Design of Offshore Wind-Powered Pump-Propelled Environmentally Friendly Ship Based on Spiral Vertical-Axis Wind Turbine

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Abstract. In this study, a new concept offshore wind-powered pump-propelled environmentally friendly vessel is designed for offshore navigation to protect the marine environment. The ship adopts shaft-vertical wind power generation technology and pump-propulsion technology, which will greatly promote the upgrading and innovation of existing ships in terms of power. In addition, the launch of the vessel will further promote the development of marine power batteries and the application of vectorial magnetic hydrodynamic propulsion technology. By adopting this environmentally friendly ship, environmental pollution in offshore coastal areas can be reduced and marine protection can be promoted. If the ship is successfully launched, it will make an important contribution to China's shipping industry and environmental protection.

Keywords: Offshore Wind Power Pump Push, Ships, Shaft Vertical Wind Power Technology, Pump Push Technology.

1. Introduction

To promote the sustainable development of the oceans, the team is committed to designing a new high-performance, environmentally friendly and energy-saving ship for offshore navigation. The ship relies on a variety of advanced technologies, including high-efficiency wind turbine power generation technology, integrated power management technology, high-performance vector pumping technology and environmentally friendly hull design technology, to ensure stable power supply and excellent power output when the ship is traveling on the sea, and at the same time, reduce the environmental pollution of coastal areas by offshore vessels, to promote the protection of the oceans, and to provide China's solutions for the global marine environmental governance, contributing to the Chinese wisdom. Contribute to the global marine environmental governance by providing Chinese solutions and contributing to Chinese wisdom.

For the market, according to the ship registration data of China Classification Society (CCS), the net weight tonnage of China's inland waterway ships in 2018 was about 195 million tons. Industry analysis, according to 50% electrification ratio calculation, the corresponding net weight tonnage of electrified ships is 0.975 billion tons, according to the electric boat needs lithium battery 1.3KWh per ton calculation, lithium battery theoretical demand will reach 127GWh, the market capacity is very considerable. In terms of cost, research data from the Institute of Lithium Institute of Industrial Research shows that the operating cost per 100 kilometers of the ship, diesel-powered ships for 4320 yuan, LNG-fueled ships for 4440 yuan, electric ships for 3272 yuan, electric ships have a significant advantage. As for the technology, the axial-vertical wind power generation technology has been widely recognized and matured after decades of development, and has relevant application conditions; the vector pump push technology was firstly applied to submarines, and is now widely used in small and medium-sized yachts, which also has relevant application conditions [1, 2].

To sum up, we initially propose a new type of environmentally friendly ship with wind power for auxiliary power generation, and summarize and summarize the background of this direction, the

existing application technology, and carry out innovation, and conduct a comprehensive analysis and design of the project's power propulsion system, shape design, and power generation system.

2. Overall project design program

In this study, two reconfigurable magnetically coupled thrusters are used as the main power unit of the propulsion system, and each thruster is equipped with vector reconfiguration capability of two degrees of freedom, which possesses higher maneuverability and flexibility. The vector thrusters have both propulsion and maneuvering guidance capabilities, which can reduce the need for the number of thrusters, thus ensuring maneuverability and at the same time reducing navigational resistance and energy consumption. Moreover, the ship adopts wind power generation to increase the ship's endurance, realizing the purpose of energy saving and emission reduction. This work adopts vertical spiral wind turbine, and the spiral wind turbine is characterized by low starting wind speed, small size, beautiful appearance, and low running vibration. Installing multiple spiral wind turbines can make higher power generation, which not only reduces pollution but also effectively utilizes wind energy (Fig.1).



Figure 1. Preliminary design

3. Existing theories underpinning the work

3.1. Principle of wind turbine

The instability of wind speed can make the wind turbine output fluctuation is not stable, not easy to be directly utilized by the load. In the wind speed is very weak or no wind, not enough to drive the fan rotation, can not produce electricity, so need to add batteries, in order to make it become the second power supply system. Because the power generated by the fan is unstable, can not be used and stored directly, only through the rectifier rectifier can be converted into chemical energy, and stored in the battery. Because the battery is generated by the DC power, and the ship's own power grid and most of the power devices are AC power, so it is necessary through the inverter will be converted from the DC battery output to AC power and then connected to the ship's power grid. The whole process has gone through two major conversions, namely: "electrical energy → chemical energy → electrical energy" and "AC → DC → AC" process [3].

Wind power generation is through the wind force will be driven by the spiral of the fan, the spiral through the growth rate driven fan internal motor work, is the wind energy into mechanical energy and then converted to electrical energy process. According to Bates' theory, the power of wind turbine is affected by air density, wind speed and wind area, namely.

$$P = \frac{1}{2}\rho A C_p v^3 \tag{1}$$

$$\lambda = \frac{\omega R}{v} = \frac{\pi R n}{30 v} \tag{2}$$

Where, ρ is the air density kg/m3; v is the wind speed m/s; A is the area of wind energy captured by the wind turbine; R is the radius of the wind wheel m; ω is the angular speed of the wind turbine machinery, rad/s; C_p is the output power coefficient of the wind turbine.

