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OPTIMISATION OF WIND TURBINE WITH DIFFUSER USING CFD TOOL

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ABSTRACT

A wind turbine or wind power plant is a device that converts kinetic energy from the wind into electric current. Mechanical energy is simply created when the wind turbine blades spin and a generator is turned, thus producing electricity. Diffuser can increase turbine power output primarily by increasing mass flow rate through the blades because of controlled diffusion of the turbine wake which which lowers the exit plane pressure considerably below atmospheric, and secondarily by reducing blade tip losses. The principle object of this project is to fully assess comparison of angular velocity and moment with the effect of the shape parameter on the diffuser performances. This behaviour is partly observed when turbine is mounted within the diffuser.

KEYWORDS: wind energy, DAWT, Diffuser, air velocity.

INTRODUCTION

Wind energy is now the world's fastest growing energy source. A wind turbine or wind power plant is a device that converts kinetic energy from the wind into current. Mechanical energy is simply created when the wind turbine blades spin and a generator is turned, thus producing electricity. The wind turbines that generate electricity today are new and innovative.

Developments in the field of aerodynamics, mechanical/electrical engineering, control technology, and electronics provide the technical basis for wind turbines commonly used today.

Power is available from the kinetic energy of the mass of air moving in wind. The amount of energy that wind carries increases by a factor of two as its speed increases and is proportional to the mass of air that passes through the plane of the area swept by the rotors. As power is the product of energy (work) within a given time frame, the power of wind increases by a factor of three as the speed of wind increases. Because of the low density of air (Pair=1.25 kg/ m3), the power density of wind is much lower than that of water power (Pwater=1000 kg /m3), for instance.

The simple momentum theory dealt that a maximum of only 59.3 percent of the natural wind energy contained in the swept area of wind turbines blades can be converted to shaft power. In reality due to the aerodynamic inefficiencies, the practical convertible fraction for conventional wind turbines is between 30 to 40 percent.

The Advanced and innovative Concept Project of wind Energy program is dedicated to improve the attractiveness of wind energy conversion system (WECS) as an energy alternative by reducing the specific cost of available wind power by minimizing the capital cost the energy conversion machinery .The Diffuser Augmented Wind Turbine(DAWT) is one of these advanced concepts currently under redevelopment.

Our departure from tradition was to recognize that economic factors necessitate development of very short and compact diffusers. Thus sacrifice of technical perfection is justified if the energy conversion system can produces low cost power.

The enclosure of a wind turbine by a diffuser produces increased power output by two independent processes: 1) An increase in flow velocity and moment (or mass) through the turbine blades by virtue of controlled diffusion of the turbine wake, and
2) A reduction in turbine blade tip losses. Because of the potentially large gain possible from the first process, our primary concern is in this direction; tip loss reduction is an inherent secondary benefit.

LITERATURE REVIEW
In this we came to know that the energy generated by a wind turbine is mainly proportional to its swept area and to the third power of the wind velocity and moment approaching its rotor. Therefore, expanding the swept area and/or increasing the wind velocity and moment can significantly increase the output power. Flanged diffuser is the most used tool for increasing wind power produced by small wind turbines. The open angle is one of the main geometric parameter of the diffuser. The principal object of this paper is to fully assess the effect of this parameter on the diffuser performances. Results obtained from numerical simulations and experiments show that the ratio between the free stream velocity and the wind velocity recorded in the inlet section of an empty diffuser ($u/U\infty$) increases linearly with the open angle reaches a maximum for an angle of about 10° (numerical simulation) and 7° (experiment measurements) and then decreases. This behavior is partly observed when a wind turbine is mounted within the diffuser. In this case, when the open angle exceeds the values of 12°, the ratio ($u/U\infty$) decreases slightly before becoming constant and therefore without significant effect on increasing wind velocity and moment.

