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A REVIEW ON THE PERFORMANCE OF HELICAL DARRIEUS VERTICAL AXIS WIND TURBINE

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Abstract — This paper presents a review on the performance of Helical Darrieus Vertical Axis Wind Turbine (VAWT). It is known that torque delivered by vertical-axis wind turbines with either straight or conventional blades to their shaft fluctuates throughout 360° azimuthal angle. In contrast, a rotor with helically twisted blades delivers a relatively steady torque to the shaft. Over the years, numerous adaptations for this device were proposed in order to improve the self starting ability of turbine in urban area. Low noise level, rugged design, minimum maintenance, good performance in complex winds, safe operation in the urban environment and esthetic appearance are some advantages of using this type of machine. The aim of present article is to gather relevant information about Helical Darrieus VAWT, bringing a discussion about their performance. It is intended to provide useful knowledge for future studies.

Keywords: Helical Darrieus, VAWT, Aerodynamic, Review

I. INTRODUCTION

In recent decades, the global concern with the consequences of indiscriminate exploitation of non-renewable energy resources has increased. Pollution, global warming and reduction of political and economic viability in the use of non-renewable energy resources are some consequences of this exploitation. The use of renewable energy and decentralized power generation are alternatives to reduce the exploitation of conventional energy resources and its impacts, contributing to a sustainable development of societies.

II. HELICAL DARRIEUS VAWT

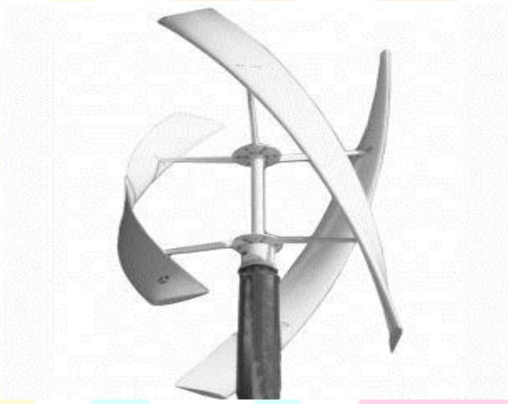

Figure 1 Helical Darrieus rotor

Helical Darrieus VAWT is vertical axis lift type wind turbine which is majorly suitable for electricity generation at domestic level. The vertical axis wind turbine has a number of blades in the shape of a helix as shown in figure 1. The blades are vertical and run from the top of the turbine to the bottom held in place by spider supports, the flat section in the middle of the blades catching the wind and causing them to rotate. Because of the helix shape, the blades can take up the wind from any direction; this is a big advantage as yaw or pitch mechanism is not required also saving weight, energy, and reducing noise levels. It also has the advantage of being accessible for maintenance. [1-5]
Since 1988, many inventors protect their ideas similar to Helical Darrieus VAWT, but in 1997 Gorlov has patented very first Helical Darrieus hydro turbine from which modern design of Helical Darrieus VAWT has been adapted. Gorlov (1997) [1], protected his idea by US patent 5 642 984. In this patent Gorlov invented helical turbine assembly which is capable of providing high speed unidirectional rotation under a fluid flow. The helical turbine also has been provided with multiple concentric layers of helical blades which do not overlap each other. Due to this torque and power output are increases.
The Helical Darrieus VAWT has following advantages:

- Low noise level;
- Rugged design;
- Minimum maintenance;
- Good performance in complex winds;
- Safe operation in the urban environment;
- Esthetic appearance. [3].

III. THE PERFORMANCE OF HELICAL DARRIEUS VAWT

Prior art pertaining to aerodynamic design/study of Helical Darrieus VAWT is reviewed in subsequent topic. The aerodynamic performance and wake dynamics of vertical-axis wind turbines having straight blades, curved blades and helically twisted blades have been investigated by Scheurich et. al. [2] using the Computational Vorticity Transport Model (VTM) as shown in figure 2.

Both straight-bladed and curved-bladed vertical-axis wind turbines suffer from azimuthal variation in the loading on their blades. This variation in loading tends to oscillations in the torque and power that is output from the turbine and it produce vibration that is transmitted to the tower and the foundations of the system. In addition, the oscillations in the loading on the blades can lead to increased fatigue of the rotor structure and reduce the design life of the turbine.