The maximum power points corresponding to each wind speed are connected together to form the optimal power curve, and the relationship between the optimal power of the wind turbine and the rotational speed is as follows:

$$P_{max} = kn^3$$

$$k = \frac{\frac{1}{2}\rho A R^2 C_{pmax}}{\lambda_{opt}^2}$$

Connecting each maximum power output point gives the Popt curve, also known as the optimal power curve. From Fig. 2, it can be seen that to keep the power on the optimal power curve, it is necessary to change the speed of the generator in time when the wind speed changes [3].

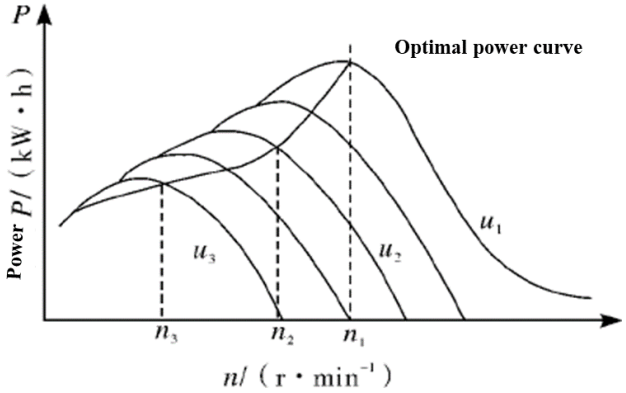


Figure 2. Power curve at different wind speeds and optimal power curve graphs

3.2. Principle of wind energy utilization

Before the emergence of the steam engine, wind energy is second only to firewood as the main source of energy, until the middle of the 19th century, some countries are still utilized wind energy accounted for more than 20% to 30% of the total energy consumption. 19th century due to the development of coal and petroleum, the use of wind energy is gradually relegated to secondary status. In recent years, due to energy shortages and environmental pollution is becoming more and more serious, wind energy has been re-emphasized. In addition to being used for shipping, water lifting, desalination and heating, wind power generation has also developed rapidly.

Bates' theory is a basic theory about the efficiency of wind energy utilization in wind power generation. The derivation process is as follows:

The mass of wind passing per unit time at the blade:

$$M = \frac{\rho s(v_1+v_2)}{2} \tag{3}$$

According to Newton's second law, the kinetic energy absorbed by the blade is equal to the difference between the residual kinetic energy of the wind and the initial kinetic energy of the wind, and we get:

$$P = \frac{M(v_1^2-v_2^2)}{2} \tag{4}$$

Get:

$$P = \frac{\rho(v_1^2-v_2^2)(v_1^2+v_2^2)s}{4} \tag{5}$$

From the basic formula for wind energy:

$$P_0 = \frac{\rho v_1^3 s}{2} \tag{6}$$

Then there is:

$$\frac{P}{P_0} = \frac{(1+\frac{V_2}{V_1})(1-\frac{V_2}{V_1})}{2} \tag{7}$$

Where, v1 is the entering wind speed, v2 is the residual wind speed, ρ is the air density, s is the area of the blade sweeping the wind, P is the kinetic energy of the conversion, and P0 is the initial kinetic energy of the wind.

This shows that P/P0 is a cubic function of v2/v1, and the derivation yields two stationary points, 1/3 and -1. Since v2/v1 is positive, when v2/v1=1/3, P/P0 is at its maximum value of 16/27. In principle, as long as an object that can generate asymmetric forces in the flow of the wind can produce rotations, flattenings, or vibrations, thus obtaining wind energy. The key is how much wind energy can be obtained with what size and cost. Wind turbine according to the flow mechanism can be divided into lift type and resistance type; according to the direction of the rotor axis relative to the wind flow can be divided into the wind horizontal axis type, horizontal axis type and vertical axis type; according to the size of the power, can be divided into miniature (1 kilowatts or less), small (1 ~ 10 kilowatts), medium-sized (10 ~ 100 kilowatts) and large-scale (more than 100 kilowatts) [4, 5].

In recent years, there are also many new wind turbines in accordance with the aerodynamic principles of innovation, where Cp is the power coefficient of the wind turbine

$$C_p = (0.44 - 0.0167\beta)sin\left[\frac{\pi(\varphi-3)}{15-0.3\beta}\right] - 0.00184(\varphi-3)\beta \tag{8}$$

Where P is the wind turbine output power; S is the wind turbine blade swept area. The theoretical maximum value of the power coefficient Cp, then the wind energy utilization max) = 0.593, known as the Bates limit. At present, the world's largest operating wind turbine power of 3000 kilowatts.

Wind energy utilization is a comprehensive engineering technology. It must be analyzed and researched from the aspects of technical feasibility, economic cost-effectiveness and safety in use. The recent development trend of wind turbines is mainly medium and small, used for water lifting, power generation with battery packs or in conjunction with diesel engines, etc.; at the same time, the development of large and medium-sized wind turbines is underway to consider windmill group technology for grid-connected power supply as well as sail shipping technology, etc. [6].

