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Experimental Study of Exhaust System of Cooling Tower using VAWT

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ABSTRACT

To harness clean energy from the exhaust of induced draft cooling tower without affecting the performance of cooling tower. A vertical axis wind turbine (VAWT) is mounted over the top of cooling tower in a cross wind orientation to utilize exhaust wind in a useful work done. This turbine system was not only recover the waste kinetic energy, but also be able to reduce the power consumption of fan motor and increase the intake speed of cooling tower. Wind energy from the outlet duct of this experimental setup of cooling tower utilize for the production of 12 Watt, which is 6.5 % of fan consumption. The overall turbine efficiency is 14.2 %.

Keyword: Cooling tower, Darrieus wind turbine, Exhaust system, Fossil fuels, Induced draft cooling tower, recuperation, Unnatural wind resources, Vitality, VAWT

INTRODUCTION

Higher demand of energy with the increase of population causes the depletion of fossil fuels day by day. Renewable resources such as biomass, wind, solar and tidal are one of the means to reduce the consumption of fossil fuels. It is obvious that the fossil fuel reserves are finite, oil reserves are vanishing greatly due to higher demand of power generation with the increase in population. In short period of time consumption of fuel is incredible and burning of fossil fuels causes seriously impacted on climate [1]. Faisalabad experiences low wind speed throughout the year (average wind speed varies from 2.5 to 3.6 m/s and wind probability >= 4 Beaufort (%)) [2]. Thus extracting wind energy by using conventional wind turbines would not be suitable. So it is convenient to utilize unnatural resources of wind, may be a way to generate electricity. In urban areas like Faisalabad, it is one of the most energy demanding city in Pakistan because of industrial sector that needs electricity the most. Be that as it may, an inventive thought to create clean vitality from unnatural wind assets in urban regions is exhibited. The option wellspring of wind is from the fumes air frameworks (i-e), cooling towers.

It is a clean energy power generation setup that can be use practically in the industries. A power driven fan that is mounted over the top of Induced draft cooling tower that exhaust the heat of water into atmosphere and causes the water to cool down, this exhaust that is in the form of wind and vapours utilize for production of electricity, as this wind is enough for the rotation (RPM) of wind turbine generator. VAWT is placed at the outlet of cooling tower at a specific distance where the maximum wind speed utilizes to give a positive torque in the area of the turbine rotation. The performance of the turbine (VAWT) and its effects on cooling tower performance were investigated in this paper. This system can be used as an auxiliary power for building electricity need or fed into electricity grid for energy demand. The energy output is foretelling and coherent, having simpler design of turbine. The way that there are quantities of cooling tower applications and unnatural fumes air assets universally makes this have extraordinary business sector inert qualities or capacities that might be created and prompt future achievement or helpfulness.

FEASIBILITY OF BUILDING MOUNTED/INTEGRATED WIND TURBINES (BUWTS)

The vitality era potential and specialized possibility of sitting wind turbines in the constructed environment have been evaluated. The study incorporates different arrangements of Building Mounted/Integrated Wind Turbines (BUWTs), thought to be generally yet not as a matter of course only in urban zones: from turbines arranged alongside structures, through turbines mounted on structures, to turbines completely coordinated into the building fabric. It is inferred that wind vitality could make a huge commitment to vitality prerequisites in the manufactured environment and that a more nitty gritty assessment of the asset is defended. Specifically, through a blend of new-form with particularly outlined wind vitality gadgets and retrofitting of (ideally confirmed) turbines on existing structures, it is assessed that the accumulated yearly vitality creation by 2020 from wind turbines in the manufactured environment could be in the reach 1.7-5.0 TWh (reliant on the appropriation of establishments as for ideal wind speed) bringing about yearly carbon dioxide reserve funds in the extent 0.75-2.2 Mt CO_2. These figures speak in between 1.5%-4.5% of the UK residential division power request in 2000. Dutton et al [3], over half of carbon dioxide outflows in the urban range are from the warming and cooling operations connected in structures. Giving renewable vitality straightforwardly to structures would add to decreasing their carbon dioxide outflow. Wind turbine that fuses inside fabricated environment (i.e. near or on structures) is characterized as Building Mounted/Integrated Wind Turbine (BUWT). BUWT are turbines that are fit for working close to structures and exploiting any conceivable enlargement on the nearby wind stream in light of the learning of the engineering included. They can be either freely upheld or be a part of the building outline [3].

