Efficacy Measurements of Commercially Available Ceiling Fans

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Abstract: This study examines the performance parameters of commercially available ceiling fans. Air flow, efficacy, power factor and input power are measured at various speed levels. This study also compares standardization adopted in manufacturing after comparing two same models of commercially available ceiling fans. From the study it has been observed that ceiling fan's efficacies, power factor are not according to standard. Further improvements in performance at low speed are recommended. It has been found that considerable amount of power can be saved by using standard fans while running at low speed which leads to the saving of the cost of energy generation.

Keywords: Efficacy Measurement, Ceiling Fan performance, Standardization

I. INTRODUCTION:

Pakistan is suffering from electricity crisis, as only 55% of its population is able to get electricity [1]. That shows the increased demand and supply gap[2]. Several home appliances are not energy efficient. Since, Pakistan has hot climate conditions; therefore, ceiling fan has high consumption in usage [3-5].

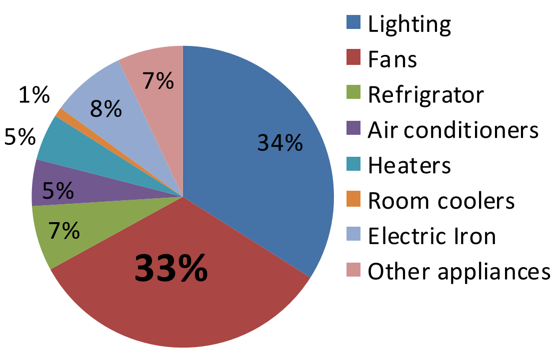

Fig 1: Share of domestic appliances in Electricity Demand[5]

Fig. 1 shows that ceiling fans are the major electricity consuming appliances. Therefore, it demands attention on standardization and energy efficient usage. In order to achieve the energy efficient ceiling fans to save energy, standards of fan size, airflow and efficiency must be known. The Energy Star standardization is adopted by countries [6, 7] to save national energy consumption. Table 1 and 2 describes the energy star standards rating of standard size, airflow and efficacy requirements[8].

This Paper is organized a follows: Section II illustrates methodology adopted, Section III describe test results and Section IV is conclusion with recommendations should be adopted.

Table 1: Standard Size of Ceiling Fans[8]

Room Dimensions	Suggested Fan Size
Up to 75 ft^2	29 – 36"
76 – 144 ft^2	36 – 42"
144 – 225 ft^2	44"
225 – 400 ft^2	50 – 54"

Table 2: Standard Air Flow and Efficiency [8]

Fan Speed	Minimum Airflow(CFM)	Efficiency Requirement (CFM/Watt)
Low	1,250	155
Medium	3,000	100
High	5,000	75

II. METHODOLOGY

A. Test Bench

In this study a test bench is developed as shown in Fig.2. The dimensions of the selected room are 9 ½ ft width, 12 ft height and 15 ft long. For such a room 56 inch ceiling fan is appropriate. Therefore four 56 inch fans, two fans from each brand are selected of two leading commercially available brands, for the testing purposes. Fan 1 and Fan 4 are of same brand, while Fan 2 and 3 are of another same brand.

The testing measures Input Power, Harmonics, Air flow, power factor and RPM (rotation per minute). For the input power and harmonic analysis Fluke 1735 Power logger is used. While for air flow and RPM anemometer and tachometer are used respectively.

B. Procedure:

RPM of a ceiling fan were fixed with tachometer and power parameters such as, power factor, input power and harmonics were measured through power logger. For the measurement of air flow 12 stations were established starting directly below the center-line of the fan and going out 6 inch increments from centerline take the readings on both sides of center point for accuracy as shown in Fig 3. The measurement of all parameters was repeated for 4 samples of ceiling fans used in this study.

Since the ceiling fan's efficacy is represented in CFM/Watt (cubic feet per minute per watt) .The air flow velocities (m/sec) measured by anemometer are multiplied by corresponding area (m^2) between two measuring stations to get volumetric flow (m^3/sec) then converted into CFM.