3.3. Selection and design principle of wind power device

Since the key component of wind turbine capturing wind energy is the impeller, the good or bad design of wind turbine blades has a direct impact on the utilization efficiency of the wind turbine. At present, the important task in the research and development of wind power generation technology is the design and research of wind turbine blades. Most of the blades of traditional wind turbines use airfoils, but due to the different working environment and structure of wind turbines, airfoils cannot utilize wind energy efficiently. Overseas countries have researched and developed many wind turbine blades on the basis of airfoils, mainly including NACA airfoil series, SERI airfoil series, FFA-W airfoil series and RIS-A airfoil series, etc. For the vertical axis wind turbine, the design and research of airfoils are mainly based on the aeronautical airfoils. For vertical axis wind turbines, the chosen airfoils are mainly NACA symmetrical airfoils, and the National Research Council of Canada and the San Diego National Laboratory of the U.S. have carried out experimental research on the NACA series airfoils, and there is a large amount of experimental data available for researchers' reference [7]. Comparatively speaking, domestic research lags behind foreign countries to a certain extent, and most of the results are mainly based on foreign research methods and theories, thus seriously restricting the development of China's wind power industry.

(1) Development history of wind power device

Axial vertical wind turbine development is an important turning point in the 20's actually 30's a French engineer named Darrieux put forward the lift resistance hybrid axial vertical wind turbine generator, since then the power generation efficiency of the axial vertical generator to a high level of enhancement, which makes the axial vertical generator into the vision of the national wind power

researchers [8]. In the 1980s, the shaft-vertical generator click after half a century of development, has produced several mainstream generator forms (Fig.3).

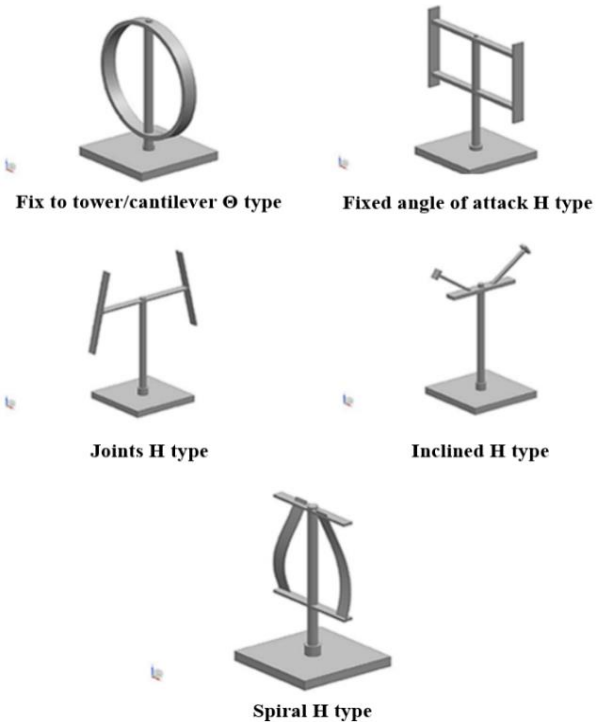


Figure 3. Vertical axis fan modeling diagram

(2) Two-dimensional airfoil theory

The two-dimensional airfoil theory allows for a basic force analysis of the airfoil forces on the wind. From the two-dimensional airfoil theory, the relative velocity of the airfoil and the magnitude of the angle of attack of the incoming flow determine the aerodynamic performance on the airfoil, as shown in Figure 4.

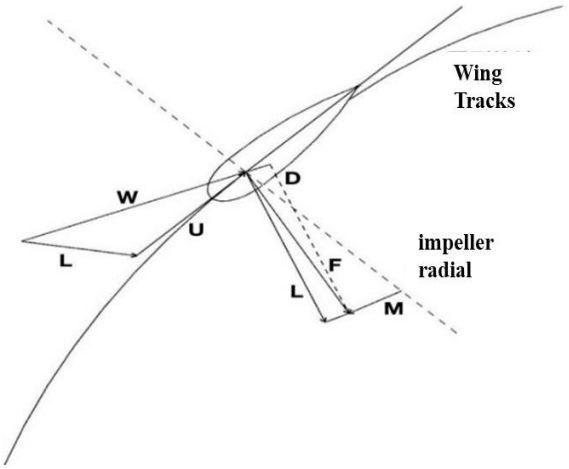


Figure 4. (Math.) two-dimensional wing theory

Wind turbine rotor axis in the radial line of the impeller, the blade rotates with the wind turbine along the wing trajectory movement, the incoming wind enters from the left side, the vector V is the external wind speed, U is the linear velocity of the blade circumferential motion, W is the blade synthesized air velocity that is the relative wind speed, the combined force F acting on the blade can be decomposed into the component perpendicular to the relative velocity L and parallel to the relative velocity component D, the synthetic force in the direction of the forward direction of the blade M is the component of the force to push the wind wheel rotation, the torque is formed by this synthetic force [7]. The force M in the forward direction of the blades is the force that pushes the wind turbine to rotate, and the torque of the wind turbine's rotating shaft is formed by this synthesized force [7].

