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AN OVERVIEW OF HORIZONTAL AND VERTICAL AXIS MAGNUS WIND TURBINES

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Abstract-

The product of a Japanese start-up called Challenergy, technology called the Magnus Vertical Axis Wind Turbine (VAWT) could make use of those damaging winds. Instead of the traditional propellers found on regular wind turbines, Magnus VAWT has a rotating cylinders that power a vertical-axis generator. It relies on the 'Magnus effect', a phenomenon that explains why air curves when passing by a spinning object. A Magnus VAWT turbine consequently has three vertical cylinders that rotate around a vertical axis to generate power. It's already been tested in Nanjo City in Okinawa, Japan, where it withstood wind speeds of 225kph/140mph.Although they're don't appear to be as efficient as regular wind turbines, if Magnus VAWT turbines can capture even some of the kinetic energy from a typhoon, that won't matter.

Keywords— Horizontal axis wind turbine,Vertical axis wind turbine,Magnus effect,rotating cylinders.

INTRODUCTION

It has been found that conventional HAWT and VAWT has many limitations during its operation. Regular wind turbines have propellers. They work fine in most scenarios, but during typhoons they can be dangerous and the propellers can break. Consequently, they're often switched off when a typhoon is approaching. It's one of the reasons why wind power hasn't caught on in Japan, though the mountainous terrain is also a factor.While global wind power capacity is now more important than the nuclear power industry, Japan has very few wind turbines and the Japanese government is aiming for it to account for a mere 1.7% of electricity production by 2030.
These limitations of both the turbines during very high wind speed forced the researchers and scientist to find some solutions for smooth operation of wind turbines in any conditions.The magnus effect is the result of the

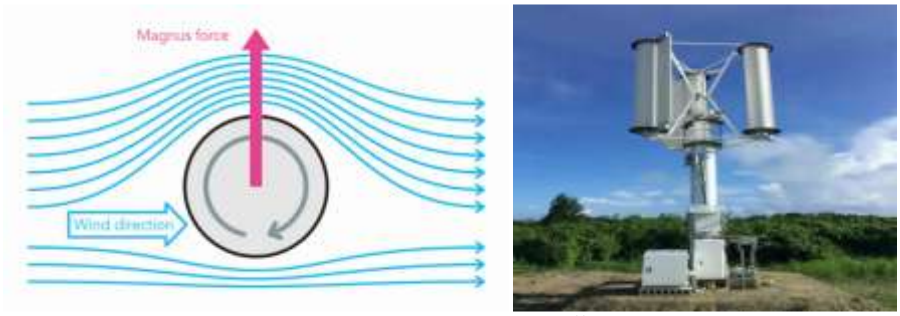

Figure 1 Magnus effect VAWT installed in in Nanjo City in Okinawa

Figure1 shows the VAWT working on Magnus Effect. In the present work the author took the review of different available articles of various researchers who are working on the above said effect.Their findings are presented as below:

Omar Faruqi Marzuki et al[1]conducted a study on **The Effect of Sandpaper Surface Roughness on Cylinder Blades of Magnus Wind Turbine.**The Magnus wind turbine is an invention that uses rotating cylinders as blades to extract energy from the wind**.** This invention overcomes the limitation of operating a wind turbine at low wind speed conditions. However, research regarding the torque generated by enhancing the surface roughness of the Magnus wind turbine is still lacking. Thus, the study aims to understand the effect of varied sandpaper surface roughnesses on the Magnus wind turbine torque output. The approaches used are:

experimentation using a 6 cylinders modelinside a wind tunnel for Magnus force comparison, a Magnus wind turbine model for torque performance andsmoke flow visualisation for boundary layer analysis. The results show that the torque coefficient produced by P40 sandpaper to smooth the surface roughness is 0.079–0.016, which is nearly a five times improvement in the torque coefficient. On the other hand, the tip speed ratio further increases from smooth to rough surface enhancement (0.057–0.147). This significant finding indicates that the Magnus wind turbine performance can be further improved using sandpaper surface roughness.

