Performance Analysis of Turbo Ventilator

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Abstract

Air Ventilation is the intentional introduction of ambient air into a space and is mainly used to control indoor air quality by diluting and displacing indoor pollutants it can also be used for purposes of thermal comfort or dehumidification. It is necessary in buildings to remove 'stale' air and replace it with 'fresh' air: Helping to moderate internal temperatures. Helping to moderate internal humidity. Replenishing oxygen. Reducing the accumulation of moisture, odours, bacteria, dust, carbon dioxide. A Turbo Air Ventilator is one such device which is used for proper ventilation. Because of the simple operating mechanism and relatively affordable price, a turbine ventilator which is driven by natural wind force is always a preferred choice to ventilate the building without depending on air conditioning system which is usually associated with global warming, finite fossil energy depletion and sick building syndrome (SBS)
Turbo ventilator is an alternative to motor driven ventilating systems. The rooftop turbo ventilator is now widely accepted for industrial ventilation as well becomes important ventilation feature, which is used for ventilation of commercial, residential, and many institutional buildings. It works effectively at very low wind speeds hence always functional. Many researchers found that performance of turbo ventilator depends on its various operating parameters and environmental conditions. Therefore, study of turbo ventilators in details has become the focus area of research. In this paper detailed study about the current improvements and future scope of the turbo ventilator is done. The results of analytical and the experimental works are analyzed by considering its performance for the various applications.

Keywords- Ventilation, Turbo ventilator, Environment, Performance

1.INTRODUCTION

Proper ventilation is must for any industry to provide safe, efficient, effective working and healthy environment to the human. Vent ilat ion is a process of removing stale hot air and providing fresh cool air. It balances temperature, supplements oxygen and removes harmfu l products such as mo isture, dust, smoke, heat, fly ing bacteria, carbon dio xide etc. Turbo ventilator operates on natural wind energy hence it is most cost effective in respect of operational and maintenance. These systems are environmental friendly, as no power is consumed in its operation.

The turbo ventilator is always better option to ventilate the buildings which doesn't require any external power. Originally the patent on the

concept of turbo ventilator was taken by Meadows. [1] It was considered as a one of the type of the roof

ventilator. The same concept developed by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). [1]

Co mmercial production of turbo ventilator was manufactured by Ed monds of Australia in the year 1934. [1] These devices are commercially available in the market since many years; however a few literatures are available on the design and aerodynamics of the unit.

There are two different modes of ventilation techniques. (Ref. Khan et al. [2])

1.1. Passive Ventilation Technique

This is simplest method of ventilation with different types of roof openings without any moving parts. There are several types of openings commercially available v iz., static vent, dormer vent, gable vent, ridge vent, etc. This ventilation takes place due to stack effect. Stack effects are due to temperature differences between the inside and outside of the room. When the inside room temperature is greater than the outside, warm indoor air will rise up and exit through openings. The vacant volume of hot air replaced by cooler and denser air fro m doors and windows. Figure 1 shows schematic d iagram o f this technique.

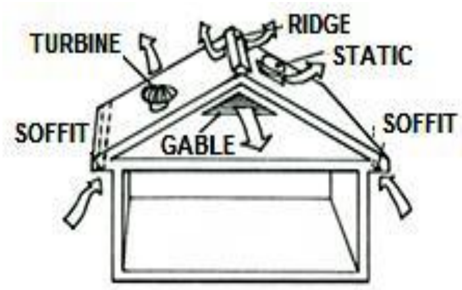

Fig. 1. Passive Ventilation Technique

1.2. Active Ventilation Technique (Wind Driven)

Active ventilators include fan d riven exhaust systems i.e. Turbo ventilators. Th is system works on natural wind energy. A turbo ventilator consists of number of vertical blades (it may be curved or straight blades) in a spherical array mounted on a frame. At the center, a shaft is supported by upper and lower bearings. A rainproof do me is on top of the frame . When wind blows on the blades the resulting lift and drag forces cause the turbine to rotate. Due to this rotation, produces a negative pressure at the center of the turbine ventilator which ext racts hot air. Air enters the turbine axially via the base duct and is then expelled radially. In the absence of wind, a turbo ventilator still remains effective due to stack effects. Figure 2 shows active ventilation technique.