Under this defined condition we can calculate the lift coefficient C_l and drag coefficient C_d using the equations.

$$C_l = \frac{L}{\frac{1}{2}\rho W^2 c} \tag{9}$$

$$C_d = \frac{D}{\frac{1}{2}\rho W^2 c} \tag{10}$$

Where ρ is the air density and c is the chord length.

3.3.3 Blade tip speed ratio

For spiral type vertical axis wind turbines, the blade tip speed ratio is defined as the ratio of the linear velocity at the tip of the wind turbine blades to the incoming wind speed. For horizontal axis wind turbines, the circumferential velocity at the maximum radius is the blade tip linear velocity, while for vertical axis wind turbines it is the linear velocity of the blades at the maximum radius away from the main axis, which is usually denoted by the symbol λ.

$$\lambda = \frac{2\pi Rn}{V} = \frac{\omega R}{V} \tag{11}$$

Where R is the radius of the wind turbine, n is the rotational speed of the wind turbine, ω is the angular velocity of the wind turbine, and V is the incoming wind speed.

By reviewing the information and calculations we get that for the spiral H type of shaft vertical wind turbine tip speed ratio is between 3 and 5.

(3) Wind turbine solidity

The ratio of the projected area of the wind turbine blades to the swept area of the wind turbine is called the solidity, which is an important design parameter of the wind turbine that determines the torque characteristics of the wind turbine, especially the starting torque (Figure 5). For horizontal axis wind turbine and vertical axis wind turbine the real degree is expressed differently [8], for axis vertical wind turbine the formula is:

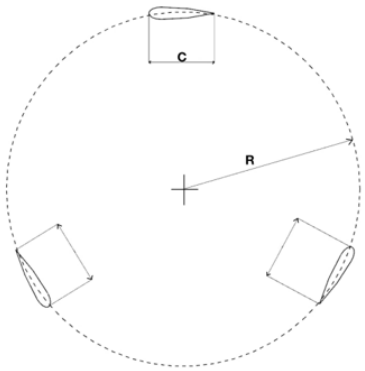


Figure 5. Wind turbine blade projection

$$\sigma = \frac{BC}{2\pi R} \tag{12}$$

Where, B denotes the number of blades, C denotes the chord length of the blades and R is the radius of rotation of the wind turbine.

(4) Principle of wind energy utilization coefficient

Refers to the degree of the size of the wind turbine to draw energy from the natural wind energy, also known as the power coefficient, generally expressed as C_p:

$$C_p = \frac{P}{E} \tag{13}$$

Assuming that the volume of gas flowing through the cross-sectional area S per unit time is V, then it can be obtained:

$$m = \rho V = \rho S \tag{14}$$

Where: m is the gas mass, V is the gas velocity

At this point C_p can be expressed as:

$$C_p = \frac{P}{E} = \frac{P}{\frac{1}{2}\rho S v^3} \tag{15}$$

Where: P is the actual power, ρ is the air density, S is the sweeping area of the wind wheel, the unit is m2, v is the incoming wind speed.

3.4. Pump push principle

Pump push technology through the propulsion pump spray water as the propulsion power. The structure of the pump jet propeller by the conduit, rotor and stator composition. Because of the special design of the conduit and guide stator into the tube seawater optimization, so that the rotor impeller can work in a uniform flow field, fluid pulsation force is small, smooth operation, vibration noise, and the use of incoming stamping, so that the rotor in the high-speed range has a very good performance of the anti-bubble to delay the blade of the air bubble generation.

For the representation of force and velocity in the hull coordinate system, u is the velocity of the hull along the X_B axis, i.e., longitudinal oscillation velocity, v is the velocity of the hull along the Y_B axis, i.e., transverse oscillation velocity, and r is the rate of change of the angle between X_B and X_E, i.e., the angular velocity of the bow rocking. X_P, Y_P are the longitudinal and transversal propulsion force on the hull, X_S, Y_S are the longitudinal and transverse viscous hydrodynamic force on the hull, and X_W, Y_W are the longitudinal and transverse viscous hydrodynamic force on the hull. W, Y_W are the longitudinal and transverse disturbance forces on the hull, N_P is the propulsive moment on the hull, N_S is the hydrodynamic moment on the hull, and N_W is the disturbance moment on the hull. The ship is operating in a fluid that drives a portion of the surrounding fluid, resulting in an additional drag force (moment) on the hull. This part of the resistance (moment) is generally regarded as an increase in the ship's mass (moment of inertia), i.e., additional mass and additional moment of inertia. After considering the additional mass and additional moment of inertia of rotation [9], the equations of control of ship motion obtained by kinematics and dynamics analysis are:

$$\begin{cases} (m+m_x)u-(m+m)vr = X_P+X_S+X_W \\ (m+m_y)u-(m+m)vr = Y_P+Y_S+Y_W \\ (I+J)r = N_P+N_S+N_W \\ x = u\cos\theta - v\sin\theta \\ y = u\cos\theta + v\sin\theta \\ \theta = r \end{cases} \tag{16}$$

Where m_x and m_y are the additional hull mass in the longitudinal and transverse directions, respectively. m is the mass of the ship, I is the inertia of the hull over the center of gravity, and J is the additional inertia of the hull over the center of gravity.

