PERFORMANCE INVESTIGATION, SIMULATION AND TESTING OF VERTICAL AXIS WIND TURBINE WITH OMNI-DIRECTIONAL DUCT FOR TALL BUILDING IN URBAN LOCATION

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ABSTRACT

In this paper an efficient design for enhancing the performance of the ducted wind turbine (DWT) mounted in the tall buildings is presented. The DWT generates differential pressures and also causes mass flow through a building integrated turbine. By the help of Catia V5 software a successful design was completed for building mounted duct wind turbine and also computational fluid dynamics (CFD) modelling of optimum design with an octahedral casing was chosen. A comparative study is done with the results of CFD analysis and actual wind turbine. By this innovative design cost of the tower is completely reduced and also omnidirectional intake helps in capturing wind with the seasonal direction. During the wind pressure the flow within augmented openings which subsequently accelerates, expands and releases into the environment. The process involves capture, acceleration and concentration of wind into the turbine. The increased kinetic energy will drive the permanent magnet generator.

Keywords: ducted wind turbine, tall buildings, permanent magnet rotor, Catia V5, computational fluid dynamics.

INTRODUCTION

As we know that wind is abundant source of energy, but the problem lies in harvesting it. By implementing venturi concept, the performance of wind turbine can be enhanced. It is claimed that, using a duct system, the incoming wind can be enhanced and thereby the power output also increased. In this research work introduces the various author concepts are [1] W.T. Chong and K.C. Pan, *et al*, introduces the concept of performance investigation of shrouded wind turbine has advantages over conventional wind turbine and implemented power-augmented-guide-vane (PAGV) has 5.8 times efficiency higher was analyzed by CFD. [2] Yuji Ohya and Takashi karasudani, developed a new wind turbine system consists of a shroud diffuser and the efficiency is 2-5 times better than the bare wind turbine and due to vortex formation behind the rim, draws more mass flow inside the wind turbine. [3] R. Noble introduces the vertical axis wind turbine of low tip speed ratio less than 5 and also investigated for the 2-D flow around VAWT blades by CFD is very strongly studied. [4] Francisco Toja- Silva and Antonio Colmenar- Santos, results shows that horizontal-axis wind turbines have better performance in flat-terrain applications, where as in buildings vertical-axis wind turbines generates more power. [5] W.T. Chong and K.C. Pan, *et al*, introduced Omni-directional-guide-vane (ODGV) integrates wind power generation system improves the power output of a VAWT and it has great potential to be sited in urban areas for on-site and grid-connected power generation. [6] Islam Abohela, Neveen Hamza and Steven Dudek, introduced the concept of CFD simulations for the purpose of identifying the effect of different roof shapes on the energy yield and positioning of roof mounted wind turbines covering different buildings. [7] A. Korobenko, M.C. Hsu, I. Akkerman and Bazileys, Introduced the concept of Full-scale, 3D, Time dependent aerodynamics modeling and simulation of a derrieus-type vertical-axis wind turbine (VAWT) using sequence of meshes with increased resolution to assess the computational requirements for this problems. [8-15] introduced the concept of VAWT for the tall buildings and also compared with the CFD modeling for the various types of duct in the wind turbine.

SYSTEM DESCRIPTION

As we know, the wind energy is an abundant source of renewable energy, but the problem lies in the harvesting. How efficiently the system can be designed is very important.

The Figure-1 shows the overall design of the duct system which is designed using CATIA. Following are the advantages of the use of venturi augmented duct system.

a) Increased velocity is obtained at the turbine.
b) In low velocity of wind, power output can be obtained because of the usage of venturi section.
c) Since it consists of omnidirectional intakes, change in direction of wind will not differ the performance of the wind turbine.

