A Promising Performance of Modified Turbine Ventilator in Improving Thermal Comfort Level

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Abstract:

Turbine ventilator becomes a preferable option nowadays to ventilate spaces due to negligible operating costs and a great performance offered. Turbine ventilator basically performs at an optimum level in premises that are having at least 150% of opening air. However, modern premises nowadays are designed having insufficient opening air intake. Thus, the modification towards the existing turbine ventilator seems crucial to be done. In this study, some modifications towards the existing turbine ventilator were made by adding a fan which was joined to a set of propeller. The performance of modified turbine ventilator in improving thermal comfort level was examined and compared with the existing turbine ventilator. Predicted Mean Vote (PMV) of 1.686 and Percentage People Dissatisfied (PPD) of 59% were recorded for a premise with existing turbine ventilator. Whereas, for a premise with modified turbine ventilator PMV and PPD recorded respectively were 1.503 and 51%. It is proven that the modified turbine ventilator offers a promising performance in improving thermal comfort level.

1. Introduction

A great proper ventilation system is a must nowadays in order to provide people a healthy and cosy indoor environment. Due to the advantages offered; high efficiency, negligible operating costs and low maintenance, turbine ventilators are often opted.

Basically, turbine ventilator performs at an optimal level in premises that are having at least 150% of an opening air. However, modern premises nowadays are designed having insufficient opening air intake. Therefore, the modification towards the existing turbine ventilator should be made to ensure a great performance and practicality of using turbine ventilator [1].

In 1973, Felter et al. [2] have introduced the modified ventilator with an added fan. However, the fan is operated by using electrical energy which consists of more components to be manufactured thus increasing the cost of production. In addition the user has to pay for the electrical energy used to operate the fan.

Shockey [3] has disclosed a ventilator consisting of a turbine and a fan configured to force air from a ventilated space. The fan is coupled to the turbine so that rotation of the turbine results in rotation of the fan at a rotational speed greater than that of the turbine. However, the invention requires more energy from the wind to turn the turbine and the fan which in combination

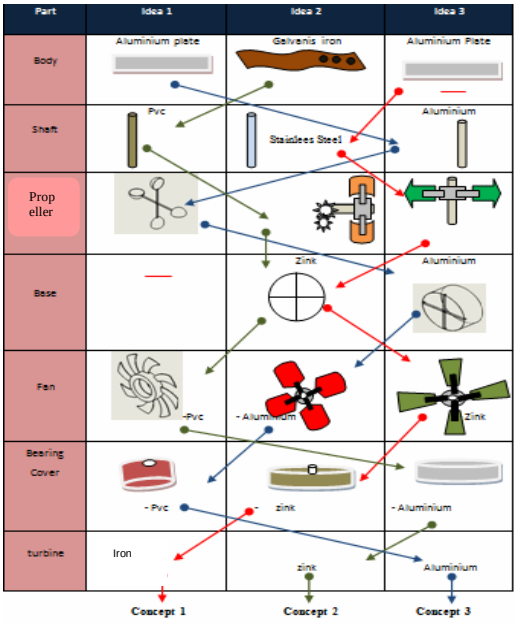
possesses a higher value of inertia momentum. This is because part of the wind energy which is initially used to turn the turbine only has been transferred to turn the fan as well.

In this study, some modifications towards the existing turbine ventilator were made by adding a fan which was joined to a set of propeller and powered by wind. The performance of modified turbine ventilator in improving thermal comfort level was examined and compared with the existing turbine ventilator.

2. Methodology

According to Thariq [4] and Normayati [5] the use of existing turbine ventilator could only provide thermal comfort indexes of PMV=1.686 and PPD=59.06%. This is due to the nowadays building that having an opening air intake of less than 150%. The practicality of using turbine ventilator ought to be improved by incorporating a fan onto the existing ventilator.

Table 1: Morphology chart



There are several attempts to configure a fan onto the existing turbine ventilator by previous researchers [2,3]. Each configuration basically differs in term of mechanism, shape, component, and material used.

There are three ideas of concepts that have been generated in this study (see Table 1). These ideas have then been brought into three different concepts shown in Figure 1, 2, and 3. The concepts are basically evaluated in terms of function, durability, safety, ergonomic and cost as shown in Table 2.

Concept 3 has been marked to be the best design with the highest score of 7.3.

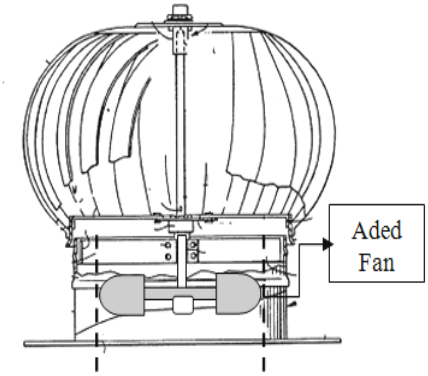


Figure 1: Concept 1

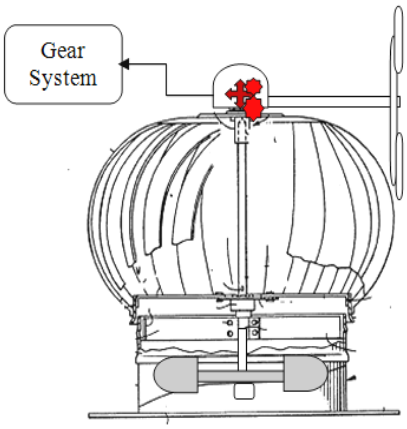


Figure 2: Concept 2

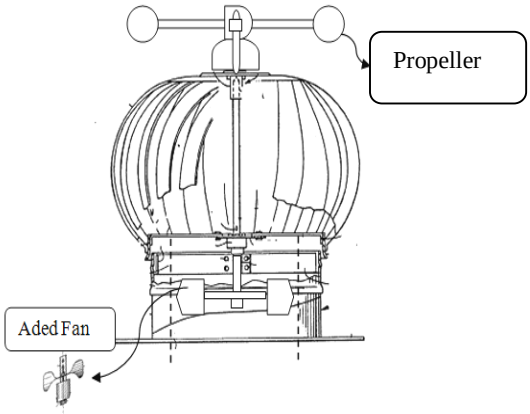


Figure 3: Concept 3 [6]

