Design of System for the Power Production from Waste Air of Exhaust Fans at Industries & Buildings

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Abstract*—Apart from issues like population rise, unemployment, illiteracy and political governing factors, one of the most important problems developing countries like India are facing today is in power sector. In terms of fuel, coal-fired plants account for 57% of India's installed electricity capacity, compared to South Africa's 92%; China's 77%; and Australia's 76%. After coal, renewal hydropower accounts for 19%, renewable energy for 12% and natural gas for about 9%.[1] In the last few decades various methods have been developed to use renewable source of energy, especially solar and wind energy. Wind power, as the good alternative to conventional fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation and uses little land. This paper describes that how we can use the wind available to us from exhaust fans, previously which was wasted. A solution to energy problems for any developing nations.

***Index Terms*— Projects, Power generation, Wind turbine, Exhaust air**

I. INTRODUCTION

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. Although a relative new comer to the wind industry compared with Denmark or the United states, India has the fifth largest installed wind power capacity in the world. In 2009-10 India's growth rate was highest among the other top four countries.[2]

There are the numbers of ways of producing electricity from wind in India on small scales which are very effective and economic. We have found the one of the effective way i.e. the use exhaust fans at industries. The exhaust fans are used to remove the unwanted or unnecessary air at industries or at the buildings. In order to run those exhaust fans electrical energy is consumed. At present the air that the fans throw out is of no use or we can say it is wasted. If we can make use of that waste air in order to generate electricity then the power lost in terms of running the exhaust fan can be reduced. This can be done by placing the turbine in the way of exhaust air and coupling that turbine with the DC generator. The power produce can be used to run the other equipments such as light bulbs, LEDs, etc.

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Thus the air which was wasted before, can be used now to produce the power which will save both electricity and money. For use of this renewable energy, we had developed a system to utilize these source of energy. This paper describes how we have designed “Power Production From Waste Air Of Exhaust Fans At Industries & Buildings”.

II. LITERATURE REVIEW [3]

Energy is vital for everything on earth and even more so for the progress of a nation. It has to be conserved in a most efficient manner. Over the past 20 years, wind power is reported as the fastest growing renewable energy resource in the world (at the rate of 30% annually) in many countries as it is a clean, cost-effective and sustainable resource. In Malaysia,an innovative idea was developed as a solution to alleviate this problem which is to extract wind energy from man-made wind resources i.e. cooling tower. Usually, an exhaust air system provides air that has great potential to be extracted into useful energy because it is higher in wind speed and almost constant in range compared to natural wind. These advantages will result in the installation of wind generators at low wind speed zones to become feasible. For this purpose a novel energy recovery system for wasted exhaust air was designed. It is done by conducting a number of experimental tests on both actual and fabricated small scaled cooling tower in order to investigate the feasibility of mounting a vertical axis wind turbine (VAWT) with an enclosure on the top of an exhaust air system.

The energy recovery system is targeted to produce on-site clean energy generation from the exhaust air system without causing the negative effects on the performance of the original exhaust air system. This innovative design of an energy recovery system is to reuse the released air from an exhaust outlet as well as natural wind to produce electricity. It is done by mounting two vertical axis wind turbines (VAWTs) that are integrated with an enclosure above the outlet of a cooling tower. Fig. 1 depicts the general arrangement of the designed system. Supporting structure is the main structure for the entire system to hold the VAWTs, guide vanes and enclosure. It can be installed either horizontally or vertically above the exhaust air system depending on the incoming air’s direction to the turbine.