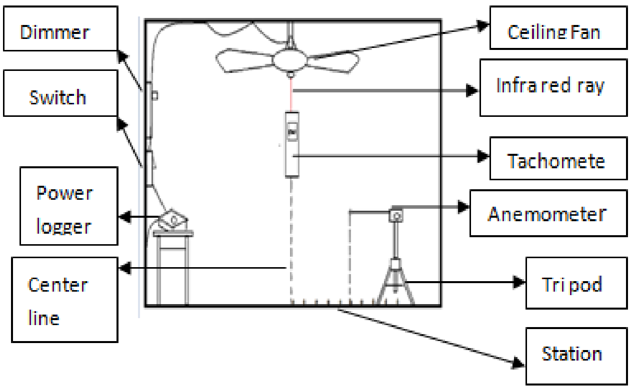

Fig. 2: Overall View of the test bench

III. Test Bench Results

A. Impact Of Speed Levels On input power and Power Factor:

Testing shows considerable power factor decrement with speed variation, such that reactive power increase as the speed decreases, as observed from Fig. 3. Furthermore the deviation of measured input power consumed at full speed level from rated one is shown in Fig. 4.

B. Impact Of Speed Levels on Efficacy

Efficacy is defined as the ratio between airflow and consumed power and the unit is CFM/Watts and it can be higher than 100. The comparison between standard airflow and measured airflow produced by all sample fans at different speed levels is shown in fig. 5. The red line indicates the standard rating. While the Efficacy measurements are shown in Fig. 6.

C. Impact of Speed Levels on Harmonics

(A) **Voltage Harmonics**

The Figs.7 & 8 represents that the voltage THD (Total harmonics distortion) before and after the dimmer. It shows that voltage THD is not present on the supply voltage i.e. before dimmer while, with decrease in speed there is a precise change in amplitude of THD. It is also observed that supply voltage fulfills the criteria of IEEE 519 i.e. voltage THD is less than 5 %[9]. High amount of voltage THD are observed after the dimmer. That clearly depicts dimmer as the main source of the production of harmonics. Furthermore, ceiling fan contribution can be seen in Fig. 7, as magnitude differs between them.