Maro Jinbo et al[2] presented the work on **MPPT of Magnus Wind System with DC Servo Drive for the Cylinders and Boost Converter.**This work presents an algorithm MPPT (MaximumPower Point Tracking) for a Magnus wind system with aDC servo drive system (DCdrive and BLDCmotor) to rotate the turbine cylinders.The optimal cylinders rotation is the one to deliver the maximum power extracted from the wind tracked by fixed and adaptive step HCC (Hill Climbing Control) acting on the servo drive. The proposed wind system consists of a PMSG (Permanent Magnet Synchronous Generator), a three-phase diode rectifier, a DC/DC (boost)converter, and a resistive load. Furthermore, the boost converter acts with the fixed step HCC algorithm to track the maximumpower operating point. Therefore, the MPPT for a Magnus wind system requires both tracking for the optimal cylinder speed and the optimal generator speed. The researchers found that, The simulation results presented in this paper refer to the maximum mechanical power as provided in Table 5 for wind speeds between 5.5m/s and 7.5 m/s to reach the electrical generated power Pgen and load electrical power Po. These\ results prove that the control methodology applied to the boost and load resistor R designs is correct as well as the specified values.The algorithms “HCC Cylinders” and “HCC Boost” effectively track the optimal cylinder rotation to provide the maximum net generated power Pgen and the maximum load power Po, respectively. The Magnus wind system as discussed in this paper performs correctly the wind speed steps passing from3.0 m/sto 7.5m/s in order to increase the turbine mechanical power and wind speed steps passing from 7.5m/s to 5.5m/s in order to decrease the mechanical power, during the instants when performing the energy conversion and transfer of the maximum electrical power to the load.

O F Marzuki et al[3] have presented **An Overeview of Horizontal-Axis Magnus Wind Turbines, which suggest that the** Magnus force shows extraordinary results in producing lift force, hence gives rise to its application. One of the applications is by replacing airfoil-shaped blades of wind turbine with the rotating cylinder blades. This is known as Magnus Wind Turbine (MWT), where it generates lift force on the rotating cylinder that perpendicular to the incoming wind flows. Due to high consumption of fossil fuel, natural gas and coal that risk our and earth health. Thus to overcome this conundrum, MWT is one of the innovative approaches to harvest the low wind speed energy. Finally they concluded that this overview strengthens the idea that horizontal-axis MWT is feasible as sustainable energyharvester. There are several ways to improve the MWT performance and one of them is by utilizing the surface roughness effect on rotating cylinder that include fins, dimples, groove, porous, sandpapers and so on. Moreover, considering all evidences, it seems that there is no fixed number of cylinder blades for MWT. Despite its exploratory nature, this overview offers some insights into current state-of-the-art horizontal-axis MWTs. Further research could also be conducted to determine the power usage and thepower produced from the MWT, and the effect of number of rotating cylinder blades.

A. M. Mgaidi et al [4], also presented **A Review Study on Magnus Wind Turbine for Accessing the Aerodynamic Performance.**They suggested that the Wind energy became an increasingly important and wide spread renewable energy source in the last decades, while it is significant technical development has led to a wide variety with more effectiveness. Magnus wind turbine (MWT) represents one of main application of horizontal wind turbines that are viable in low wind speed regimes and also suitable for the urban areas. Numerous numerical and experimental investigations have been performed to analyse and improve the design and performance of MWT, However, most of these studies revolved around aerodynamic performance of magnus turbine. This paper reviews the application of Magnus effect devices and concepts especially in wind energy that have been investigated by various researchers and concludes with discussions on future challenges in their application.They concluded that,based on the previous studies that have been displayed through achieved open literature review on MWT which could summarized in continuous research work to design the configuration, verify the results and improve performance. Numerous theoretical and practical studies were performed on MWT included distinguished patents, experimental results that contribute to the implementation of subsequent studies, in addition to numerical studies that keep pace with software developments. This review attempts to create a window of opportunity to help researchers’ and practitioners’ efforts and also to meet their requirements for easy access to sustainable tourism publications. While the previous studies have been investigated the impact of MWT design parameters on its effectiveness and performance, a few of available researches have been indicated to the effect of free-end spinning cylinder on MWT performance. Where free end status of each rotating cylinder exhibits alternating vortex shedding causing large fluctuating pressure force that can lead to vibration or even structural failure. Besides that, the vibration amplitude of free end rotating cylinders has exhibited the bell shape, that indicates to the losses in consumed power and leads to reduce the efficiency. Perhaps one of the most prominent proposals that lead to overcome the effects and risks of mentioned problem could be summarized in adding of a supportive outer ring surrounded the magnus wheel.