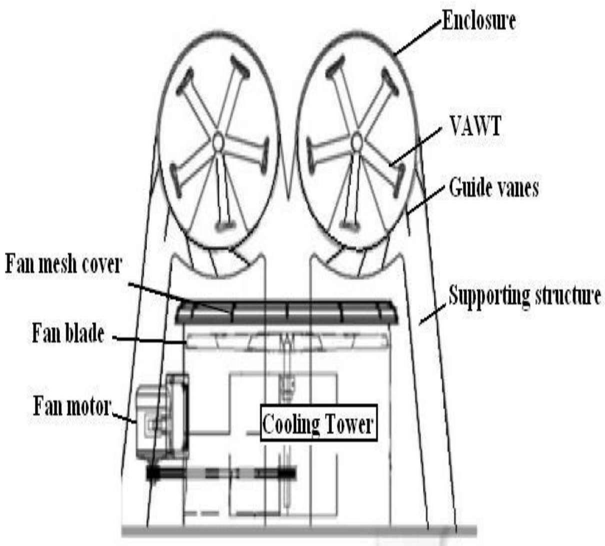


Fig.1 General Arrangement of the energy recovery system in cooling tower

Following the same we had developed an energy recovery system for the exhaust fans. Exhaust fans are also throwing the air at the speed higher than natural wind. This helps to produce the energy or in other words to recover the waste energy.

III. SYSTEM SETUP

A vertical axis wind turbine (VAWT) with an enclosure is mounted above the outlet of a exhaust fan to harness the wind energy for electricity generation. The VAWT is positioned at a specific area and distance at the outlet of the exhaust air source to avoid negative impact on the performance of the exhaust air system while capturing more air.

The design can be either in the horizontal or vertical direction. To capture the wind exhausted from the bottom(or top), the system can be installed horizontally with supporting structure at both the ends of the power transmission shaft with generator at one side and bearing at the other side. If the exhaust air is blowing from side/wall, the system can be either horizontal or vertical. The generator can be mounted for vertical installation of the system. The enclosure design is optimized to guide the wind and create a venture effect (to increase the wind speed) before the wind-stream enters the wind turbine.

The concern on safety is minimized by mounting the turbine inside an enclosure; a mesh can also be used to cover the enclosure (to avoid any external material striking the blades or danger caused by the blade failure). Diffuser-plates form parts of the enclosure and are mounted at specific angles to draw more wind and accelerate the flow. The is also equipped with guide vanes to guide the wind to the correct angle of the attack of the VAWT blades. The design is illustrated in Fig. 2

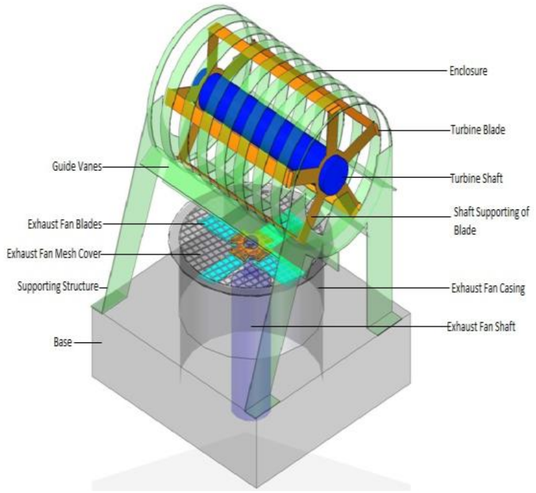


Fig. 2 (general arrangement of energy recovery system in exhaust fan)

IV. PROPOSED DESIGN

Table .I.Requirements of Exhaust Fans

REQUIREMENTS OF EXHAUST FANS
• Diameter of exhaust fan : 500 mm • RPM of Exhaust fan: 1440 • Temperature of air: 42^0 c (315 K) • Atmosphere pressure : 1 bar(10^5 N/mm^2) • Density of air: 1.106 kg/m^3 • Volumetric flow rate:2.94 m^3/s • Area: 0.19625 m^2 • Velocity:14.98 m/s • Angular velocity: 1.5 rad/sec • Speed of wind turbine:150 RPM

Table .II. Design of Bearing ForTurbine Shaft

DESIGN OF BEARING FOR TURBINE SHAFT
• Inner diameter of bearing : 35mm • Outer diameter of bearing: 62mm • Axial width of bearing : 14mm • Bearing number: 6007 • Shaft RPM of wind turbine: 250-350 • Expected life of bearing : 10000hrs • Bearing radial force: 392 N(approx.) • Life L_{10} : 980 million revolution • Dynamic load capacity : 3893.69N

