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A Report on Design and CFD analysis of McCauley Vertical axis wind turbine

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Abstract-Urban wind turbines face an up-hill battle, as many people feel they are too big, too expensive, and potential eyesores. However McCamley just unveiled a prototype for a new vertical-axis turbine with a revolutionary design that allows it to overcome many of the issues associated with large horizontal-axis turbines.

McCamley's vertical-axis turbine can cope with stronger, more turbulent gusts that are often found in urban environments.

This project consists of design of McCamley Vertical axis windmill in Pro-e software and its CFD analysis in CFX and finds the optimum angle of contact that gives maximum velocity and pressure contour.

Keywords:- Wind Mill, vertical axis turbine, McCamley

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I.INTRODUCTION

The McCamley wind turbine is designed to be mounted on buildings in built-up areas to help facilitate a growth in Urban Renewable Power (URP). It can also be mounted on a pole and be positioned in open or remote areas to provide power to locations with no grid connection.

This McCamley Windmill has the unique feature that it can start at very low wind velocity at 1.8 m/s because of its stator, while other windmill starts at 3-4 m/s wind velocity.

II.LITERATURE REVIEW

Past windmill had to be manually directed into the wind, while modern windmills can be automatically turned into the wind.

There have been many improvements to the windmill over the years. Windmills have been equipped with air breaks, to control speed in strong winds. Wind turbine generators have been equipped with gearboxes to control [shaft] speeds.

As the 21st century began, fossil fuel was still relatively cheap, but rising concerns over energy security, global warming, and eventual fossil fuel depletion led to an expansion of interest in all available forms of renewable energy. The fledgling commercial wind power industry began expanding at a robust growth rate of about 25% per year, driven by the ready availability of large wind resources, and falling costs due to improved technology and wind farm management.

III. DESIGN OF McCAMLEY VAWT

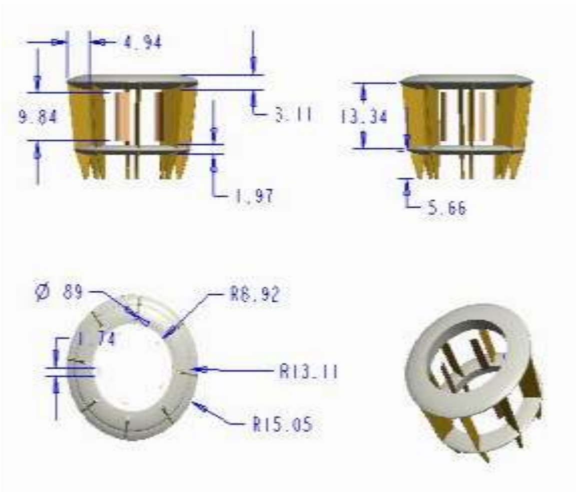
Prototype testing continues with the MT01 flying on top of a tower block in Lyaskovets, Bulgaria and at Keele University in the UK. Data collected from turbine is being used by engineering team as part of ongoing test program.

The CAD model is designed in Pro-e wildfire 4.0

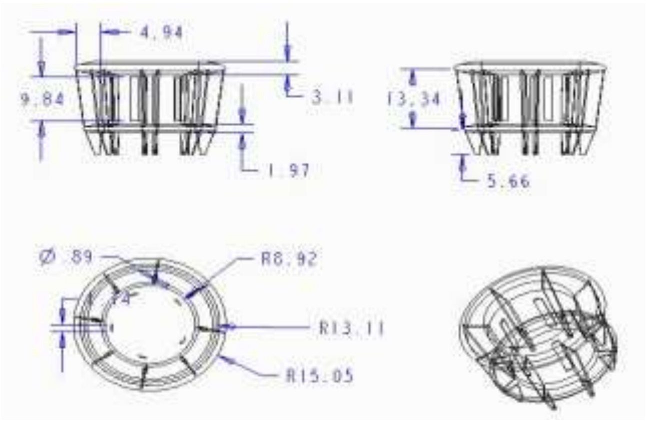
There are three basic Pro/ENGINEER design steps from conception to completion:

1) Part Design
2) Assembly Creation
3) Drawing creation

Each design step is treated as a separate Pro/ENGINEER mode, with its own characteristics, file extensions, and relations with the other modes.



Design of VAWT
Figure No 1



Wireframe Design
Figure No 2

IV. CFD REPORT

1. Mesh Report

Table 1. Mesh Information for CFX Domain
Nodes Elements Default Domain 44745 183449

2. Physics Report

Table 2 . Domain Physics for CFX

Domain Type Location Default Domain Fluid B378

Materials – AIR

Fluid Definition Material Library

Morphology Continuous Fluid

Table 3 . Boundary Physics for CFX Domain Default Domain

Boundaries **Setting:**

Boundary – inlet Flow Regime - Subsonic

Type – INLET Mass and Momentum

Location – inlet

Normal Speed - 7.0000e+00 [m s^-1]

Boundary – outlet Flow Regime Subsonic

Type – OUTLET Pressure Mass and Momentum - Average Static

Location – outlet Relative Pressure - 1.0000e+00 [Pa]

Boundary – Wall Mass and Momentum - No Slip Wall

Type – Stator Wall Roughness - Smooth Wall

Location - wall

Boundary – wall

Mass and Momentum – Free Slip Wall

V. CFD ANALYSIS

The program ANSYS ICEM CFD allows you to view and edit geometry, blocking and mesh files. The mesh file is the output which will be used in later CFD simulations.