Xiaojing Sun et al[5],carried out their study on **A Three-Dimensional Numerical Study of the Magnus Wind Turbine with Different Blade Shapes.**Although the Magnus type wind turbine has many benefits over conventional blade-type wind turbines, it normally has low wind energy utilization efficiency.Therefore, it is important to seek effective ways of improving the Magnus wind turbine power performance in order to promote its application. As blade aspect ratio is a critical parameter influencing the Magnus wind turbine performance, a 3D numerical study of a Magnus type wind turbine which is equipped with cylindrical blades with different aspect ratios has been conducted in this paper. In addition, various cylinder shapes, including truncated cone and wavy cylinder, have also been used and their effects on the performance of the Magnus wind turbine are analyzed. Performance characteristics such as power, torque, and thrust coefficients of the Magnus turbine with different blade shapes are compared and discussed with the aim of identifying the desirable blade characteristics for this type of turbine.
In the present work, influence of different cylindrical blades on the aerodynamic performance of a Magnus wind turbine was investigated with the aid of CFD simulations. The following conclusions can be drawn from the preceding results:
• For the Magnus turbine equipped with straight circular cylinders, it was apparent that the power coefficient Cp of the turbine is highly dependent on the length-to-diameter ratio b of the cylinder. At a fixed cylinder rotation rate a, larger b results in a wider operating range of tip speed ratios k and higher Cp. At the same k, the turbine with cylinder having larger b can also achieve higher Cpmax at high a, in spite of the fact that its Cp can be relatively low at small a.• When operating at low a and k, the Magnus turbine whose blades have a shape as the frustum of a cone has a lower Cp compared to that of the turbine with circular cylinder. However, its maximum efficiency Cpmax can be markedly promoted if the turbine and the conical frustum runat relatively high values of k and a.
• According to the three-dimensional numerical simulation of the flow past a wavy cylinder, the mean lift coefficient of a wavy cylinder can only reach a value close to that of a straight cylinder if the rotation speed of the wavy cylinder is twice as fast as that of the straight cylinder. In order to enable the Magnus turbine using wavy cylinder to generate a high torque, the wavy cylinder has to be rotated at a rather fast speed, which will accordingly consume a lot of energy and result in a low Cp of the Magnus turbine.
• Controlling the rotational speed of the cylinder can be an effective method for regulating the power produced and axial thrust of a Magnus wind turbine

.O. F. Marzuki et al [6],conducted experimentation for **Investigation on the Effect of Surface Roughness on the erformance of Magnus Wind Turbine.**Wind turbine that used airfoil-shaped blades cannot harvest wind energy at low speed wind condition efficiently.A wind turbine that used Magnus effect is proposed to overcome the wind speed problem. Magnus wind turbine (MWT) performance can be further enhanced by using sanded surface on the rotating cylinder blades but the surface roughnesseffect on MWT are not yet fully explored. Experimental approach by wind tunnel is conducted in order to understand the effect of surface roughness. Blades rotation speed and wind speed are the controlled variables. Meanwhile, torque, torque coefficient and tip speed ratio are the measured variables. The experiment shows that sanded surface roughness cansignificantly increase the MWT performance up to four times based on torque production in comparison with the smooth surface. In conclusion, the results proved that surface roughness can be used to improve MWT.
They summarized that, the rough surface roughness using sanded paper will improve the MWT torque up to four times in comparison with smooth surface roughness. The finding also showed that the effect of surface roughness is more beneficial towards rotating cylinder as it increases the overall aerodynamic performance in comparison withthe airfoil-shaped blades. Based on the experiment results for torque generated from the surface roughness, it gives an idea for future research. Nevertheless, the finding inthis experiment gave the insight in understanding the effect of surface roughness on the wind turbines blades.The recommendation for future research in the effect of surface roughness on the MWT is to explore the effect in different range of sanded surface roughness coefficient. Based on current improvement shown from the effect of surface roughness, the MWT performance can be further improved using a higher or lower sand paper roughness coefficient to be more efficient and sustainable in future.

