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REVIEW ARTICLE

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FERRIS WHEEL WIND TURBINE (KAATHADI)

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ABSTRACT

This invention relates to a wind turbine made up of number of airfoils (likely as that of the wings on an aircraft) attached at both ends to circular frames. These air foils at various positions on the circular frame convert the kinetic energy of the wind into various forces such as lift, impact and drag forces, thereby rotating the circular frame. The rotational motion of the circular frame is coupled to an alternator, thereby generating electric energy is generated.

Key Words— Ferris Wheel, Wind Turbine, Airfoil Design, Alternator, Electrical Energy

I. INTRODUCTION

The Ferris wheel wind turbine makes use of the concepts of wind turbine and airfoil technology. An Airfoil (in American English) or Aero foil (in British English) is the shape of a wing, blade (of a propeller, rotor, or turbine), or sail (as seen in cross-section). A wind turbine is a device that converts kinetic energy of wind into electric energy. Incorporation of the basics of airfoil in the field of wind turbine forms the base for Ferris wheel wind turbine.

II. AIRFOIL

An airfoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. Subsonic flight airfoils have a characteristic shape with a rounded leading edge, followed by a sharp trailing edge, often with a symmetric curvature of upper and lower surfaces. Foils of similar function designed with water as the working fluid are called hydrofoils.

The lift on an airfoil is primarily the result of its angle of attack and shape. When oriented at a suitable angle, the airfoil deflects the oncoming air (for fixed-wing aircraft, a downward force), resulting in a force on the airfoil in the direction opposite to the deflection. This force is known as aerodynamic force and can be resolved into two components: lift and drag. Most foil shapes require a positive angle of attack to generate lift, but cambered airfoils can generate lift at zero angle of attack. This "turning" of the air in the vicinity of the airfoil creates curved streamlines, resulting in lower pressure on one side and higher pressure on the other. This pressure difference is accompanied by a velocity difference, via. Bernoulli's principle, so the resulting flow field about the air foil has a higher average velocity on the upper surface than on the lower surface. The lift force can be related directly to the average top/bottom velocity difference without computing the pressure by using the concept of circulation and the Kutta-Joukowski theorem.

A fixed-wing aircraft's wings, horizontal, and vertical stabilizers are built with airfoil-shaped cross sections, as are helicopter rotor blades. Airfoils are also found in propellers, fans, compressors and turbines. Sails are also airfoils, and the underwater surfaces of sailboats, such as the centerboard and keel, are similar in cross-section and operate on the same principles as airfoils. Swimming and flying creatures and even many plants and sessile organisms employ airfoils/hydrofoils: common examples being bird wings, the bodies of fish, and the shape of sand dollars. An airfoil-shaped wing can create downforce on an automobile or other motor vehicle, improving traction.

Any object with an angle of attack in a moving fluid, such as a flat plate, a building, or the deck of a bridge, will generate an aerodynamic force (called lift) perpendicular to the flow. Airfoils are more efficient lifting shapes, able to generate more lift (up to a point), and to generate lift with less drag.

III. WIND TURBINE

A wind turbine is a device that converts kinetic energy from the wind into electrical power. The term appears to have migrated from parallel hydroelectric technology (rotary propeller). The technical description for this type of machine is an aerofoil-powered generator.

The result of over a millennium of windmill development and modern engineering, today's wind turbines are manufactured in a wide range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging for auxiliary power for boats or caravans or to power traffic warning signs. Slightly larger turbines can be used for making contributions to a domestic power supply while selling unused power back to the utility supplier via the electrical grid. Arrays of large turbines, known as wind farms, are becoming an increasingly important source of renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels. Wind turbines can rotate about either a horizontal or a vertical axis, the former being both older and more common. They can also include blades (transparent or not) or be bladeless.

HORIZONTAL AXIS DESIGN: Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. Since a tower produces turbulence behind it, the turbine is usually positioned upwind of its supporting tower. Turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted forward into the wind a small amount.

Downwind machines have been built, despite the problem of turbulence (mast wake), because they don't need an additional mechanism for keeping them in line with the wind, and because in high winds the blades can be allowed to bend which reduces their swept area and thus their wind resistance. Since cyclical (that is repetitive) turbulence may lead to fatigue failures, most HAWTs are of upwind design. Turbines used in wind farms for commercial production of electric power are usually three-bladed and pointed into the wind by computer-controlled motors. These have high tip speeds of over 320 km/h (200 mph), high efficiency, and low torque ripple, which contribute to good reliability. The blades are usually colored white for daytime visibility by aircraft and range in length from 20 to 40 meters (66 to 131 ft) or more. The tubular steel towers range from 60 to 90 meters (200 to 300 ft) tall.