Fig. 2. Active Ventilation Technique

II.REVIEW OF LITERATURE

This literature survey reveals the work done by various scientists on analytical, experimental and CFD (co mputational Fluid Dynamics) analysis of turbo ventilators and is listed below in chronological order. So me researchers have even analyzed the turbo ventilator with additional extractor fan attached at the bottom of the shaft.

The turbo ventilator performance was discussed in terms of (i) Ventilation rate or mass flow rate and (ii) Rotational speed for different wind speeds and Air temperature.

Alex Ravel [3] used following two wind ventilators for testing.

i) Ventilator A: Ed mond's Hurricane H400
Vertical vane ventilators with 400 mm throat diameter.

ii) Ventilator B: IVR's Low line turbo LTV400
Spherical vane ventilators with 400 mm throat diameter.

These tests were carried out at ambient temperature conditions, with zero degree temperature difference between inside and outside air and so obtain the comparative values of flow through the ventilators at wind velocity ranging fro m 4 to 16 km/hr, the discharge coefficients range obtained is as follows;

Ventilator A --------- $0.43 < C_d < 1.06$

Ventilator B---------- $0.00 < C_d < 0.44$

The discharge coefficient C_d is the ratio of actual flow rate through a turbo ventilator to flo w rate through an open circular duct of same throat diameter.

Thus, ventilators A was found to be more effective in air ext raction as compared to ventilator B under identical conditions.

The test stand developed for measurement of the flow rate by using a standard nozzle is (AS 2360) as shown in Fig. 3.

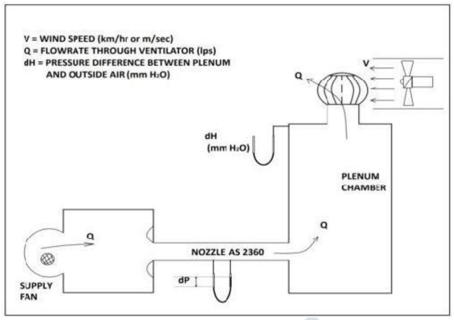

Fig3 :The test stand developed

Experimentation carried out air simu lated condition at residences and factories in Taiwan, shows the substantial extraction of air through turbo ventilator.

The experiments were also conducted with additional extracted fan at the bottom of the shaft were conducted, wh ich resulted into better mass flow rate as shown in Fig. 6 However, it was concluded that the additional extractor fan at bottom o f the turbo ventilator sized 500 mm and 360 mm do not have appreciable changes in the mass flo w rate induced. For design and development of any new model o f the turbo ventilator structural factors are considered. [5]

Lai and Kuo, [6] found that ventilation for bathrooms was improved by providing a large turbo ventilator. The conclusions were that the turbo ventilator did add to the ventilation rate significantly and the induced negative pressure helped to reduce odors and moisture in the roo m.

Dale and Ackerman, [7] observed that speed and direction of wind affects on the mass flow rate of the turbo ventilator.

III.EXPERIMENTATION

Experiment is carried out by combining an air-driven turbo ventilator and extractor fan operated by solar-power, as shown in Fig. 8. The prototype of 500 mm diameter hybrid turbo ventilator developed by Lai [9] which is replaced by the existing inner blade with 400 mm extractor fan showed that it increase the mass flow rate (m^3/s), especially with a rated rotational speed of turbo ventilator is 1500 rp m and at wind speed of up to 5m/s. if the speed goes beyond this fan did not contribute to the airflow. Study found that extractor fan enhancement was negative.

Khan et al., [11] the experiments were carried out on four commercial turbo ventilators as shown in Fig. 9.