G. Sriram et al [7] carried out **Numerical Investigation of the Magnus Effect on a Rotating Circular Cylinder at Relatively Low Reynolds Numbers: Applications to the Design of Magnus Self- Starting Vertical-Axis Wind Turbines.**A novel variant of the articulating vertical-axis wind turbine (Giromill) is the Magnus-vertical axis wind turbine (M-VAWT). The articulating straight blades have been replaced by rotating Magnus Cylinders which produce powerful lift forces. Such special features, enable M-VAWTs to be capable of

operating in complex terrains coupled with hostile wind environments. To help in the design of a Magnus cylinder of an M-VAWT, a computational and experimental study of the flow past a rotating cylinder, at relatively low Reynolds numbers, was carried out.
Their Concluding Remarks were, a computational and experimental study of the aerodynamic characteristics of a rotating circular cylinder was carried out. In order to achieve high Magnus effects and thereby high performance of Magnus wind turbines, it is imperative that end plates should always be used to avoid tip losses and the spin ratio should be chosen close to S = 2 in order to achieve ordered wake deflection leading to high lift co-efficient and high lift to drag ratios.

Dahai Luo et al [8],developed an **Analytical Solution on Magnus Wind Turbine Power Performance Based on the Blade Element Momentum Theory.**The researchers suggested that instead of using conventional horizontal axis wind turbine blades, a Magnus wind turbine is equipped with rotating cylinders, which rotate around their own axes
according to the principle of the Magnus effect. Based on the blade element momentum(or BEM) theory, an analytical analysis of the Magnus wind turbine power performance is conducted and its expression of power coefficient has been derived in this paper. The analytical solution has shown that there is a close relationship between the power coefficient of Magnus wind turbine and its physical parameters such as the tip rotor solidity, the tip speed ratio of Magnus turbine, and the relative speed of the cylinders rotation. In addition, a numerical BEM computation for the power coefficient of Magnus wind turbine is also performed using experimental lift and drag coefficients of a rotating cylinder obtained in the previous literature in order to validate the analytical solution. As a result, the aerodynamic characteristics of Magnus wind turbine observed in this study will be of some guiding significance for the initial research and preliminary design of Magnus wind turbines.Their Concluding remarks were,
1. An analytical solution to the power performance of Magnus wind turbine based on the idealized inviscid flowtheory has been developed using BEM and also modified to consider the real operating condition. The power coefficient CP has been found to be a function of the tip rotor solidity rT, the tip speed ratio k1, and the relative speed of the cylinders rotation k2. The constraints among those three parameters and their inter-relationships are illustrated in Figs. 5–8 presented in this paper, which will be of some guiding significance for the initial research and during the preliminary stage of Magnus wind turbine design.
2. The analytical solution of the power coefficient CP derived in this paper is only an ideal result as the drag of a rotating cylinder has been ignored and will certainly be different from its real value in practical applications. However, a numerical BEM computation using the experimental lift and drag coefficient of the rotating cylinder from the previous literature has been carried out in order to identify the impact of the absence of the drag on the power coefficient calculation. Similar results to those obtained by using the numerical BEM can be achieved after the analytical analysis have been corrected according to the experimental data. However, since the real operating conditions of a Magnus turbine are fairly complex, further corrections to the analytical solution obtained here will be required.