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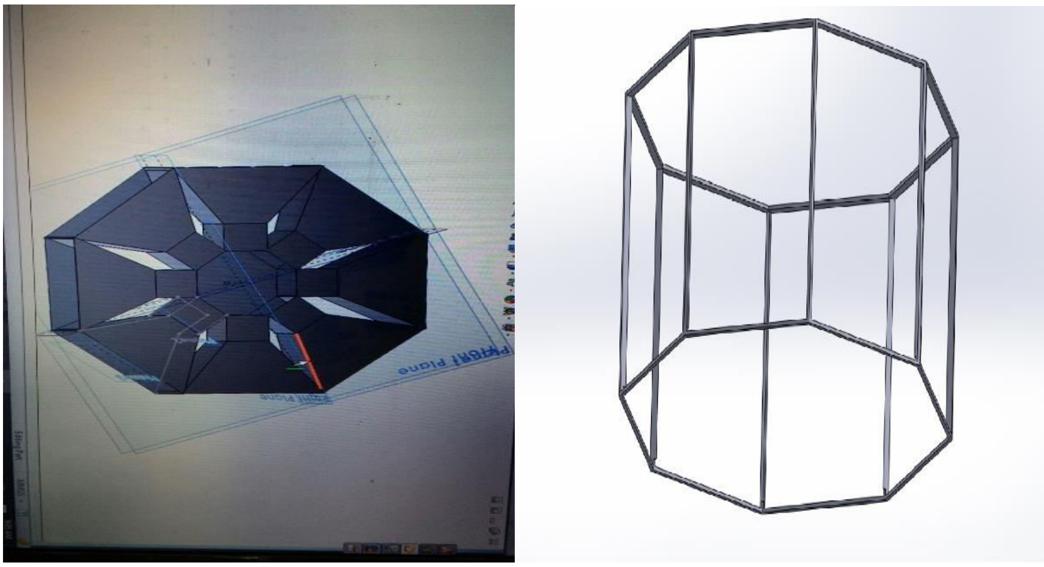

Figure-1. Design of the duct system by Catia V5 modeling software.

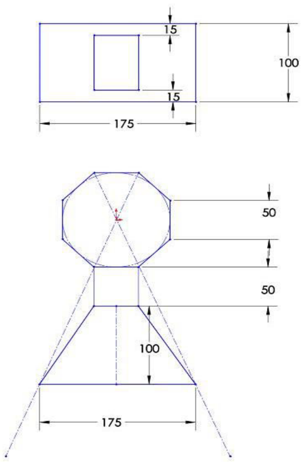

Figure-2. Dimensions of ducted wind turbine.

When we describe the working of the system, the wind is collected in the outer duct and passes to the turbine through venturi section. In the casing the vertical axis turbine is placed. In venturi, the velocity is increased and the pressure is decreased. This increased wind speed can be utilized for the power generation.

Figure-3. Ducted wind turbine.

POWER CALCULATION

The mathematical model to determine the power available in the wind turbine of swept area A is;

Pw = ½ ρAV3

where,

P_w = the power available in the wind beam of cross-sectional area A (Watts),

ρ = the density of wind (kg/m^3)

A = the swept area of Savonious rotor (m^2)

V = the speed of wind (m/s)

The limiting power co-efficient of any design of rotor, determined by Betz, is C_p(max) = 0.59.

According to this limit, no turbine can extract power from wind more than this value. The value of C_p varies from design to design. The real achieved value

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of C_p, even in the best designed wind turbines is well below the Betz limit. It is not more than 0.45. Hence, the power co-efficient needs to be incorporated in wind power equation to determine extractable power from the wind beam that hits the rotor, and is given by;

Pm = ½ ρAV3 C_p

Where,

Pm = the extractable mechanical power,

C_p = co-efficient of performance of the rotor and

ρAV3 = the power of upstream wind (Pw) that hits therotor.

Turbines are usually characterized by performance curves, which give C_p as a function of Tip Speed Ratio (λ).

λ = (ω×R)/V

Where,

ω = the angular velocity of Savonious rotor and

R = the radius of the Savonious rotor.

RESULT AND DISCUSSIONS

FLOW ANALYSIS

The flow analysis is based on Navier Stokes equation which formulates the principle of conservation of mass, momentum and energy in the form of partial differential equations.

The computational domain is divided into cell and discretization is carried out.

MESH INFORMATION

Table-1. Mesh information.

Domain	Nodes	Elements
Default Domain	960	686

COMPUTATIONAL CONDITIONS

Table-2. Computational conditions and parameters.