The forces on a pumped vector propulsion vessel during motion can be divided into two main categories: hydrostatic and hydrodynamic. Hydrostatic forces generally refer to the gravity and buoyancy of the hull. Hydrodynamic force refers to the pump jet vector propulsion ship in motion, the pump jet vector propulsion hull, the command deck and the spiral mixed-flow water jet propulsion and other attachments and fluid interaction force. The fluid generates a reverse force on the pump-jet vector propulsion ship, and the hydrodynamic force is affected by the speed and the state of navigation. When studying the horizontal plane maneuvering performance of the pump jet vector propulsion ship, the center of gravity and the center of buoyancy will not change and the gravity and buoyancy are equal in size, so the hydrostatic force on the ship is negligible, simplifying the problem to the magnitude of the fluid force depends on the hydrodynamic force on the pump jet vector propulsion ship.

$$F = F_f + B + G + F_1 \tag{17}$$

$$M_f = M_f + M_B + M_G + M_{F_1} \tag{18}$$

Where, F_f-hydrodynamic force of the ship in the process of movement; B-buoyancy force of the ship; G-ship's own gravity; F_1-helical mixed-flow water jet thruster thrust; M_{F_f}-ship's movement process M_{F_f}-moment generated by hydrodynamic force during ship's movement; M_B-moment generated by buoyancy force of ship in water; M_G-moment generated by ship's own gravity; M_{F_1}-moment generated by thrust force of spiral mixing water jet propeller.

The thrust generated by the work done by the impeller of the spiral mixed-flow pump can be obtained by the momentum theorem, and the formula for the pump jet thrust F_1 and the transverse force F_2 (the force perpendicular to the ship's hull in the horizontal plane) is:

$$F_1 = Q_m(V_j - V_s) \tag{19}$$

$$F_3 = F \times sin\delta = Q_m(V_j - V_s) \times sin\delta \tag{20}$$

Where V_j-Spiral mixed-flow water jet thruster inlet velocity, m/s; V_s-Spiral mixed-flow water jet thruster outlet velocity, m/s; δ-vector spray angle; Q_m-mass flow rate kg/s.

3.5.Modeling and simulation principle based on UG

(1) Modeling principle

Modeling technology is the core technology of CAD/CAM and the fundamental reason why computers can assist humans in design and manufacturing activities [10]. Without a usable model there is no subsequent simulation analysis, processing and other related modules to achieve. Currently the main modeling methods are geometric modeling and feature modeling. Geometric modeling is based on geometric information, topological information established, is the earliest design method of CAD/CAM; feature modeling in addition to containing geometric information also includes non-geometric information, such as material information, size, shape tolerance information, heat treatment and surface roughness and other information. Therefore, feature modeling technology is known as a milestone in the development of CAD/CAM.

The following is a specific impeller example to briefly explain the feature modeling method: (1) First of all, establish the rotary feature, draw the contour line through the sketch. (2) By establishing the extraction surface, select the YZ plane as the interface, and use the YZ plane as the reference surface to establish the spline curve. (3) Build the shown feature by building sheet command. (4) Build the art spline with XZ plane as the reference plane, and build the rotated feature with the angle range of 180 degrees. (5) Create the spline curve and project it onto the rotated surface. 6) Repeat step (5). (7) Create mesh surface features and draw four surfaces on the top, bottom, left, and right sides. (8) Finally, the impeller model can be obtained by generating array features and summing function (Figure 6) [11].

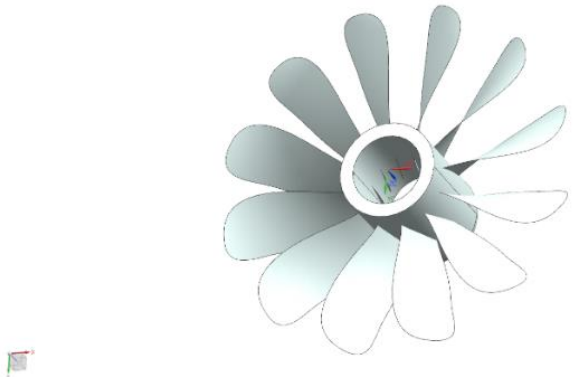


Figure 6. Impeller model drawing

Through the modeling of the above examples, summarize the modeling ideas, establish a suitable coordinate system, select the benchmark; sketch; establish the required features; use Boolean operations to get the final model; post-processing; including rendering, exploded views and so on.

On the basis of this basic modeling for the impeller, we mainly mastered the difficulty of modeling the impeller blade surface. Subsequently, we refer to a large number of paper materials and proceed to the modeling of vertical axis spiral fan blades. In this study, five types of vertical-axis vertical fans (Fig. 5) are first modeled to prepare for the next step of motion analysis and working force analysis.

(2) Principle of Simulation Mechanical Analysis

UG/Motion is the main part of UG/CAE (Computer Aided Engineering) module, using the function of UG/Motion to give certain kinematic characteristics to each part of the three-dimensional solid model, and then set up a certain connection relationship between the parts to establish a motion simulation model, and then can be assembled for the motion mechanism. After that, the motion mechanism can be analyzed for assembly and motion reasonableness, such as interference checking, trajectory envelope, etc., and the motion parameters of the motion mechanism can be obtained. Through the motion simulation to verify the reasonableness of the design of the motion mechanism, and can use the graphical output of the displacement, coordinates, acceleration, speed and force changes of each component to optimize the motion mechanism.