Ahmad Sedaghat [9],focused on **Prospectus and Challenges in Design and Modeling of Magnus Type Wind Turbines.**One of attracting concepts has been the use of Magnus effect to produce lift from rotating cylinders in various engineering applications. With emerging innovative Magnus type wind turbine technology, it is important to determine power performance and characteristics of such generators as correctly as possible. As stressed by Seifert, there is lack of theories in design and modelling of using Magnus force in engineering which is particularly noticed for the horizontal axis Magnus type wind turbines. In this study, the importance of research carried out for determining lift and drag forces of rotating circular cylinders is highlighted and reviewed. Then, the theoretical methods used in designing commercial aerofoil type wind turbines are extended to apply on the Magnus types. New formulation is presented for potential flow around the Magnus blades. The blade element momentum (BEM) theory is formulated for the Magnus wind turbines. A cubic function for angular induction factor is found from the BEM analysis which is strongly dependant on the drag to lift ratio. It is also observed that the relative wind incidenceangle and the local power coefficient of the Magnus cylinder are independent functions of spin ratio.
Their Concluding remarks were,the subject of using Magnus force from rotating bodies is fascinating many engineers and scientists to design innovative devices in aerospace and naval engineering. There is a renew interest in Flettner type ships in naval engineering due to increasing trends of fossil fuel costs and climate change concerns. There is also some success in development of Magnus type horizontal axis wind turbines in Japan which encouraged this research work. The subject of Magnus effects were extensively reviewed by Seifert who suggests that there are lack of specific methods and modelling available on how to design the lifting device from the Magnus effects. This paper is particularly concentrated on development and extension of models and theories that are usually used in wind energy community to design and to extend our understanding from the horizontal axis Magnus type wind turbines. It is well known that the drag to lift ratio is the most crucial

parameter in designing and modelling the aerofoil type commercial type wind turbines; likewise, the findings of this research is also suggest that the success of any Magnus type horizontal axis wind turbine may be dependent on reducing the drag to lift ratio for large commercial application of Magnus effect in wind industry. The present power coefficient calculations for the Magnus wind turbine may show some merit for some small wind turbine applications; however, more experimental results on innovative application of Magnus effect is still needed to guarantee success of using Magnus force in large wind turbine applications. From the experimental results on drag and lift of spinning cylinders, the optimum value of drag to lift ratio is suggested equals to 0.2 which offers the power coefficient of 0.35 at the blade speed ratio of unity. This is not as yet promising for small wind turbine applications in low wind speeds unless designs such as Murakami's Magnus wind turbine with spiral ribs have someway tackled such poor performance.

Honglin Zhang et al [10] suggested the **Application of Magnus Effect and Lift Blade in High Altitude Wind Power.**A high-altitude wind power generation system scheme is proposed. The cylindrical airship is surrounded by the lifting blade of H-type vertical axis wind turbine.The blades are used to drive the airship to rotate. The airship rotating under the wind has a magnus effect, and the generated lift maintains the floating state of the airship. The paper establishes its 2D numerical simulation model. The turbulence scheme adopts SST k-w and the y+ value is controlled between 5~10. The slip grid method is used to calculate the parameters when the model has a Compactnessl degree of 0.4, and the airship's lift-to-drag ratio is 7 and power coefficient is 13%, the corresponding tip speed ratio is 2.33. Then in this tip speed ratio, the working condition of the wind turbine at 3~24m/s wind speed is analyzed. It is found that the power coefficient increases slowly to 16% and the lift-to-drag ratio is between 4~7. Comparing the torque coefficient difference between the scheme and the H-type wind turbine, it is found that it performs negative work at most moments on the leeward side. The streamline diagram and pressure cloud diagram of the airship blades at different azimuth angles are analyzed, which explains the reason why the airship reduces the thrust and generates lift. It is concluded that the scheme has certain rationality. Further they concluded that,The number of nodes of the airfoil blade and the sliding interface is increased later. The operating parameters of the thin blade, the thick blade and the curved blade are compared and analyzed. Although the variation characteristics of the parameters are different, the overall parameters are roughly the same as the variation trend, which is:
1. The airship guides the wind due to the rotary motion, deflecting the wind direction to the upper end of the airship, and greatly reducing the horizontal thrust it receives.
2. The rotation of the airship drives the surrounding airflow to rotate, and superimposes with the incoming wind speed, so that the wind speed at the upper end of the airship is multiplied and the wind speed at the lower end is reduced and a vortex is generated, thus generating a lift-to-drag ratio of 4~7, so that the airship can remain buoyant under the wind force.
3. Due to the presence of the airship, the power coefficient is greatly reduced compared to the H-type vertical axis wind turbine, which can only be maintained between 12%~16%. However, as a scheme to maintain the floating state under the wind, this design has certain rationality.

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