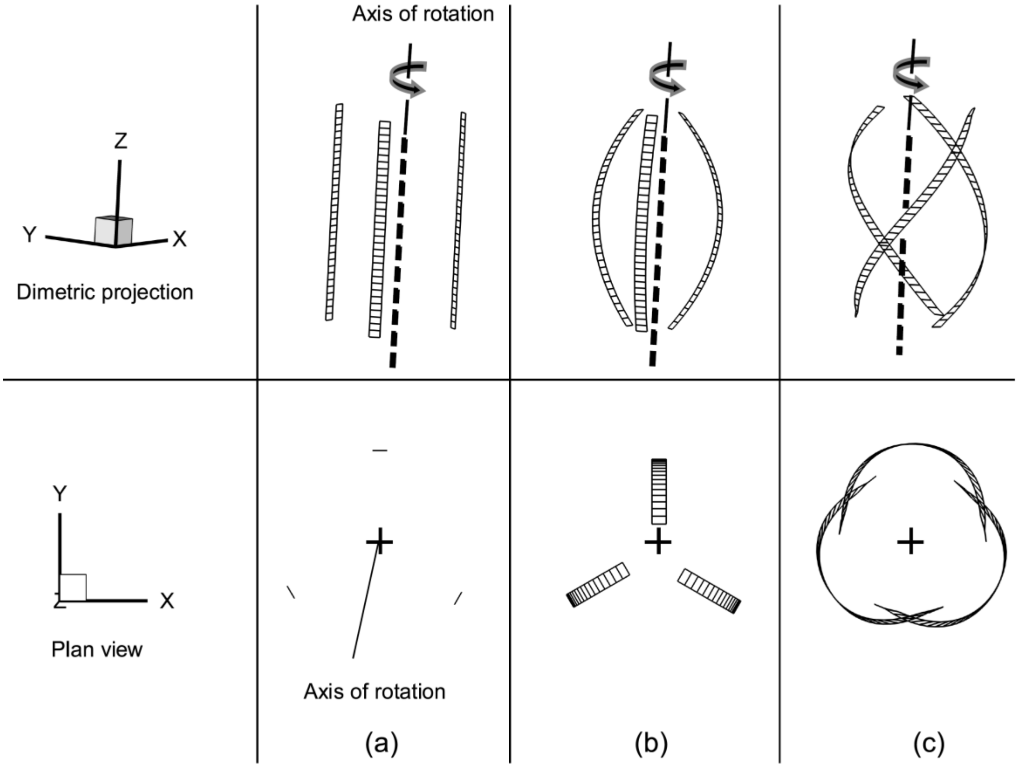

Figure 2 Geometry of the vertical-axis wind turbines with (a) Straight blade (b) twisted blade (c) helically twisted blade, [2]

The introduction of helical blade twist can reduce significantly the oscillations in power output from the turbine. This is demonstrated in figure 3, where the variation of the unsteady component of the power coefficient (ΔC_p), for one turbine revolution is presented for the three different turbine configurations. It should be noted that at the tip speed ratio of five at which the simulations were conducted, the mean power coefficients for the turbines with straight, curved and helically twisted blades were 0.094, 0.235 and 0.386, respectively.

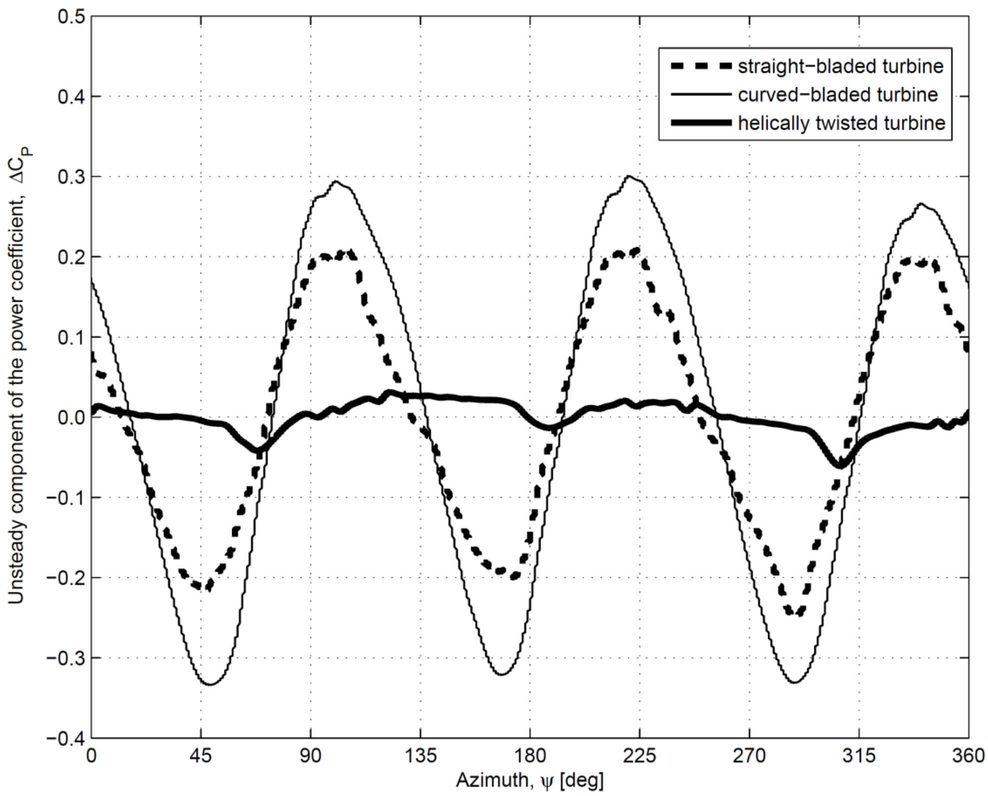

Figure 3 Variation of power coefficient with azimuth by VTM [2]

Van Bussel et. al. [3], developed the concept of a small VAWT for use in the built environment was, through a series of wind tunnel experiments, developed with success into a prototype. With this wind tunnel model a number of power curves were generated. They are presented in figure 4.