The steps to realize the motion simulation function are: (1) Establish a motion analysis scene. (2) Carry out the construction of the motion model, including setting the linkage characteristics of each part, setting the motion vice between two links and adding the mechanism load. (3) Set the motion parameters, submit the motion simulation model data, and output the motion simulation animation and control the motion process. (4) The data output of the motion analysis result and the table, change curve output, and the analysis of the motion characteristics of the mechanism artificially.

4. Specific application design

4.1. Design of wind power generation device

In order to improve the efficiency of sufficient work, this study from the thesis literature of the existing data on the five models to choose, proposed to determine the most relevant to the team's current work design of the type of shaft vertical fan blade.

After the team's discussion, we mainly compared the fixed to tower/cantilever Θ type, helical H type, and articulated H type. The main models that we compared were the fixed to tower/cantilever Θ type, helical H type, and articulated H type.

Table 1. Comparison table of spiral H-type and articulated H-type

	Spiral H	**Fixed to tower/cantilever Θ type**	**Joint H**
Blade shape	intricate	intricate	simpler
yaw system	unnecessary	unnecessary	unnecessary
noises	incline	moderate	incline
Generator position	ground level	ground level	ground level
Blade Load	few	few	moderate
Self-starting performance	general	general	no good
Impact on towers	few	few	few
Requirements for the base	few	moderate	moderate
fabrication	intricate	simpler	simpler

As shown in Table I above, the spiral H-H typeas no disadvantages over the fixed-to-pylon/cantilever Θ-type and the articulated H-type, except for the disadvantage of relative structural complexity. The spiral H-type was proposed at the end of the last century, and the design won the Edison Patent Award in 2001. After 20 years of research by researchers from various countries, the technology is now relatively mature, and its ideal working efficiency has reached about 35%, and its

reliability has been greatly improved. And its low noise and low requirements for the base are very suitable for the ship's working environment. Therefore, the team finally focused on the spiral H-axis vertical wind turbine and decided to use this design as the main structural feature of the "New Concept" sail.

After determining the structural characteristics of the H-axis vertical generator, we will use the relevant function modules of UG to analyze it, and to determine a relatively suitable wing shape and structure.

Through the above theoretical analysis, we have established the helical shaft-vertical wind turbine model as shown in Fig. 7 and Fig. 8.

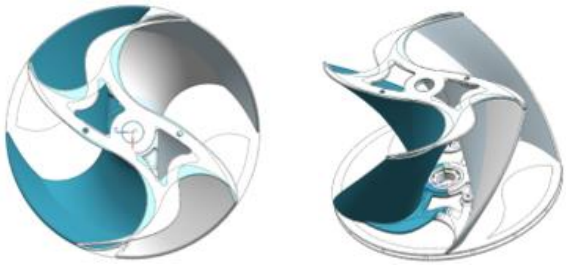


Figure 7. Core fan model view (left) and core fan model view (right)

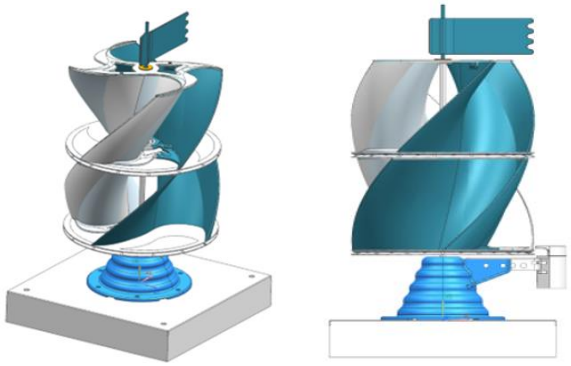


Figure 8. Fan effect view (left) and fan effect view (right)

After that, we then used the UG/Motion module to carry out motion simulation and mechanical analysis of the model, and in the UG/Motion module, we carried out finite element analysis of the model. Through the powerful mechanical analysis function of UG, we obtained the following results with the fan blade angle of attack as the independent variable.

(1) According to the data obtained from the simulation we plotted the relationship between the angle of attack and the lift coefficient and the angle of attack and the drag coefficient icons respectively (Fig.9).