Table 2: Matrix evaluation

	FUNCTION	DUR ABILI TY	SAFETY	ERGONOMIC	COST	TOTAL
WEIGHT	0.4	0.2	0.2	0.1	0.1	1.00
CONCEPT 1	3 / 1.2	6 / 1.2	5 / 1.0	6 / 0.6	7 / 0.7	4.7
CONCEPT 2	6 / 2.4	3 / 0.6	4 / 0.8	5 / 0.5	6 / 0.6	4.9
CONCEPT 3	8 / 3.2	6 / 1.2	7 / 1.4	7 / 0.7	8 / 0.8	7.3

** Weight/Total 1.00- Maximum, ≈ 1.00- Very Important, ≈ 0.1- less important*

Figure 4: Prototype development and Installation [6]

The next stage was to develop a prototype and bring this concept out (see Figure 4). This prototype was installed at the same premise used by Thariq [4] and Normayati [5]. Environmental parameters such as air temperature, air velocity, relative humidity and CO_2 concentration were physically measured. The performance of existing and modified turbine ventilator in terms of improving thermal comfort level was then investigated and compared.

3. Results and Discussion

Comparison of PMV index for a premise without ventilator (WO), with turbine ventilator (TV) and with modified turbine ventilator (THTV) is presented in Figure 5. There is an improvement of 14% in terms of PMV for a premise with a modified ventilator, whereas only 4% of improvement for a premise with an existing ventilator.

This improvement is mainly due to the modification adopted to the ventilator which is by adding a fan that is joined to a set of propeller. This added fan basically helps to suck more hot air from the premise, despite only a turbine used for an existing ventilator.

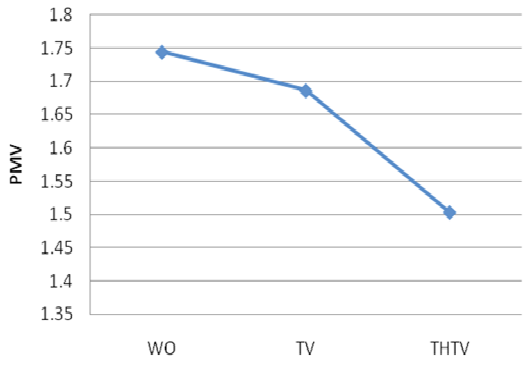


Figure 5: PMV index for a premise without ventilator (WO), with turbine ventilator (TV) and with modified turbine ventilator (THTV)

This invention differs to the Shockey's [3] whose the fan is configured and attached directly to the turbine using a gear system. Such system requires a large wind speed to operate both turbine and fan.

From the physical measurement, it is up to 23% of outdoor air velocity can be sustained in the premise of using modified ventilator. Whereas, it is only about 7% of outdoor air velocity can be sustained in the premise with the existing ventilator.

Figure 6 shows the percentage of people dissatisfied (PPD) towards thermal comfort level in the premise before and after installing ventilator. After installing the existing and modified ventilator, the indoor air temperature reduces about 4° and 2° respectively.

It is about 63% of people dissatisfied towards thermal comfort level in the premise before installing any ventilators. However, after installing the modified ventilator the percentage of people dissatisfied drops to only 51%.

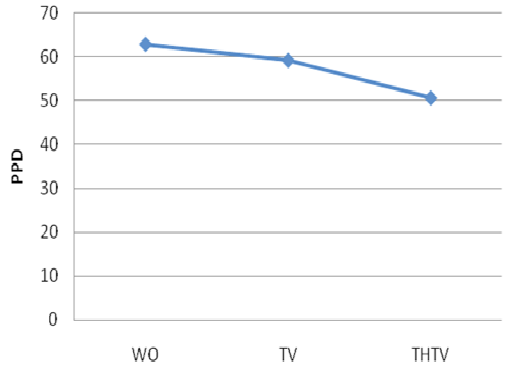


Figure 6: PPD index for a premise without ventilator (WO), with turbine ventilator (TV) and with modified turbine ventilator (THTV)

4. Conclusion

This new potential breakthrough, i.e. the modified turbine ventilator, differs to the existing turbine ventilator in terms of its mechanisms. The existing turbine ventilator uses only turbine to ventilate premises. Whereas, for the modified turbine ventilator, beside turbine, it also uses a fan which is joined to a set of propeller by a shaft producing a great centrifugal force to suck the hot air inside-out from premises.

The performance of modified turbine ventilator in improving thermal comfort level was examined and compared with the existing turbine ventilator. Predicted Mean Vote (PMV) of 1.686 and Percentage People Dissatisfied (PPD) of 59% were recorded for a premise with existing turbine ventilator. Whereas, for a premise with modified turbine ventilator PMV and PPD recorded respectively were 1.503 and 51%. It is proven that the modified turbine ventilator offers a promising performance in improving thermal comfort level.

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