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Use of Double Plane Blade Ceiling Fan: A Literature Review

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Abstract – *The first ceiling fan appeared in the early 1860s and 1870s, in the United States. At that time, any kind of electric motors were not there to power the fan. Instead, a stream of running water was used to drive a system of belts which would turn the blades of two-blade fan units, in conjunction with a turbine. The ceiling fan was invented with electrical power by Philip Diehl in 1882; he had engineered the electric motor used in the first electrically powered Singer sewing machines, and in 1882 adapted that motor for use in a ceiling-mounted fan. There is no need of belt drive as each fan had its own self-contained motor unit.He was almost immediately up against fierce competition due to the commercial success of the ceiling fan. He continued to make improvements to his invention; such as to combine both functions in one unit; he fitted light kit to the ceiling fan. Most ceiling fans were made by World War I with four blades instead of the original two, which made fans quieter and allowed them to circulate more air.*

I- INTRODUCTION

Ceiling fans are frequently used as a common household appliance in the tropical region. The wide-spread utility of ceiling fans is attributed to affordable purchasing, operational and maintenance costs. Air circulation inside the room and energy consumption is two extremes of design specifications that can be traded off by improving motor and blade designs. Improvement in motor design is generally achieved through material changes that directly results in cost increase. Any alteration in blade design requires manufacturing of new jigs and fixtures in the process line. The goal of this literature review is to compare the many design of blade &arrangement of the ceiling fan which will help to modify the newly design double blade ceiling fan in sense of high air flow rate &low power consumption.

Comparative study between conventional ceiling fan blades and newly developed aerodynamic blades

Schmidt and Patterson (2001) performed a comparative study between conventional ceiling fan blades and newly developed aerodynamic blades. In their study, they concluded that the new aerodynamic blade designs were vastly more efficient and can save power consumption by up to a factor of three. They also noted that ceiling fans display a humped velocity profile, in which the fan velocity rises near the center of the blade, touches a maximum value, and then starts falling along the blade length at a surface beneath the fan. One of the principal problems with the humped-velocity profile is that, while a very slight air movement is detectable beneath the ceiling fan (hub region), subsequently airflow velocity escalates and reaches a peak value between the blade tip and fan blade center.

Investigation of the flow field of a ceiling fan with no furnishing in the room

Ankuar*et al*. (2004) experimentally investigated the flow field of a ceiling fan with no furnishing in the room. They also tested and explained the humped profile of a ceiling fan blade. Moreover, the flow pattern was characterized into eight regions. Region 1, immediately beneath the fan, has the greatest flow velocity starting from the center of the blade towards the blade tip; less velocity is detected at the center of the fan (beneath hub area). Air is flowing upwards in Region 2 (wall and floor area) and mixes with air in Region 3 (ceiling area) where it becomes dense. Region 4 is between 1 and 2 and has a velocity magnitude in the order of less than 0.1m/s. Flow reversal is observed in this region and in Region 2. All other regions are adjacent to the ceiling fan blade and have different velocity profiles. They also found that winglets and spikes on the ceiling fan blades improved the overall air flow rate.

Development in an analytical solution to predict the air flow velocity distribution

Ramadan *et al*. (2011) developed an analytical solution to predict the air flow velocity distribution in the downward fan plane to the floor. They also numerically simulated the ceiling fan model and found their results with Ankuar. They concluded that the local downward air flow velocity distribution can be increased by varying the fan rotation speed and confirmed this from their two correlations.

Study to improve the air circulation of ceiling fans

Schiavon&Melikov [2], Bassiouny&Korah [3] and Mahlia et al. [4] carried out computational as well as experimental studies to improve the air circulation of ceiling fans. It is revealed that the air circulation depends upon fan speed, diameter, location, blade angle and number of blades. Downward velocity of ceiling fan is explicitly dependent on ceiling fan rotation speed.

Study on a blade profile similar to cambered airfoil

Mahlia et al. [4] proposed a blade profile similar to cambered airfoil. At low rpm, the cambered blade produce less airflow in comparison to conventional fans but at medium and high rpm cambered fan blade shows greater value of airflow. However, the new blades possess higher size to weight ratio and have high level of complexity while manufacturing.

Parametric study of rake angle for the purpose of design improvement

Lin and Hsieh [5] enhanced the performance of the hidden ceiling fan using computational modeling and experimental validation. It is found that ‘inhale return’ phenomena occur due to inappropriate housing designs. And Afaq et al. [6] computationally modeled the flow field of ceiling fan inside a generic square room and conduct parametric study of rake angle for the purpose of design improvement. The results indicate that the fan efficiency can be increased by varying the rake angle.

