force = F = ma$$

$$F = \left(\frac{3}{9.81}\right) \times 11.70$$

$$F = 3.579 N$$

$$Power = P = \frac{2\pi N(T)}{60} = \frac{2\pi \times 200}{60} \times 3.579 \times 0.5$$

$$P = 37.48 \text{ watt}$$

D) For 4 blade ceiling fan

$$Force = F = ma$$

$$F = \left(\frac{3.25}{9.81}\right) \times 11.70$$

$$F = 3.876 N$$

$$Power = P = \frac{2\pi N(T)}{60} = \frac{2\pi \times 200}{60} \times 3.876 \times 0.5$$

$$P = 40.59 \text{ watt}$$

V. RESULT

We have considered the 5 different blade angles as shown in following table and these blade angles represent their maximum air velocity. By these the maximum air velocity is obtain at 10 blade angle of ceiling fan.

<table>
<thead>
<tr>
<th>Blade Angle</th>
<th>Maximum air Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>10.74</td>
</tr>
<tr>
<td>10</td>
<td>11.07</td>
</tr>
<tr>
<td>11</td>
<td>10.93</td>
</tr>
<tr>
<td>12</td>
<td>10.79</td>
</tr>
<tr>
<td>13</td>
<td>10.73</td>
</tr>
</tbody>
</table>

Table 1: Maximum Velocities of Different Blade Angle

Therefore optimum design can be obtained at 10 blade angle of ceiling fan. Hence following table considered only 10 blade angle. The power at 2, 3, 4 no. of blades is shown in following table. Therefore the energy consumption i.e. power is maximum by using 4 no. of blades and velocity is also maximum. The power and velocity is moderate by using 3 no. of blades and the power and velocity is least by using 2
Therefore optimum design is 3 no. of blades ceiling fan.

<table>
<thead>
<tr>
<th>No. Of Blades</th>
<th>Air Velocity (m/s)</th>
<th>Power (watt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>23.14</td>
<td>34.34</td>
</tr>
<tr>
<td>3</td>
<td>33.21</td>
<td>37.48</td>
</tr>
<tr>
<td>4</td>
<td>44.28</td>
<td>40.59</td>
</tr>
</tbody>
</table>

Table 2: Power consumption of Number of blades

Therefore, from tables 2 the 3 number of blades ceiling fan is optimum design by using 10 blade angle.

VI. CONCLUSION

As we have studied about CFD analysis of ceiling fan. By these we conclude that the maximum air velocity is obtain at 10\(^{th}\) blade angle.

Also the power consumption and air velocity is optimum at 3 no. of blades of ceiling fan. So we can conclude that 3 numbers of blades of ceiling fan is optimum design.

REFERENCES