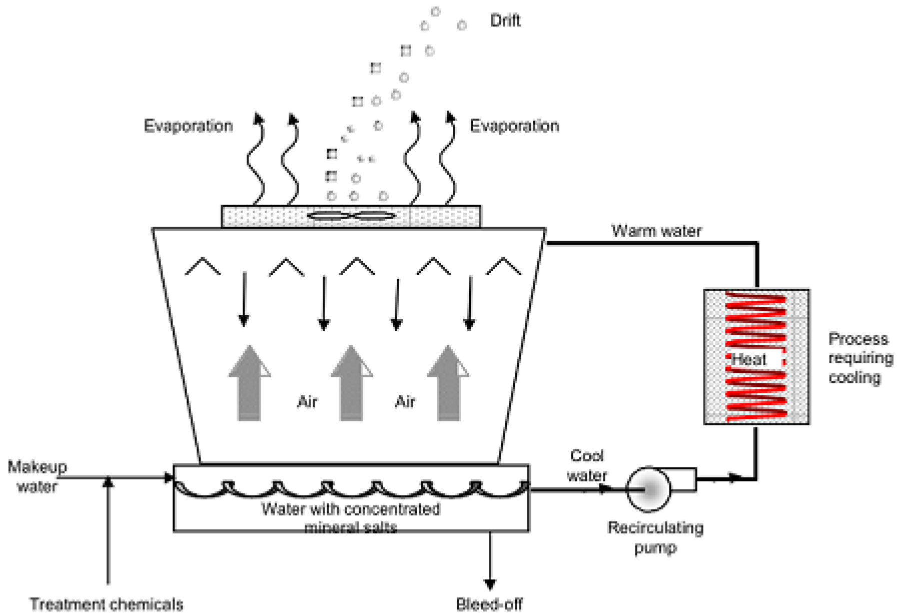

Fig.1 Schematic working of cooling tower

AIR RECOVERY WIND TURBINE GENERATOR

The fumes air vitality recuperation wind turbine generator is an on location clean vitality generator that uses the upsides of released air which is rugged, steady and unsurprising. Novel way to deal with concentrate the vitality from fumes fans utilizing vertical pivot wind turbine is illustrated. The way that there is a wealth of unnatural fumes air assets all around causes this to have extraordinary business sector potential i.e. cooling towers [4]. Not just it is able to do producing power always when fumes framework is in operation additionally decrease the power utilization by the fumes air framework [5]. It is a vitality recuperation framework and not planned to swap fossil fuel for vitality interest of a nation. Be that as it may, this framework empowers the low wind speed nations particularly in urban regions to saddle wind vitality from fumes air assets which are reliable and unsurprising. The power created from this framework can be utilized for business purposes or can be encouraged into the power network [6]. Since there is a characterized measure of released wind stream from cooling tower, VAWTs are mounted on top of the cooling tower to use the released air motor vitality which is higher and more reliable when contrasted with the common wind. The same idea is connected to the turbocharger in auto vehicle. In a typical car engine, the fumes gas from engine is a waste and scattered to the atmosphere. In an engine with turbocharger, the turbocharger utilizes the fumes stream from the exhaust stream to turn a turbine, which thus turns an air pump [7]. The power created is utilized to help the performance of engine. The same idea was utilized where the waste fumes air released from a cooling tower is utilized to turn a turbine for energy recuperation.

EXPERIMENTAL SETUP AND PROCEDURE

The exhaust air energy system is employed for the assembly of inexperienced energy from unnatural wind resources. It's a system within which energy is reuses for the electricity production. The system consists of rotary engine rotor assembly that is mounted on the exhaust air system by supports and a DC static magnet motor. The rotary engine is darreius sort vertical axis turbine (VAWT). Betting on the dimensions of exhaust air outlet over one rotary engine will be used. The air hits the blades of the rotary engine with a pre-set angle to start out its motion.

Any quite exhaust air system will be used from that the air is constant and better in speed. Cooling is AN example of exhaust air system. It's used as heat removal device that transfers heat from a method system through AN evaporation method whereby a number of the water is gaseous into the moving air stream drawn. For AN elicited draft cooling, the conventional discharged air rate is regarding nine m/s so as to sufficiently reject the warmth to the setting [8]. VAWT is mounted on the cooling to utilize its exhaust air because it is consistent than natural wind.

Modelled Experimental Setup

This setup model is similar to cross flow induced draft cooling tower. A prototype model of induced draft cooling tower was fabricated, with an outlet duct of exhaust fan of 2 blade axial flow fan. Setup specifications of prototype model of cooling tower is given in table -1. For the model, there are openings at two sides for the air inlet. The air is discharged through the cylindrical outlet duct with a diameter of 0.482 m. The fan mechanism is inside the box of the cooling tower model. The model wind turbine is a VAWT in which turbine blades profile is NACA 0018.