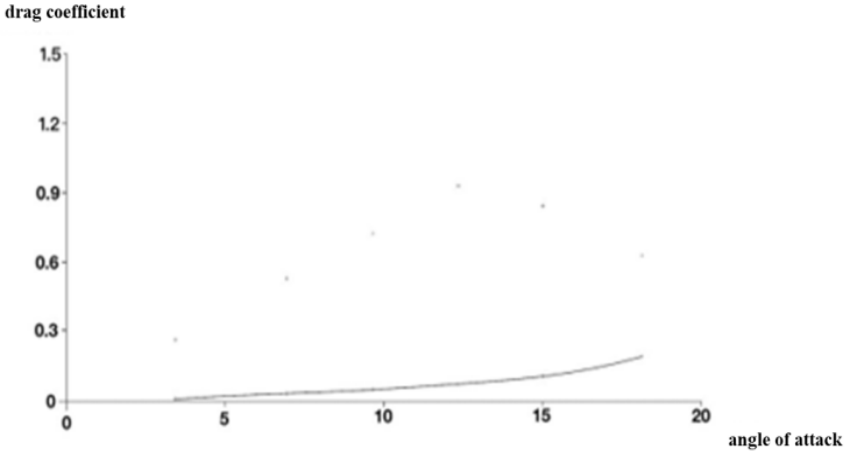


Figure 9. Angle of attack - resistance factor

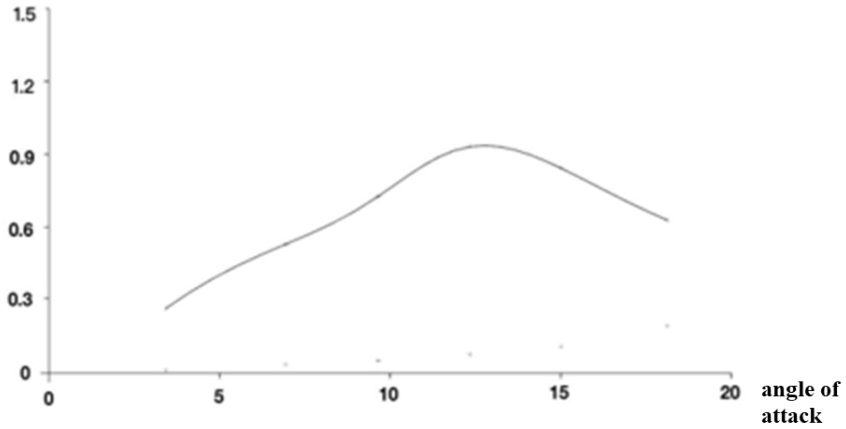


Figure 10. Angle of attack - lift coefficient

$$a+b=\gamma \tag{21}$$

As can be seen in Fig. 10, in the simulation analysis of the aerodynamic parameters of the lift coefficient and drag coefficient, we find that as the angle of attack increases, the lift coefficient increases rapidly, while the drag coefficient increases slowly. And when the angle of attack increases to a certain critical value, the lift coefficient will suddenly decrease and the drag coefficient increases rapidly, and then the state of the blade is called the stall state. The so-called stall state is when the angle of attack reaches a certain critical value, the airflow through the upper surface of the airfoil to produce boundary layer separation, resulting in the airflow from the leading edge of the airfoil to the trailing edge of the airfoil to produce a closed vortex, the airfoil's coefficient of lift decreases rapidly, the drag coefficient increases rapidly. The airfoil stall is one of the key factors affecting the aerodynamic design of wind turbine blades, and we should choose the airfoil with high lift coefficient and low drag coefficient in order to avoid the stall characteristics to the greatest extent [12].

It can be seen that the lift coefficients of the airfoils will decrease quickly after the critical angle of attack, while the drag coefficients are increasing slowly.

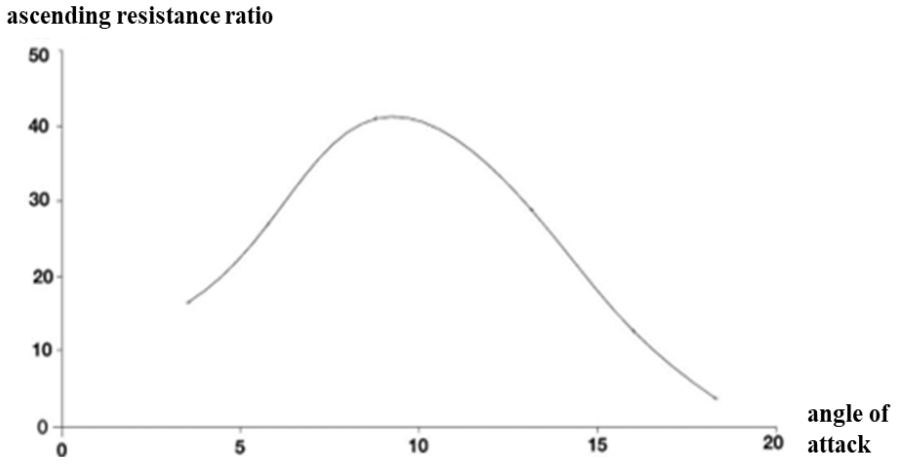


Figure 11. Angle of Attack - Lift Resistance Ratio

The lift-to-drag ratio of an airfoil is the ratio of lift to drag at the same angle of attack of an airfoil. In the related research data, it is shown that the larger the lift-to-drag ratio of the airfoil, the better its aerodynamic performance, and the more favorable it is to the startup performance of the spiral-type vertical-axis wind turbine. From Fig. 11, it can be seen that the lift-to-drag ratio of the airfoil first increases and then decreases with the increasing angle of attack. It can be seen that the condition is satisfied when the angle of attack is around 10 degrees.