1. 300 mm straight vane ventilator (Steel and Aluminu m)
2. 300 mm curved vane ventilator (Steel and Aluminu m)
3. 250 mm straight vane (Polycarbonate) transparent for day light
4. 250 mm straight vane (Po lycarbonate)

Also made test rig to measure the flow rate of turbo ventilator [11] as shown in Fig. 10.

Turbo Ventilator is placed on horizontal roof of plenum. Plenu m is a big room fro m which stale air is to be thrown outside by turbo ventilator. Wind velocity is simu lated by the variab le speed fan mounted near ventilator which is measured by wind anemo meter. When turbo ventilator starts expelling air fro m plenu m air duct will rep lenish the same amount of air.

Fig. 4. Scematic Test Stand

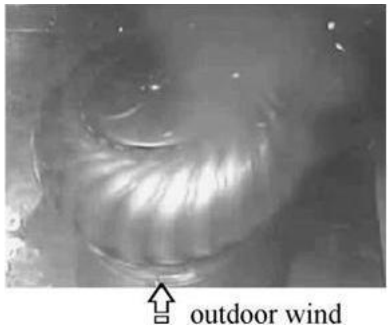

Fig.5. Top View of Flow Structure

Fig. 6. Flow Structure

Experiments are carried out on different b lade height like 170, 250 and 340 mm at same wind speed of 12 km/h and found that improvement in mass flow rate could be achieved by 13.5% if the blade height is increased by 50%. It would give different airflow rates of 65, 70 and 75 l/s, respectively

Fig.7. With Inner Fan

Porfirio R. [10] showed that improvement in air change rate (ACH) by combin ing the turbo ventilator and electric fan on g reen houses in Brazil. The study found that turbo ventilators with extractor fan connected at the bottom is having capacity to increase the ventilation rate if turbo ventilators were operated only by natural wind.

Lai C. M. (With Extractor Fan) [9]

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A nozzle meter is installed to measure flow rate going in to p lenum this is the flow rate of turbo ventilator. Ho wever the air duct and nozzle meter offers resistance to air flo w. A Booster fan is provided to overcome this resistance so that net turbo ventilator air flow is d irectly obtained at Nozzle meter which is measure by mano meters provided at the duct. The rotational speeds of the ventilators were measured by optical tachometer