Table.III.Design of Blade

DESIGN OF BLADE
• Blade length: 650 mm • Chord length:0mm • Camber height : 4mm • Airfoil thickness: 8mm • Angle of attack: 10^0 • Lift coefficient(C_L): 1.602 • Drag coefficient(C_D): 0.0167 • Pitch moment: 0.183 • Lift force: 5.979N • Drag force: 0.0623N

V. SIMULATION OF TURBINE BLADES

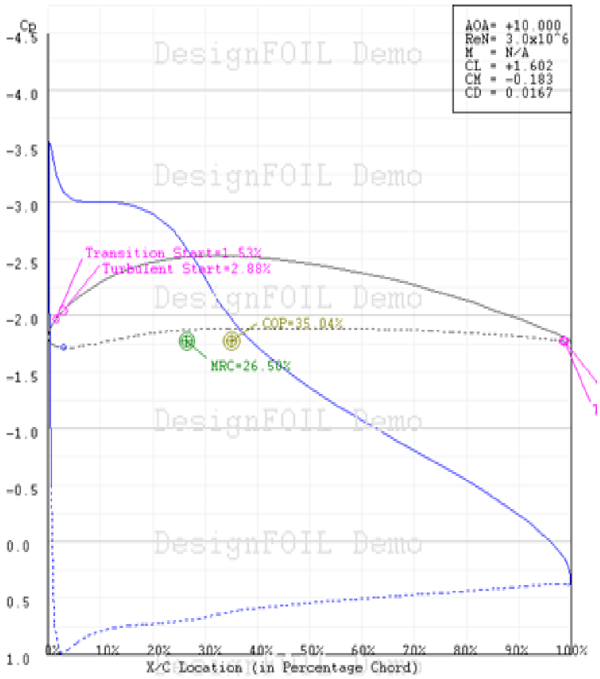


Fig.3 ($C_P \rightarrow \frac{X}{c}$ *Graph)*

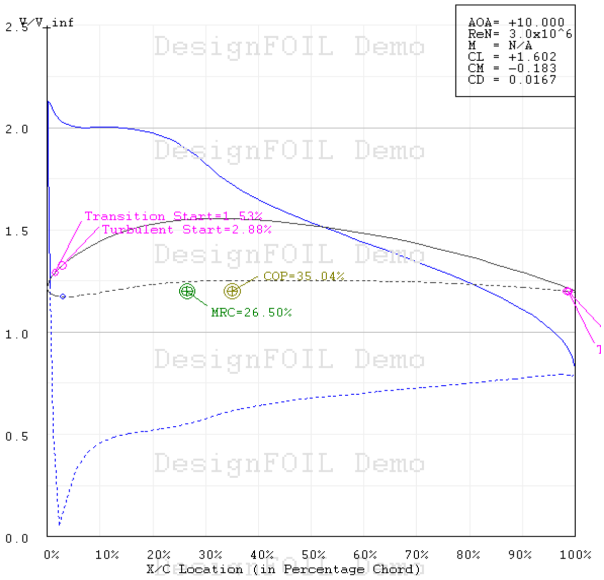


Fig.4 (V/V_inf→ X/(C) Graph)

