Design and fabrication of Electromagnetic clutch for wind turbine

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Abstract— Wind turbines are becoming popular in the renewable energy world. High cost of wind turbines, high cost for maintenance, lots of broken wind turbines were left idle, high noise level and inefficient wind are some of the major disadvantages of wind turbines. In this project experiment, we have concentrated in putting out one such disadvantage of the wind turbine. Most of the wind turbines use the wind energy to turn the mechanical parts. Often because of sudden wind currents and gusts due to heavy storms and hurricanes the mechanical components are under severe stresses. This may cause damage to both the turbine blades and the generator components. Present system to overcome this issue say hydraulic clutches and brakes is not much efficient. During the maintenance process, changing of the hydraulic fluid is very time consuming and require sophisticated machineries. Therefore the maintenance cost becomes high. To overcome this issue, the hydraulic clutches are replaced with electromagnetic clutches that are cheaper, easier to replace and more efficient. A miniature prototype model was fabricated to explain the use of hydraulic clutch in wind turbines. With this project, high cost of maintenance and breakdown of turbines can be reduced.

Key words: Electromagnetic clutch, wind turbine

I. INTRODUCTION

Wind is simply the movement of air. It is caused by the heating of the earth's surface by the sun. The heating is uneven due to the different types of land and water that causes the sun's heat to be absorbed at different rates.

Wind power is the conversion of wind energy into a useful form .Historically wind energy has been directly used for sailing boats or it has been converted into mechanical energy using windmills for pumping water of grinding grain. Today the main application of wind power is the generation of electricity using the wind turbines. Wind is called a renewable energy source because the wind will blow as long as the sun shines.

Wind farms that are used for large scales operation are usually connected to local electric networks. They also have smaller turbines to provide electric power to isolated areas. When utilities buyback electricity that is not being used by smaller house hold turbines it is called net metering. This is happening at an increasing rate.

Environmentalists favour wind energy as an alternative to fossil fuels for power because it is plentiful, renewable, widely distributed, clean and produces lower greenhouse gas emissions. There is a study that indicates that using wind for 70% of usage is possible at the current power prices by combining wind farms together with an High Voltage direct Current super –grid.

Today there are two kinds of wind turbines used based on the direction of the rotating shaft. They are widely in size due to their usage. Smaller turbines are used for homes and businesses and can have a capacity of less than 100 KW .Larger commercial sized turbines many have a capacity of 5 million watts, or 5 megawatts. The larger machines can be put together wind farms provide power to the electrical grid.

A Wind Turbine is a rotating machine which concerts kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery such as a pump or grinding stones, the machine is usually called a wind mill.

A. History:

The world's first automatically operated wind turbine was built in Cleveland in 1888 by Charles F. Brush. It was 60 feet tall, weighed four tons and had 12KWturbine.

Wind machines were used in Persia as early as 200 B.C. This type of machine was introduced into the Roman Empire by 250 A.D. However, the first practical windmills were built in Sistani, Iran, from the 7th century. These were vertical axle windmills, which had long vertical drive-shafts with rectangle shaped blades .Made of six to twelve sails covered in reed mating or cloth material, these windmills were used to grind corn and draw up water, and were used in the grist milling and sugarcane industries.

By the 14thcentury, Dutch windmills were in use to drain of the Rhine River delta. In Denmark by 1900 there were about 2500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30MW. The first known electricity generating windmill operated was a battery charging machine installed in 1887 by James Blyth in Scotland, UK. The first windmill for electricity production in the United States was built in Cleveland Ohio by Charles F Brush in1888, and in 1908 there were 72 wind-driven electric generators from 5 kW to 25kW. The largest machines were on 24 m (79 ft.) towers with four-bladed 23 m (75 ft.) diameter rotors.

Around the time of World War 1, American windmills makers were producing1, 00,000 farm windmills each year, most for water-pumping. By the 1930s windmills for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. In this period, high-tensile steel was cheap, and windmills were placed atop prefabricated open steel lattice towers.

A forerunner of modern horizontal-axis wind generators was in service at Yalta USSR in 1931. This was a 100kW generator on a 30 m (100 ft) tower, connected to the local 6.3 kV distribution system. It was to have an annual capacity factor of 32 per cent, not much different from current wind machines.

The first utility grid-connected wind turbine operated in the UK was built bythe John Brown Company in 1954 in the Orkney Islands. It has an 18meterdiameter, three-bladed rotor and a rated output of 100 kW.

Wind turbines require locations with constantly high wind speeds. With a wind resource assessment it is possible to estimate the amount of energy the wind turbine will produce.

A yardstick frequently used to determine good locations is referred to as Wind Power Density (WPD). It is a calculation relating to the effective force of the wind at a particular location, frequently expressed in terms of the elevation aboveground level over a period of time. It takes into account wind velocity and mass. Colour coded maps are prepared for a particular area described, for example, as "Mean Annual Power Density at 50 meters." The results of the above calculation nare included in an index developed by the National Renewable Energy Lab and referred to as "NREL CLASS." The larger the WPD calculation, the higher it is rated by class.

B. Wind Turbines:

A wind turbine is a rotating machine which converts the kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called aswindmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator, wind turbine, wind power unit (WPU), wind energy converter (WEC), or aero-generator.

Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.

Wind turbines are mounted on a tower to capture the most energy. At 100feet (30 meters) or more above ground, they can take advantage of faster and less turbulent flow.