IV.RESULTS

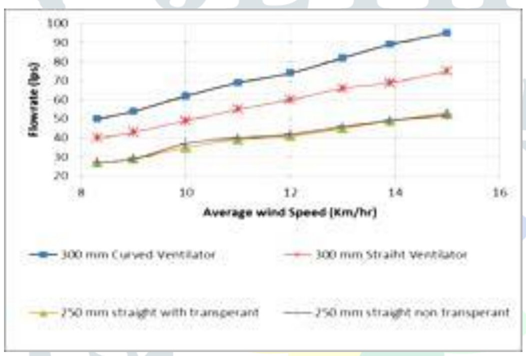

Fig.8. Mass Flow Rate Verses Average Wind Speed

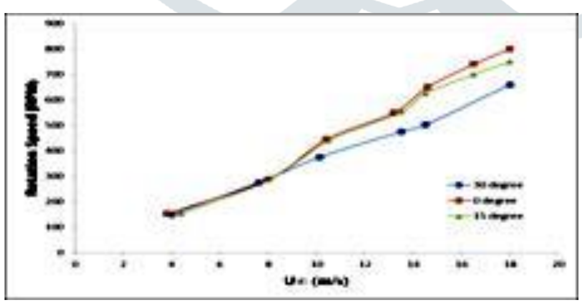

Fig. 9. Rotational Speed Verses Wind Velocity

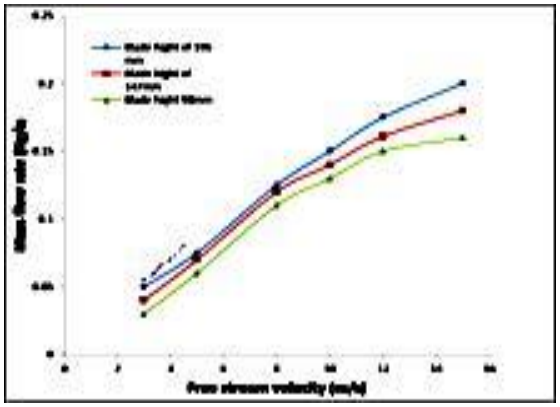

Fig. 10. Mass Flow Rate Verses Wind Velocity

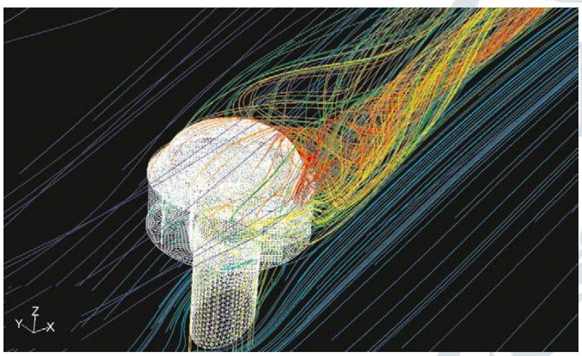

Fig. 11.3- D Stream Line Of Turbo Ventilator At 10 M/S

Design Modification

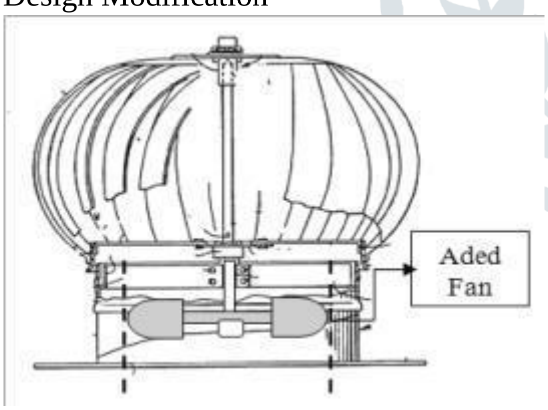

Fig. 12. Concept 1

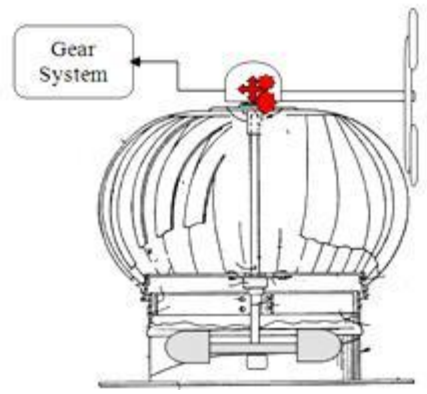

Fig. 13. Concept 2

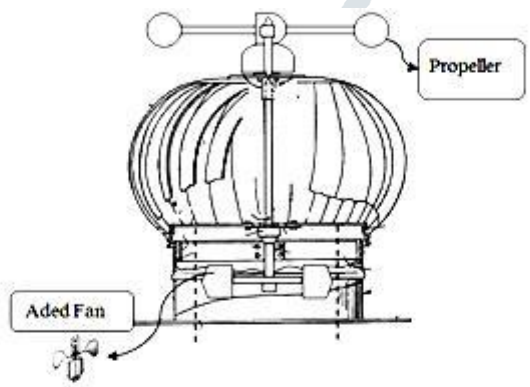

Fig. 14. Concept 3

V. CONCLUS ION

Different wind driven ventilation techniques have been studied and categorized based on review of literature, it was found that very little work has been done on various operating parameters like diameter at throat, diameter of turbo ventilator, blade design, blade width, blade angle for its performance. There is no standard design model or parametric study available.

On the basis of the previous work carried out by experimental and analytical investigation on various aspects of rooftop turbo ventilator application and performance. Th is paper has focus on the existing study and also the possible development of the turbo ventilator for the coming future. CFD is fairly reliable software and which could be used as a cost effective. It helps in future design and development of rooftop turbo ventilators with enhanced performance.

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