Steps in CFD

1. **Import CAD model**
2. **Create a meshing to solve CFD analysis**
3. **CFX Preprocessor**
4. **Mention heat transfer and type of turbulence**
5. **Define Boundary Conditions for default domains**

1 Inlet

2 Outlet

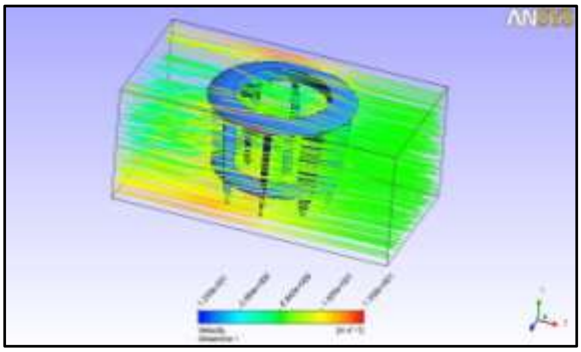
3 Wall Boundary

6. **After Pre processor switch to Solver**

We have tilted the Stator blades at three different angles and analyzed them with the help of CFX CFD.

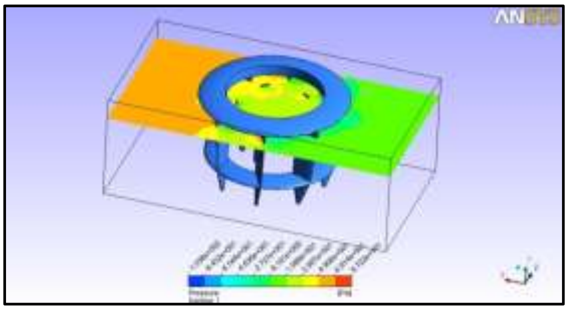
Analysis of Stator blade at an angle 10 degree.

Velocity Streamline.



Velocity Streamline

Figure No 3



Pressure Contour

Figure No 4

Similarly we have taken another two angles 30 degree and 50 degree for the analysis.

VI. WORKING

The McCamley turbine is low speed, high torque machine that is designed to be very low in both noise and vibration, to self-start in low wind speeds without taking energy from the grid and to continue generating electricity in Omni directional gusting storm winds and turbulent winds around the rooftops of tall buildings. The turbine comprises:

- A rotor and stator of revolutionary design
- An axial flux generator - advanced electronic inverters with high efficiency across the entire range of power outputs
- Control algorithms which maximize the power extracted from the available wind.

The stator's primary function is an aerodynamic augmentation device as well as providing protection from the rotating blades. Braking of an operating Turbine to cause it to stop is done electrically and regulation of the speed in high wind conditions is done by the passive governing of the blade pitch.

VII. MATERIAL USED

The main structural items of the McCamley Turbine series of roof mounted turbines make significant use of composite materials. This has been done to ensure that they can be engineered as lightweight structures with sufficient strength and stiffness and also be aerodynamically smooth. The lightweight approach is aimed at minimizing turbine structural mass to facilitate a reduction in:

- Structural reinforcement of existing building stock
- Installation equipment lifting capability required
- Man handling loads
- Shipping costs

The primary composite used is Glass Reinforced Plastic (GRP). Structural beams (all blades) use a sandwich construction where the core material is foam. Due to the nature of this foam, the GRP resin system used for the beam itself is a two part epoxy. For large panel surfaces that do not need to be a structural beam, the resin system is changed to cheaper polyester. The stable multi-leg design helps distribute wind loading and ensures a high degree of structural redundancy.

VIII. FEATURES

- Self-starting - no input from the grid is required to start the turbine
- Self-starts at wind speeds as low as 1.8 m/s
- No shut down speed can continue to operate in storm force winds
- Is able to operate in wind from any direction
- Airspeed within stator greater than wind speed outside
- Minimal noise and vibration
- Light weight design can help reduce building structural requirements
- Multi-leg design gives better load distribution into the building and
- Can be branded with corporate colors and logo without any effect on turbine
- Energy produced can be used immediately or stored

IX.REQUIREMENTSFOR PLACING

- Site Selection considerations
- High annual average wind speed
- Availability of wind $V_{(t)}$ curve at the proposed site
- Wind structures at the proposed site
- Distance to Roads or Railways

X. POTENTIAL SITES FOR TURBINE

1. Office Blocks
2. Apartment Blocks
3. Airports
4. Schools
5. Hospitals & Medical Centers etc.

XI. RESULT

CFD RESULTS				
STATOR ANGLE	VELOCITY(m/s)		PRESSURE (N/m^2)	
	Max.	Min.	Max.	Min.
10°	6.7	2	32.10	1.763
30°	6.3	3.4	27.27	7.70
50°	5.70	4.03	20.3	15

Table No 1

XII. CONCLUSION

Our work and the results obtained so far are very encouraging and reinforce the conviction that McCamley vertical axis wind energy conversion systems are practical and potentially very contributive to the production of clean renewable electricity from the wind even under less than ideal sitting conditions. It is hoped that they may be constructed used high-strength, low- weight materials for deployment in more developed nations and settings or with very low tech local materials and local skills in less developed country.

XIII. REFERENCES

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[2] Broucher+-+McCamley+Middle+East (pdf)