Research has been undertaken by Vortec Energy on the development of an efficient Diffusor Augmented Wind Turbine (DAWT). An extensive programme of both computational and experimental work has been undertaken to characterise the DAWT performance. As part of this work, the integration of a matched rotor within the diffusor has been investigated. The comparison of three types of blades, a truncated conventional wind turbine blade, a genuine turbo-machinery type blade and an empirically designed DAWT blade, was performed. Wind tunnel and controlled field tests showed that the ordinary blade-element/momentum theory, in which the usual thrust induction factor relationship was replaced by one empirically derived from DAWT wind tunnel tests, provides the best results to date

As energy consumption and energy cost approach record-breaking levels, it is becoming necessary to fully understand how to improve wind turbine efficiency. The depletion of these resources will require a sustainable and environmentally friendly energy source. Improvements to wind turbine efficiency and design will allow the limits of today to be surpassed, and someday enable us to extract all of the energy from the wind with only a few improvements in technology.

One proposed method of improving turbine efficiency is a Diffuser Augmented Wind Turbine (DAWT) as an improvement to the conventional Horizontal Axis Wind Turbine (HAWT). DAWTs are simply a HAWT with a trumpet-bell-shaped diffuser surrounding the rotor blades and extending aft. A DAWT is claimed to have a greater efficiency than conventional HAWTs, even possibly higher than the Betz limit of 59.3%. The Betz limit is the theoretical limit of efficiency in extracting energy from the wind. The efficiency increase is caused by the diffuser allowing for a greater pressure drop across the rotor blade.9 This increase in pressure drop as compared to a bare-wind turbine can be seen from the conservation of mass principle. DAWTs offer additional advantages in addition to increased augmentation, including minimizing tip losses, and being less yaw sensitive than HAWTs. However, there are many issues with DAWTs that need to be addressed to fully understand them before their greatest power output can be achieved.

PROBLEM IDENTIFICATION
Massive tower construction is required to support the heavy blades, gearbox, and generator. Components of a horizontal axis wind turbine (gearbox, rotor shaft and brake assembly) being lifted into position. Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes creating local opposition. Downwind variants suffer from fatigue and structural failure caused by turbulence when a blade passes through the tower's wind shadow (for this reason, the majority of HAWTs use an upwind design, with the rotor facing the wind in front of the tower).HAWTs require an additional yaw control mechanism to turn the blades toward the wind. HAWTs generally require a braking or yawing device in high winds to stop the turbine from spinning and destroying or damaging itself.

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PROPOSED METHODOLOGY

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TURBULENCE MODEL

Turbulence modeling is a key function for most of the CFD simulations. Virtually all engineering applications are turbulent and hence require a turbulence model because we cannot afford big enough computers to directly capture every scale of motion. Also, users of CFD typically want a steady-state solution (with all the unsteady fluctuations averaged out) rather than a detailed time-accurate one that captures every little vortex. As a result, there are unsteady (turbulent) motions affecting the flow that cannot be resolved directly; they must therefore be modelled.

In some cases, the turbulence model you use can have a huge effect on the results you obtain from CFD. This kind of disparity is largely due to the fact that no model is right all the time; they all have their limitations. Because of this, there are dozens (if not hundreds) of variations available, and more are being developed all the time.