In summary we have given the final design of the spiral shaft vertical generator (shown in Fig. 12).

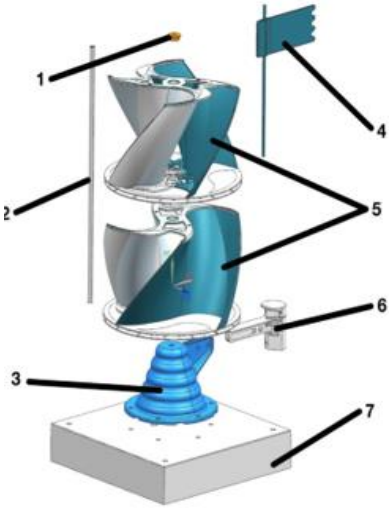


Figure 12. Axial Vertical Generator Design

Note; Shaft thrust cover; 2-rotating shaft; 3-buffer seat; 4-wind flag; 5-core airfoil; 6-wind converter; 7-base.

4.2. Pump Push Design

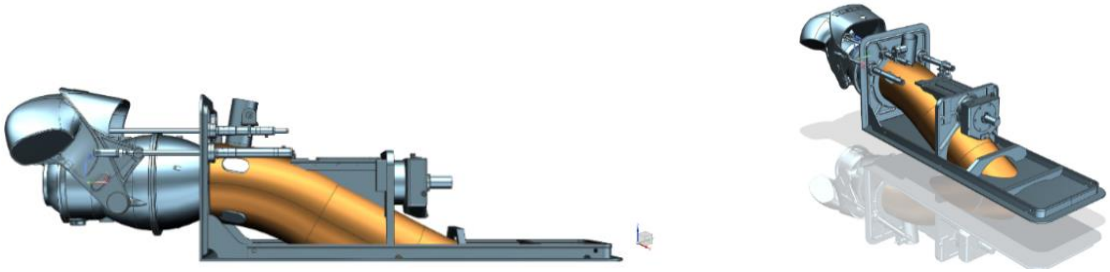


Figure 13. Pump Push Schematic

This vector thruster is a reconfigurable magnetically coupled thruster based on the propeller propulsion method, which utilizes magnetic coupling to achieve contactless torque transfer between the motor and the propeller. The thruster mainly consists of two parts: the power output mechanism and the direction change mechanism. The power output mechanism includes the main propulsion motor, magnetic gimbal and propeller, and the variable direction mechanism is a spherical parallel mechanism. The thruster transmits the output torque of the motor to the propeller contactlessly through the magnetic gimbal, and can redirect the vector thrust generated by the propeller to the desired direction without moving or changing the position and angle of the motor, thus realizing vector propulsion (Fig.13).

4.3. Battery selection

Lithium iron phosphate batteries are lithium ion batteries that use lithium iron phosphate as the cathode material. The cathode materials of lithium-ion batteries mainly include lithium cobaltate, lithium manganate, lithium nickelate, ternary materials, and lithium iron phosphate. Among them, lithium cobalt is the cathode material used in the vast majority of lithium-ion batteries. The charging and discharging reactions of lithium iron phosphate batteries are carried out between the LiFePO4 and FePO4 phases. During the charging process, LiFePO4 gradually detaches from the lithium ions to form FePO4, and during the discharging process, lithium ions are embedded in FePO4 to form LiFePO4. When the battery is charging, the lithium ions migrate from the LiFePO4 crystals to the surface of the crystals, and under the action of the electric field force, they enter into the electrolyte, and then pass through the diaphragm and then migrate to the surface of the graphite crystals via the electrolyte, and then are embedded in the graphite crystal lattice. When the battery is discharged, lithium ions are de-embedded from the graphite crystals into the electrolyte, then across the

diaphragm, migrate via the electrolyte to the surface of the lithium iron phosphate crystals, and then re-embedded into the lithium iron phosphate lattice [13].

4.4. Wind energy management system design

The development of offshore wind energy is different from onshore wind energy because offshore wind energy is set up in shallow or distant waters, and ships and helicopters have to reach locations where more complex and dangerous installations are located than onshore wind energy. The operation and maintenance of wind power generation at sea can be roughly divided into 3 major segments, one of which is the management of ship utilization; the second is the operation and maintenance of wind farms, wind turbine equipment, and pressure-boosting stations inside and outside the wind farm; and the third is the maintenance of submarine cables on the seabed where wind turbine pile foundations are located and in the area of the wind farm. The internal operation and maintenance of an offshore wind turbine is similar to that of a terrestrial wind turbine as long as the tools are available to transport specialized technicians on site. Based on this, this paper mainly discusses the classification of ship transportation routes, ship safety management, and traffic safety management of windships, with the aim of introducing an intelligent big data management model to facilitate the development of an offshore wind O&M management system.

5. Conclusion

With its maneuverability, advanced technology, long duration of operation and high efficiency, the wind-powered ship based on spiral vertical-axis wind turbine has a broad application prospect in many fields such as harbor patrol, waterway inspection, sea area detection, river patrol security, emergency response to sudden pollution incidents, water quality sampling and monitoring, offshore cruising, etc., and it has a Outstanding advantages.

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