Study on the effect of air-foil-shaped blades on air flow

Parker *et al*. (2000)conducted a detailed numerical investigation and studied the effect of air-foil-shaped blades on air flow. Parker observed that using these blades resulted in a 21% increase in air flow, and fan power consumption was reduced considerably. Son *etal*. (2009)studied the thermal effect on humans by using an air conditioner in conjunction with a ceiling fan in a room. Their studies recommended that thermal comfort depends strongly on the vertical air speed of the fan and, in addition, thermal comfort is exclusively dependent on the location of the inlet diffuser and has little to do with the use of a ceiling fan.

Study on the effect of the number of blades for linear profiles of ceiling fans

Falahat (2011) studied the effect of the number of blades for linear profiles of ceiling fans, and Adeeb*et al*. (2015) studied the effect of the number of blades for a non-linear profile. Both researchers reported that four blades were the optimum number of blades required. A four blade ceiling fan provided the maximum energy efficiency and air flow rate. Numerous techniques have been used by Afaq*et al*. (2014),Afaq*et al*. (2017), Adeeb *et al*. (2015), Lin and Hsieh (2014), and Makhoul *et al* (2013). To improve the energy efficiency and air flow rate of ceiling fans.

Study on development on a fundamental understanding of the air flow phenomena for non-linear ceiling

E. Adeeb, C. H. Sohn, A. Maqsood and M. A. Afaq. They studied on development on a fundamental understanding of the air flow phenomena for non-linear ceiling fan blades placed inside a closed room. A CFD investigation was performed to find the effect on four blade ceiling fans of four parameters. Optimization of the four-blade ceiling fan design was the main goal of this investigation. Optimization was carried out using response surface methodology (RSM). The process includes first, identified the experimental parameters, subsequently designed the experiment, and then conducted the optimization process. This paper is organized such that section 2 details the geometric description and governing equations employed to study the phenomena. Then numerical methodology and validation studies are presented. In Section 4, three-dimensional simulation results obtained by the DOE technique for different velocity profiles in terms of swirl were discussed. After this, optimization of the fan blade design by applying constraints on the data set is presented. Finally using RSM conclusion is drawn.

Effect of Number of Blades on Performance of Ceiling Fans

Ehsan Adeeb, Adnan Maqsood , and Ammar Mushtaq studied on the effect on the no. of blades on performance on ceiling fan This study helps to satisfy tradeoff between high air flow (performance) and power consumption (energy efficiency). They investigated variation in blades of ceiling fan from two to six blades in consideration with nonlinear forward sweep profile. Reynolds Averaged Navier-Stokes (RANS) technique is used to model the flow field induced by the ceiling fan inside a generic room. The performance is gauged through response parameters namely volumetric flow rate, mass flow rate, torque and energy efficiency. The results indicate that mass and volumetric flow rates are maximized for six blade configuration and energy efficiency is maximized for two blade configuration. The study indicates the importance of tradeoff between high air flow through ceiling fan and associated energy efficiency. But in this research all the blades were arranged in a single plane as a conventional fan which result in improvement in mass and volumetric flow rate for 6 blades but consume more energy compare to normal one. But if the 6 blades are arranged in two planes this may help in reduction of energy consumption with volumetric flow rate. It is same as using Biplane effect (i.e. during the evaluation of Aero planes the bi plane effect were used because at that time the engines were not enough powerful to provide thrust to the aero planes with single plane) therefore we are trying to use the biplane effect to reduce the torque on fan. Which result in reduce energy consumption of ceiling fan.

II - DISCUSSION

A throughout review of the literature revealed that volumetric flow rate is the volume of air coming down on a specified surface per time. Volumetric flow rate for different number of blades are experimented which result in maximum value of volumetric flow rate for six blade fan and minimum value for fan with two blades. An increasing trend in volumetric flow rate is seen by increasing the number of blades.

In the current literature view, a major limitation discovered that 6 blade ceiling fan consume more energy as compare to normal one and another limitation is the use of inefficient ceiling fan among the people even though there are many high efficient fan in the market. It may be the reason that there are no contour or design changes seen by the naked eyes by people/consumer in between the efficient and inefficient fan, therefore the conventional fan need new outlook so this may result in change in perception of people to use of efficient fans. Together, these studies indicate that the use of a biplane effect to reduce the torque on fan. Which result in reduce energy consumption of ceiling fan. And use of biplane will give different contour to the fan.

III - CONCLUSION

As the ceiling fan are utilized in the huge amount across the tropical areas. Therefore it is important to move toward the high electricity efficient ceiling fan with high volumetric flow rate of air inside the room. The goal of this literature review is to optimize the high efficient design and arrangement of newly design double blade ceiling fan having 6 blades. The review literature suggest that as the newly design ceiling fan having 6 blades with double plane will influence the people to use the fan which reduce the use of low efficient fan and The ceiling fan blade has a peculiar nonlinear forward sweep that helps to improve the air circulation in the room . Which has been widely documented through the literature? Moreover, minimum interference effects between blades are found for six blade configurations.

Current research support the use of 6 blade ceiling fan and different contour /design of fan as discussed above. However it is the first fan with 6 blades which are arranged in the two plane therefore it will help for further study and development in the same.

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