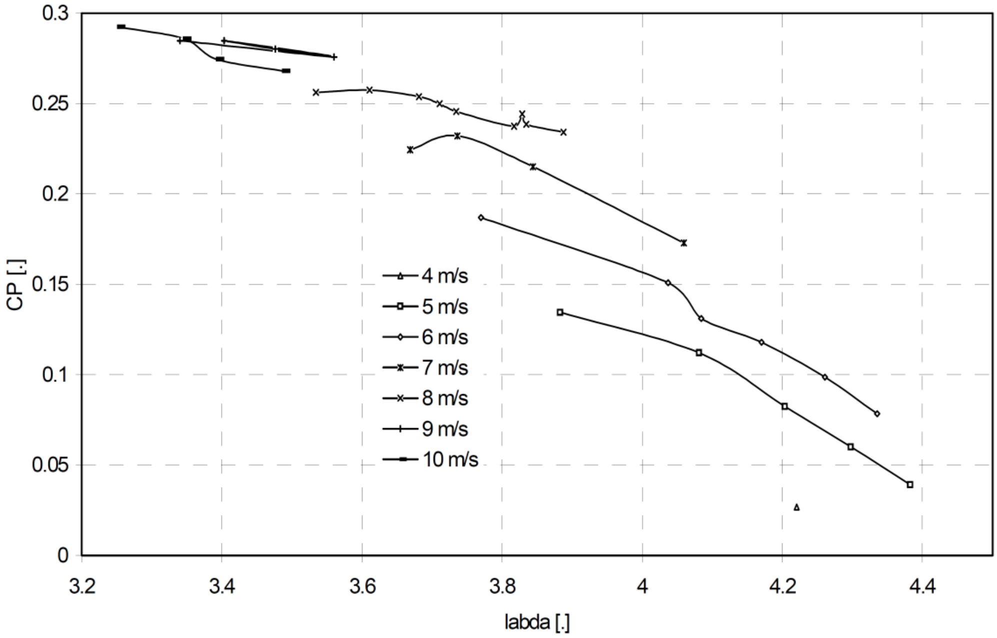

Figure 4 Measured gross performance of wind tunnel model in the open jet wind tunnel of TU Delft [3]

In this case the non-dimensional net power (measured shaft torque times rotational speed) is plotted as a function of tip speed ratio. It can be concluded from these graphs that there is a clear influence of the Reynolds number on the performance. For the higher wind speeds the power coefficient reaches a maximum value close to 0.3 at a tip speed ratio 3.2. Compared to other wind turbines of similar size, the Turby shows good aerodynamic performance. A novel feature was identified, with regard to skewed flow conditions, as are often experienced for roof top locations. Wind tunnel experiments also showed that a significant power increase was experienced at skew angles of 25 to 30 degrees, with a maximum of power coefficient of 0.175 at a tip speed ratio $\lambda = 3.25$

Kirke [4], summarizes the findings of a series of tests on several Darrieus type cross flow hydrokinetic turbines (HKTs). Tests were conducted in Australia and Canada on HKTs with fixed and variable pitch straight blades by mounting each turbine in front of a barge and motoring through still water at speed ranging from less than 1 m/s up to 5 m/s. The test were conducted on the Nerang river in Queensland, Australia on an HKT with 4 straight, passive variable pitch blade of 0.07m chord length and cambered FX 63-137 section, with and without a diffuser. The turbine was 1.2 m high and 1.2 m in diameter. Tests were then conducted at Campbell river, BC, Canada on HKTs with and without diffusers, with and without end plates. All turbines in the Canadian tests were of fixed pitch, 1 m diameter and 1.25 m high, with 3 blades of NACA0020 section and 140 mm chord. All had helical blades except for one with straight blades. According to these tests the helical blades made little difference to efficiency and starting torque but the turbine run smoothly, unlike that with fixed pitch straight blades. Bedon et. al. [5], were done experimental investigation on a VAWT with twisted blades for a Darrieus VAWT in an open field facility located in Longarone, BL (Italy). The tests were conducted in the Sandia test site and at fixed rotational speeds. Due to the low altitude over the ground of the tested rotor, a strong wind shear has been established, heavily affecting the overall aerodynamic performance.

IV. CONCLUSION AND DISCUSSION

Since 1997, various Helical Darrieus rotor design trends have been patented in order to improve the aerodynamic efficiency, self-starting ability and to reduce acoustic emission. Various research papers shows that Helical Darrieus VAWT reduces azimuthal variation significantly in power output from the turbine. It also shows good aerodynamic performance with regard to skewed flow conditions. These properties make Helical Darrieus VAWT as one of the most suitable wind turbine for urban area in roof top application

V. ACKNOWLEDGMENT

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