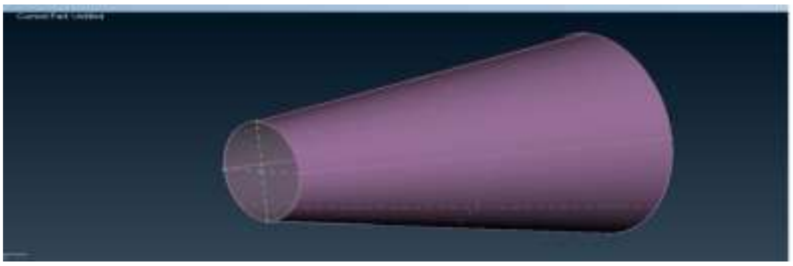
RANS-BASED TURBULENCE MODELS

The objective of the turbulence models for the RANS equations is to compute the stresses, and also these are the models that will be used for most production applications. Reynolds Averaging The rationale for Reynolds averaging is that we are not interested in the part of flow solution that can be described as "turbulent fluctuations": instead, it is the mean velocity, moment, pressure, lift, drag) that is of interest. Looking at turbulent flow, it may be steady in the mean in spite of turbulent fluctuations. If this is so, and we manage to derive the equations for the mean properties directly, we may reduce the cost by orders of magnitude: It is no longer necessary to perform transient simulation and assemble the averages: we are solving for average properties directly spatial resolution requirement is no longer governed by the Kolmogorov microscale.

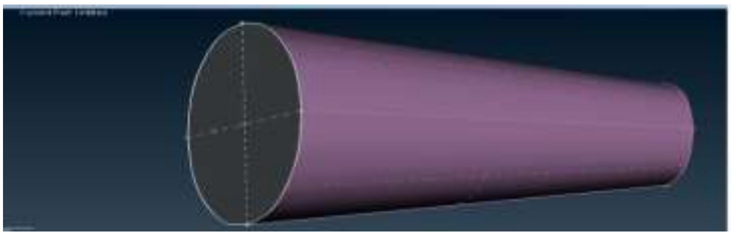
PART MODELLING IN ANSYS

Aero foil diffuser with clearance produces power two times more than power produced by rare wind turbine.

Figure:
V.1 DIVERGING DUCT



V.2 CONVERGENT DUCT



Diffuser length=30m

Convergent diameter =34m

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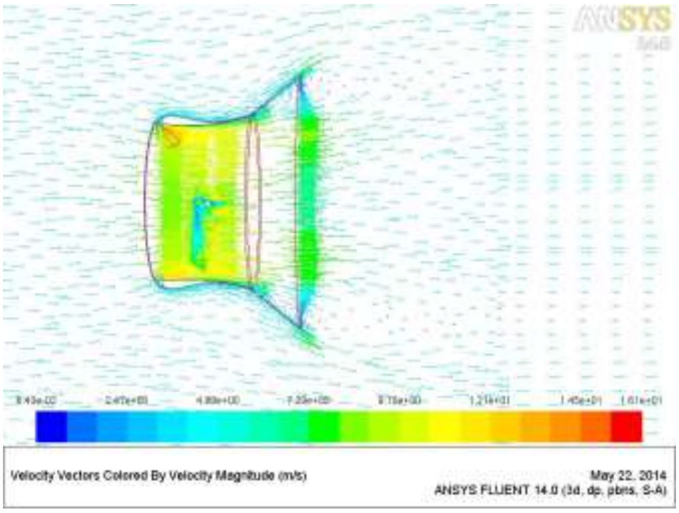
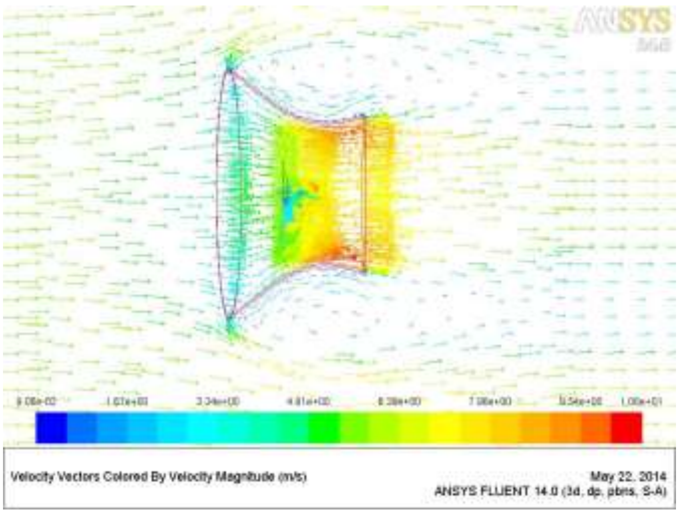
Divergent diameter=54m