Domain - Default Domain	
Type	Fluid
Location	B24
Materials	
Air at 25 C	
Fluid Definition	Material Library
Morphology	Continuous Fluid
Settings	
Buoyancy Model	Non Buoyant
Domain Motion	Stationary
Reference Pressure	1.0000e+00 [atm]
Heat Transfer Model	Isothermal
Fluid Temperature	2.5000e+01 [C]
Turbulence Model	k epsilon
Turbulent Wall Functions	Scalable

COMPUTATIONAL PARAMETERS

The domain is divided in cells. The input velocity of wind id given as 3m/s and obtained as output velocity of 9 m/s. That means the 3 fold of input velocity is obtained as output. It is observed that the venturi principle is satisfied. At inlet section the pressure is at maximum level and velocity is minimum. At outlet section velocity is maximum and pressure is minimum. The enhanced velocity of wind in the venturi section can be utilized for power generation.

VELOCITY STREAMLINE

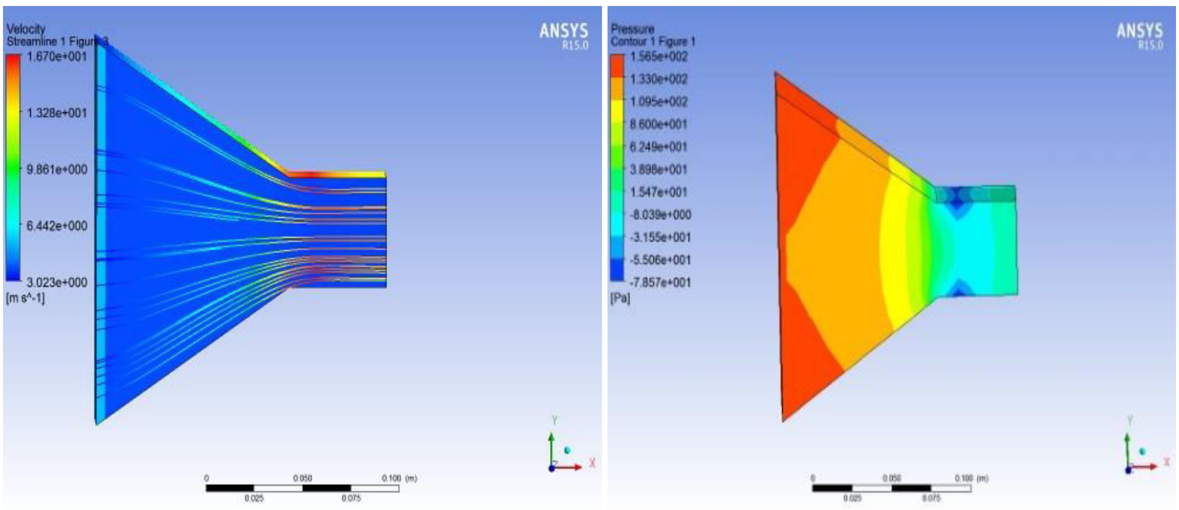

Figure-4. Velocity streamline by CFD analysis.

Table-3. Boundary conditions.

Domain	Boundaries	
	Location	inlet
	Settings	
	Flow Regime	Subsonic
	Mass And Momentum	Normal Speed
	Normal Speed	3.0000e+00 [m s^-1]

CONCLUSIONS

In this new technology of green and renewable energy harvesting called ducted wind turbine (DWT) with Omni directional has introduced. The duct was designed and improved the wind rotor performance. These types of techniques recommended for urban area tall building application without carrying any negative visual impact and public concern. From the experimental comparative study by using the digital anemometer we measured wind at average of 9m/s, the limiting power coefficient of any design of rotor determined by betz, by computational parameters the impact velocity of wind id is given as 3m/s and obtained output velocity of 9m/s. so, from the CFD, flow visualization in the DWT for Omni directional higher mass flow rate is transported, contributes then higher power and torque also more power with this DWT for Omni directional energy system, the tall buildings in future cities will have the capability of applying supplementary power for their own usage. This design eliminates the safety concern, structural design problem and visual effect with less noise. This DWT could be the future improvement for urban area tall building design.

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