Fig.2 Three Dimensional Model and Fabricated Cooling Tower Model Setup

Table -1 Setup Specifications

Prototype Cooling Tower Specifications	**Prototype Turbine Specifications**
• Height: 0.88 m • Width: 0.762 m • Outlet duct diameter: 0.482 m • Fan diameter: 0.431 m • Fan motor power: 0.184 kW • Two Film type fills of length = 0.762m, width = 0.304 m, and height = 0.508 m • Tray for cooled water: 0.736 m x 0.736 m • Submersible pump: 1000 L/H • Perforated plates for dispersion of water overfills	• Material: fibre glass • Length: 0.4065m • Chord length: 0.0716m • NACA Airfoil: 0018

Bare Cooling Tower Measurements

The bare cooling system model performance is assessed by the air rate of flow and therefore the power consumption by the fan motor. The air rate of flow is earned by multiplication of the common air speed and space at the body of water of the model. The common body of water air speed is calculated by averaging measured air velocities from all sides of the model. These measurements are conducted employing a vane-type gauge. Power consumption by the fan motor is measured employing a digital Clamp meter. associate degree acceptable methodology for menstruation air speed of a circular vessel is by dividing {the space the world the realm} into various concentrically elements of equal area with velocities taken at quarterly of the circle [9].

To determine the points for measure the outlet duct space is split into four equal elements. Every of those elements named as Band Gap wherever these bands are numbered. These discharge velocities are premeditated onto a graph to work out the discharge air distribution profile. The performance of the clean cooling system model is that the benchmark for the complete experiment. The illustrations of the wind speed that is observed through experiment at above mention bands with variable heights are shown in Fig. 4.