BOUNDARY CONDITIONS:

Inlet velocity : 6 m/s

Rotation rpm in mrf region : 10 rpm





CONCLUSION & RESULT

The turbines are placed in a position and are rotated at 10rpm and wind velocity of 6 m/s and the power output is obtained for different types of diffuser augmented wind turbines The five types of the duct are analyzed and their mass flow rates are compared using the computational fluid dynamics technology and the results are as shown in the table 6.1 These various types of the ducts are analyzed and the maximum mass flow rate is obtained in diverging model with clearance. The different types of diffuser augmented wind turbines were tested at a wind velocity of 6m/s and rotation of 10 rpm in a domain using computational fluid dynamics. The results obtained were compared for all diffuser augmented wind turbines with various parameters like moment, angular velocity, torque and mass flow rate. The aero foil diffuser with clearance gives the maximum power output of 15889.43789 watts and an increasing mass flow rate of 11246.404 kg/s. The aero foil diffuser with clearance produces power two times more than power produced by rare wind turbine

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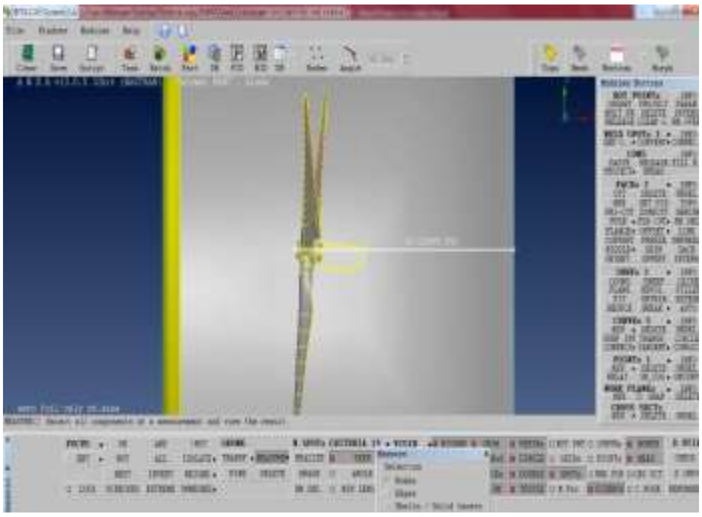
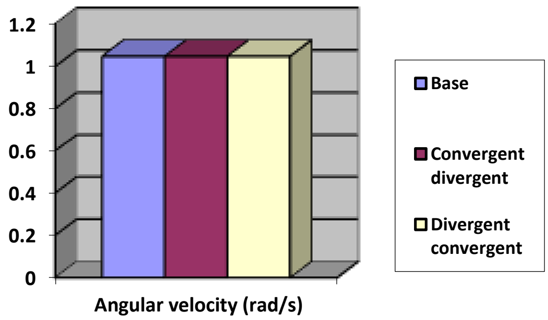
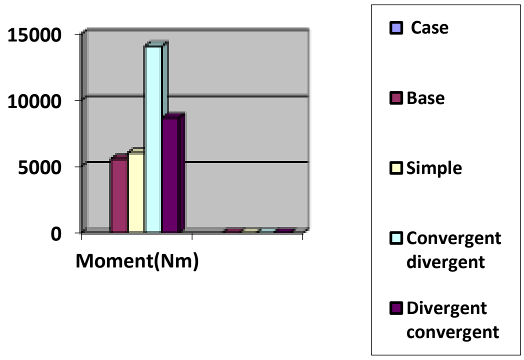
Table 6.1 Comparison of result

	Moment(Nm)	**Angular velocity (rad/s)**
Base	5562.9537	1.047198
Convergent divergent	14078.385	1.047198
Divergent convergent	8708.1018	1.047198







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