Two different types of turbines are common today: geared wind turbines or direct drive turbines. Direct drive turbines need a huge generator due to low rotation speed. Geared wind turbines are using a gear box used for stepping up the speed of the small generator. Some models operate at constant speed, but more energy can be collected by variable-speed turbines which use a solid-state power converter to interface to the transmission system. All turbines are equipped with protective features to avoid damage at high wind speeds, by feathering the blades into the wind which ceases their rotation, supplemented by brakes.

VERTICAL AXIS DESIGN: Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically. One advantage of this arrangement is that the turbine does not need to be pointed *into the* wind to be effective, which is an advantage on a site where the wind direction is highly variable. It is also an advantage when the turbine is integrated into a building because it is inherently less steerable. Also, the generator and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, improving accessibility for maintenance.

The key disadvantages include the relatively low rotational speed with the consequential higher torque and hence higher cost of the drive train, the inherently lower power coefficient, the 360 degree rotation of the aerofoil within the wind flow during each cycle and hence the highly dynamic loading on the blade, the pulsating torque generated by some rotor designs on the drive train, and the difficulty of modeling the wind flow accurately and hence the challenges of analyzing and designing the rotor prior to fabricating a prototype.

When a turbine is mounted on a rooftop the building generally redirects wind over the roof and this can double the wind speed at the turbine. If the height of a rooftop mounted turbine tower is approximately 50% of the building height it is near the optimum for maximum wind energy and minimum wind turbulence. Wind speeds within the built environment are generally much lower than at exposed rural sites, noise may be a concern and an existing structure may not adequately resist the additional stress.

DARRIEUS WIND TURBINE: "Eggbeater" turbines, or Darrieus turbines, were named after the French inventor, Georges Darrieus. They have good efficiency, but produce large torque ripple and cyclical stress on the tower, which contributes to poor reliability. They also generally require some external power source, or an additional Savonius rotor to start turning, because the starting torque is very low. The torque ripple is reduced by using three or more blades which results in greater solidity of the rotor. Solidity is measured by blade area divided by the rotor area. Newer Darrieus type turbines are not held up by guy-wires but have an external superstructure connected to the top bearing.

GIROMILL: A subtype of Darrieus turbine with straight, as opposed to curved, blades. The cycloturbine variety has variable pitch to reduce the torque pulsation and is self-starting. The advantages of variable pitch are: high starting torque; a wide, relatively flat torque curve; a higher coefficient of performance; more efficient operation in turbulent winds; and a lower blade speed ratio which lowers blade bending stresses. Straight, V, or curved blades may be used.

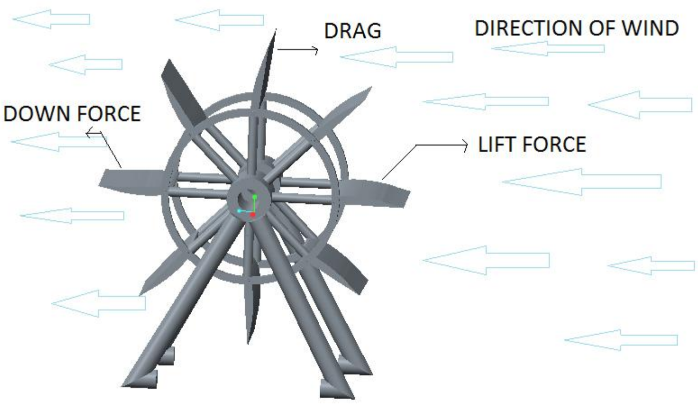
IV. TECHNICAL BACKGROUND

A Ferris wheel named after George Washington Ferris, Jr., sometimes called a big wheel, observation wheel, or in the case of very tallest examples giant wheel is a nonbuilding structure consisting of a rotating upright wheel with multiple passenger carrying components commonly called as passenger cars, cabins, capsules, gondolas or pods attached to the rim in such a way that as the wheel turns they kept upright, usually by gravity.