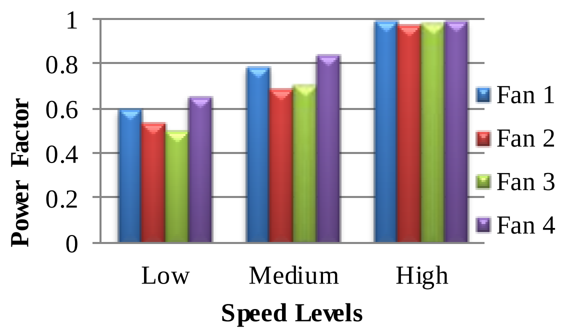

Fig. 3: Power Factor at Different Speed

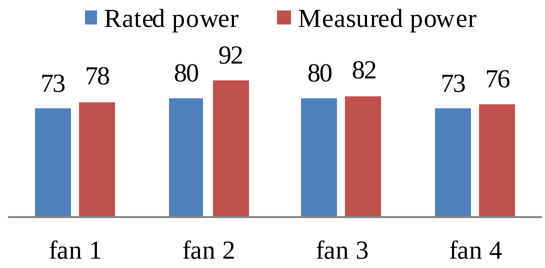

Fig. 4: Deviation of measured power with rated power

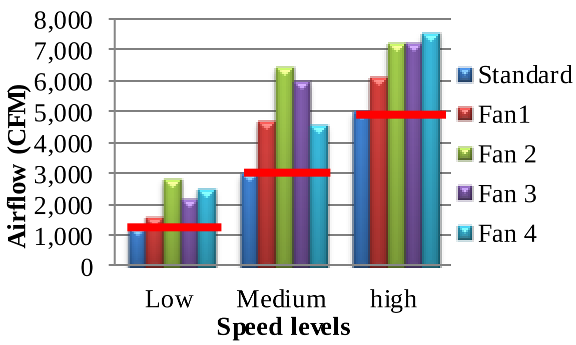

Fig. 5: Airflow at Different Speed Levels

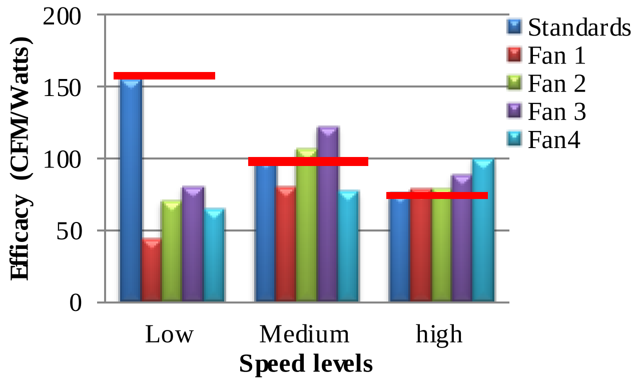

Fig. 6: Efficacy at different speed level

B. Current THD

It has been observed that the THD current before the dimmer and after the dimmer is same. In Fig.9 current THD after the dimmer are analyzed. It is observable that electronic regulator has substantial impact on current THD.

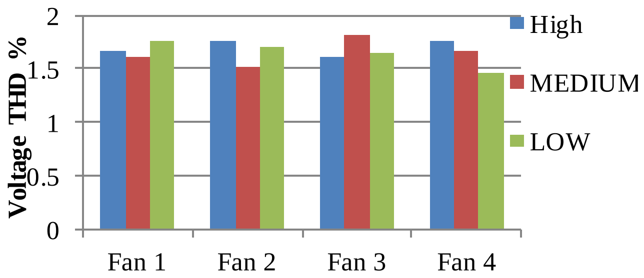

Fig. 7: Voltage THD (%) Before Dimmer

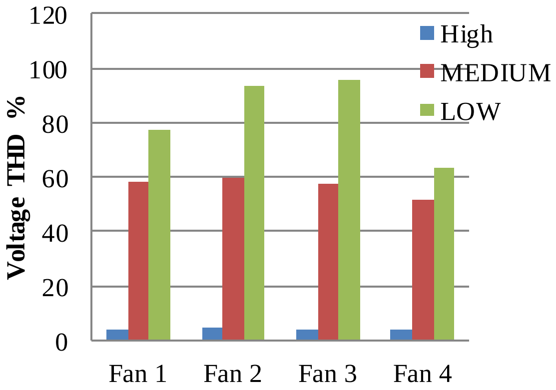

Fig. 8: Voltage THD (%) After Dimmer

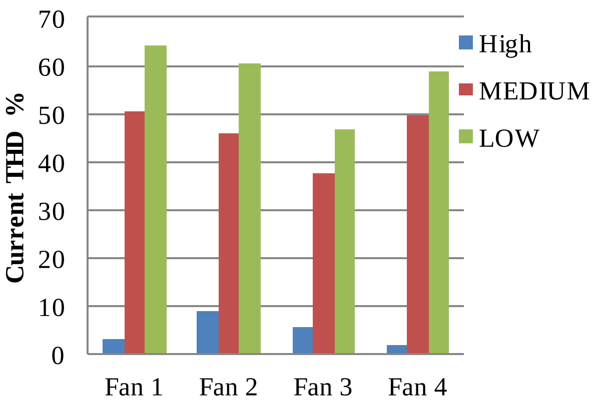

Fig. 9: Current THD

IV. CONCLUSION

It is concluded that ceiling fan samples of same brands even do not consume same input power and other performance factors. The performance of fan at low speed is significantly deviating from standards. Power factor is also considerably reduced at medium and low speed. It is also observed that there is no direct relation between harmonic components and efficacy of ceiling fans. Therefore, a ceiling fan which is efficient does not mean that it would produce low harmonic content.

Manufacturers should look into improving efficacy during low speed operation. This effort can save substantial energy. Assuming, a 10% use of fans at low speed (which increases considerably during winter), on average 21W per fan can be saved, if all fans industry observe standards while manufacturing. With an estimated number of ceiling fans in Pakistan as 53 million, possible power saving shall be 111.3 MW (i.e. 53 million fans ×10% in use × 21W). The power saving may result in savings of up to USD 111.3 million [8]. Furthermore to control harmonics content of ceiling fan, the dimmer of improved power quality instead of conventional continuous dimmer must be utilized.

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