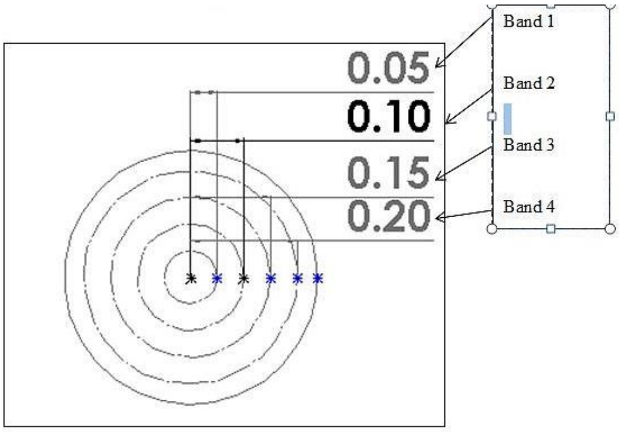

Fig.3 Measuring points for each band gap at outlet duct of cooling tower

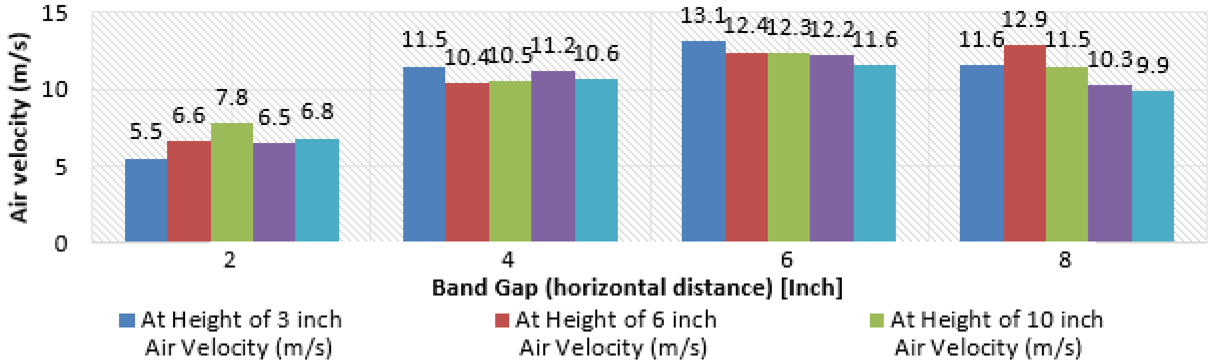

Fig. 4 Air velocity variation at specified bands

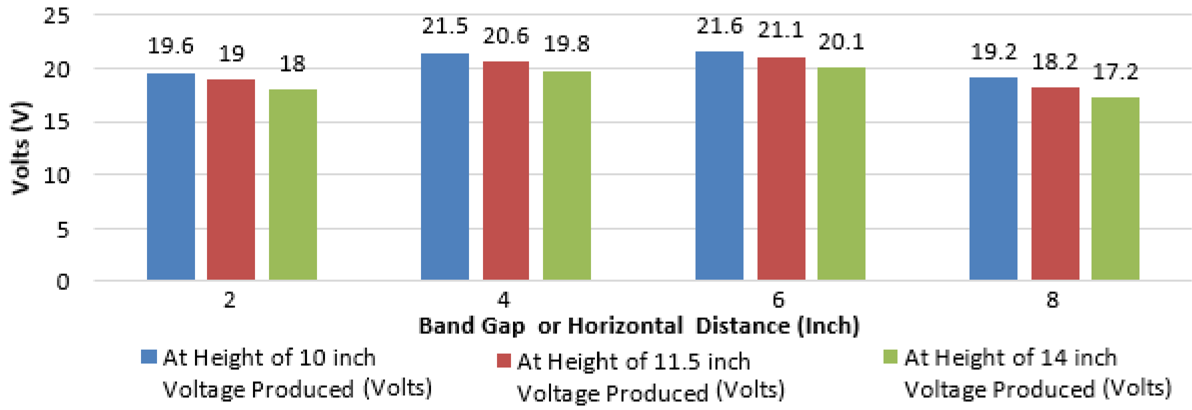

Fig.5 Turbine performance in terms of voltages [Voltage Produced by VAWT (Darrius Wind Turbine) when mounted over cooling tower exhaust at various positions]

Cooling Tower with Turbine

For the case of a cooling with rotary engine, a verify frame for the turbine and generator was made. To see the best turbine position at the outlet duct of the cooling, various positions were set and therefore the performance of turbine similarly because the cooling model air speed measurements with the assistance of vane kind gauge collected in the least positions. Taking the middle of the rotary engine as a reference, the rotary engine position was vertically varied from 0.076m to 0.355 m varies to the cooling discharge outlet. For horizontal position variation, the middle of the discharge passage (also the centre of the fan) was taken because the reference. The rotary engine was affected within the vary 0.050 m to 0.203 m with a distance of each position of 0.050 m illustrates the turbine position setting. Turbine performance in term of voltages at bound points is illustrated below:

Turbine Performance at Different Angle of Attack

By changing the angle between the cord line and the air stream the performance of the turbine is drastically change. Ultimately this affects the efficiency of the system.

The Performance of Cooling Tower Model

The performance of the cooling tower with and without the turbine at the cooling tower exhaust should be same or may be increase. The experimental results are the evidences of this fact.

Table -2 Voltages at Different Angles of Attack

Azimuth Angle (degrees)	Angle of Attack (degrees)	Volts (V)
20	7.25	23.5
40	14.35	8.4
60	21	7.2

Table -3 Cooling Tower Performance

Fan consumption	Current (A)	Voltages (V)	Power (watt)
Before installation of the turbine	0.8	230	184
After installation of the turbine	0.78	230	179.4

Overall Evaluation

Table -4 Overall Performances

Configuration		Cooling tower		Wind turbine	
Y (in)	X(in)	Intake flow rate(m/s)	Fan motor power consumption(Watt)	RPM	Voltages
10	2	2.3	179.4	590	19.6
	4			645	21.5
	6			650	21.6
	8			595	19.2
11.5	2	2.0	180	585	19.0
	4			620	20.6
	6			630	21.1
	8			560	18.2
14	2	1.9	182	550	18.0
	4			600	19.8
	6			615	20.1
	8			525	17.2

CONCLUSION

The experiment shows that the idea to harness the wind turbine with air that is being discharge from the cooling tower is possible. This idea is not only harness the wind turbine generator but also enhance the performance of the cooling tower as shown in table 3. Only key point is to locate the exact position, to install the wind turbine over the cooling tower exhaust. From experimental results, it is observed that as the rotation of the wind turbine increases the airflow rate also increase and it also reduce the power consumption of the cooling tower fan. This turbine generator system can be installed at any exhaust air system. For the safety concerns an enclosure can be setup to surround the wind turbine blades so that in case of turbine failure, turbine blades cannot be fly off. The discharged air from the exhaust has the quality and enough thrust of being able to generate steady and predictable energy. With the right wind turbine positioning and size matching, an optimum amount of energy recovery can be obtained. Based on the experimental results, when the turbine is running at a high rotational speed, the cooling tower model experiences an increasing in air flow rate or the air intake speed and a reduction in the power consumption of the fan. Thus, the waste exhaust energy recovery turbine generator is capable of improving the cooling tower performance. The overall turbine efficiency is 14.2 %. It means by installing two turbines side by side can utilize more waste energy and may increase the efficiency of cooling tower by reduction in consumption power of fan and increases the intake air flow rate.

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