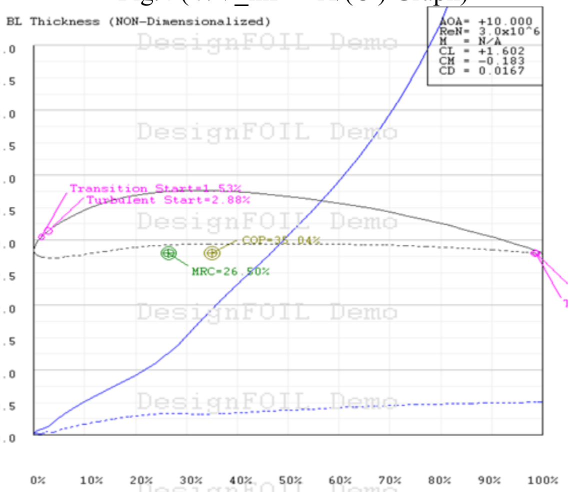


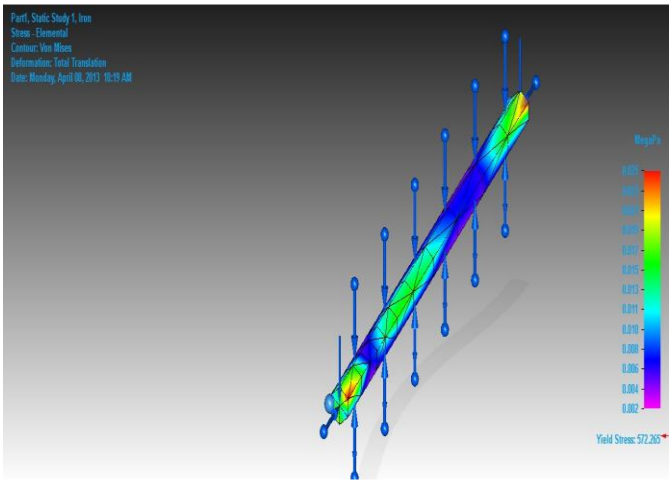
Fig.5 (*BL Thickness)*

- Fig. 3 shows the graph of C_p vs x/c.
- Fig 4 shows the graph of $V/V_{\_inf}$ vs x/c.
- Fig 5 shows the graph of blade thickness.

Where C_p =Pressure Coefficient
x/c= The term X/C refers to the location along the airfoil from 0 (nose) to the tail (100). It's a percentage of the chordlength.
$V/V_{\_inf}$= velocity distribution handy.
BL= Blade thickness

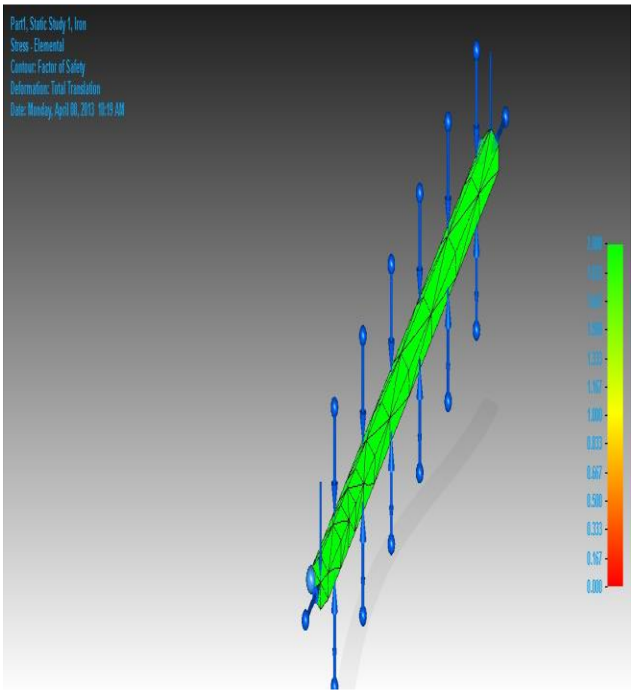
VI. SIMULATION OF TURBINE SHAFT

A. *Stress Results*



Type	Extent	Value	X	Y	Z
Von Mises Stress	Minimum	002 MegaPa	15.155 mm	193.182 mm	-8.750 mm
	Maximum	0.025 MegaPa	15.155 mm	-425.00 mm	8.750 mm

B. *Factor Of Saftey*



Factor of safety value : 2

VII. OUTPUT

The expected power output of this system with the proposed design is 3kW.

VIII. CONCLUSION

This paper presents an idea on harnessing clean energy from unnatural wind resources. Implementation of the shrouded VAWT on the outlet of exhust fan can recover a portion of the unused exhaust air for electricity generation.

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