The invention of Ferris wheel wind turbine is merely a dream-cum-instinct, where the idea of replacing the passenger cabins with airfoils originated. The passenger cabins of a giant wheel are replaced by airfoils so that the airfoils create various forces such as lift force, drag force and impact force which makes the upright wheel (referred as circular frames) to rotate by coupling this rotational motion to an alternator electric energy could be produced.

V. CONSTRUCTION

The construction of the Ferris wheel wind turbine majorly consists of two circular frames (the so called upright wheels in giant wheel), numberous airfoils are attached at both ends to the upright wheels which is mounted to the ground by firm mountings, the minimum height of the mounting is decided in such a way that the air foil is attached at the lowest point of the upright wheel, being in a full



vertical downward position doesn't touch the ground. (The number of airfoils could be increased to get better rotational response to slow winds, but still it is expected that the number depends on an optimization value based on the diameter of circular frame). The height of the mountings or the size of the whole setup could be increased such that better wind forces are met at great altitudes. Bearing arrangements are provided between the upright wheels and mountings so as to provide support as well as aid rotation of the wheels. The airfoils are attached to the circular frames at equal intervals by permanent fastening methods such that there is no relative motion in-between the airfoil and circular frame. The alternators for the wind turbine could be coupled to the circular frames at any point on the circumference of the circular frames. The arrangement of alternator is similar to that of the arrangement of prime mover in Ferris wheel. The material selection for the airfoil and circular frame is to be made as light as possible since they are the parts of the wind turbine which convert the kinetic energy into mechanical energy (rotational motion), so energy loss by dead weight is not affordable and also it should be strong enough and corrosive resistant. Other parts such as bearing arrangements and mountings are expected to be made of materials with maximum strength and corrosion resistance.

VI. DETAILED DESCRIPTION

The working theory of Ferris wheel wind turbine is purely based on airfoil action and centrifugal force. Wind force coming from one direction hits the airfoil at the right most portion of the circular frame, this airfoil which is at horizontal orientation creates lift force as the wind passes by. this lift force tends to move the airfoil upwards, since the airfoil is permanently attached to the circular frame it aids in the rotation of circular frame (i.e. a lift force created at a point on the circumference of the circular frame tends to rotate the frame by centrifugal action) as this happens, simultaneously an airfoil at the top most portion of the circular frame would be in a orientation such that the wind passing by exerts pure drag force on it and pushes it away, this force also contributes to the rotation of the circular frame simultaneously. As even this happens an airfoil at the left most portion of the circular frame will be in an orientation similar to that of automobile spoiler (an upside down turned airfoil which created lift force), the same wind creates down force as it passes through this airfoil. This down force pushes the frame downwards, creating a moment thereby helping in the rotation of the circular frame by centrifugal action. The airfoils in-between the right most and top most points of the circular frame will be exerting partial lift force or mixed forces of lift and drag which will also help in the rotation of the circular frame. Similarly, the airfoils in-between the top most and left most points of the circular frame will be exerting partial down force or mixed forces of drag and down force, by default they also contribute towards the rotation of the circular frame. The limitation with this design is that the airfoil which is at the bottom most point of the circular frame which also creates drag force but in the opposite direction to the rotation of the circular frame, hence it is a hindrance to the rotation but still it is believed that wind forces at lower altitude is lesser that at higher altitudes, so the opposite direction drag force can be neglected or considered to be overcame by the rest of the forces which aids in the rotation. The presence of compound walls (in case of wind farms) and other structures will prevent maximum wind force to this airfoil too. The number of airfoils can be increased to get more rotational response even in slow winds. But the presence of more airfoil will prevent large volume of wind passing through an airfoil and also reduces its velocity. So there must be an optimization value for the number of airfoils that can be present in a Ferris wheel wind turbine based on the diameter of the circular frame. This turbine can also be viewed as a design modification of wind harvesters. But wind harvesters use rectangular frames held horizontal. Whereas this design uses circular frames which gives centrifugal forces (as of a flywheel for an IC engine).

VII. CONCLUSION

A Ferris wheel wind turbine which uses airfoils in the place of passenger cabins of a giant wheel to provide rotational forces to the upright wheels by airfoil action in the presence of wind force thereby generating electric energy is developed. This wind turbine is expected to operate with less noise and it has advantages of simple construction and installations. It also has the capability to operate for wind forces from left-to-right and also for right-to-left forces, applying the same mechanism of airfoil action.

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