Wind turbines can be used to produce electricity for a single home or building, or they can be connected to an electricity grid (shown here) for more widespread electricity distribution.

C. Electro Magnetic Clutch in Wind Turbines:

The stator body contains the field coil, which is a copper coil cast in synthetic resin. The clutch is activated by applying a direct current to the field coil. This creates a magnetic field (red),which electro magnetically attracts the armature disc towards the input drive hub with its friction lining, and so allows torque to be transmitted from the input side to the output. The axially-located output drive hub separates from the input side when the current is cut off. A return spring ensures that the armature disc separates from the input hub.

D. Components Used:

- Stepper motor
- Bush
- Connecting rod
- Lock pin
- Regulator
- Electric circuit
- Gear reduction
- Aluminium sheets and channels

II. STEPPER MOTOR

Stepper motors are electromagnetic incremental devices that convert electric pulses to shaft motion (rotation). These motors rotate a specific number of degrees as a respond to each input electric pulse.

Typical types of stepper motors can rotate 2°, 2.5°, 5°, 7.5°, and 15° per input electrical pulse. Rotor position sensors or sensor less feedback based techniques can be used to regulate the output response according to the input reference command. Stepper motors offers many attractive features such as

- Available resolutions ranging from several steps up to 400 steps (or higher) per revolution.
- Several horsepower ratings.
- Ability to track signals as fast as 1200 pulses per second.

Stepper motors have many industrial applications such as

- Printers.
- Disk Drives.
- Machine Tools.
- Robotics.
- Tape Drives.

III. CONFIGURATION OF STEPPER MOTOR

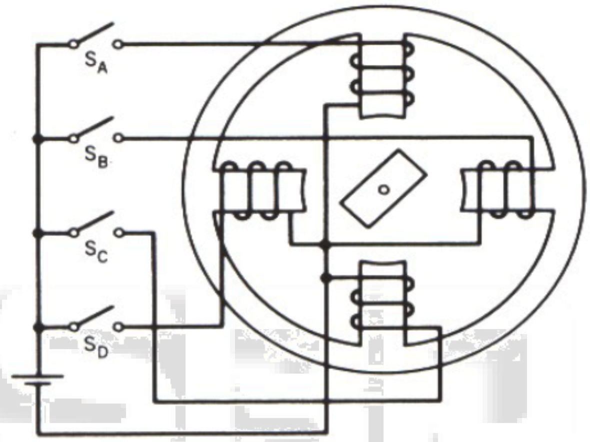

Fig. 1: CONFIGURATION OF STEPPER MOTOR

IV. PRINCIPLE OF WORKING OF STEPPER MOTOR

Stepper motors provide a means for precise positioning and speed control without the use of feedback sensors. The basic operation of a stepper motor allows the shaft to move a precise number of degrees each time a pulse of electricity is sent to the motor. Since the shaft of the motor moves only the number of degrees that it was designed for when each pulse is delivered, you can control the pulses that are sent and control the positioning and speed. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic fields is proportional to the amount of current sent to the stator and the number of turns in the windings. The stepper motor uses the theory of operation for magnets to make the motor shaft turn a precise distance when a pulse of electricity is provided. You learned previously that like poles of a magnet repel and unlike poles attract. From this you can see that the stator (stationary winding) has eight poles, and the rotor has six poles(three complete magnets). The rotor will require 24 pulses of electricity to move the 24 steps to make one complete revolution. Another way to say this is that the rotor will move precisely 15° for each pulse of electricity that the motor receives. The number of degrees the rotor will turn when a pulse of electricity is delivered to the motor can be calculated by dividing the number of degrees in one revolution of the shaft (360°) by the number of poles (north and south) in the rotor. In this stepper motor 360° is divided by 24 to get15°.When no power is applied to the motor, the residual magnetism in the rotor magnets will cause the rotor to detent or align one set of its magnetic poles with the magnetic poles of one of the stator magnets. This means that the rotor will have 24 possible detent positions. When the rotor is in detent position, it will have enough magnetic force to keep the shaft from moving to the next position. This is what makes the rotor feel like it is clicking from one position to the next as you rotate the rotor by hand with no power applied.

A. Connecting Rod:

Connecting rod is a machine member which is used to connect the two ends of the system. It is made up of a strong material like iron, steel etc. It is used to transmit motion from one end to another end. In this project a shaft of 8mm diameter was taken and the diameter was reduced to 6mm on one end. The length of the shaft is 190mm.

B. Electric Circuit:

Electric circuit is having some electric components like diode, filter capacitor and some wires. Diode is used for directing the current supply the generated power should not reverse to the source if it is reversed battery will not get power so the diode directs the current in one direction. LED is used here to demonstrate the power production. A simple circuit diagram of the circuit used in the project is shown below.

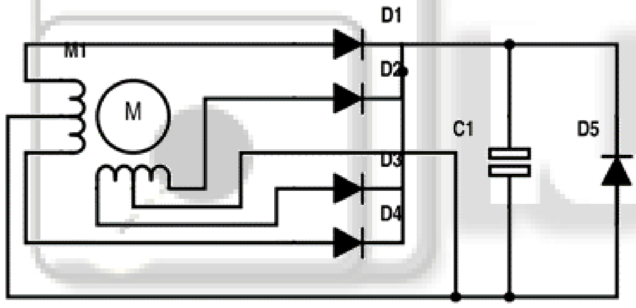

Fig. 2: Circuit Diagram of the Steppermotor

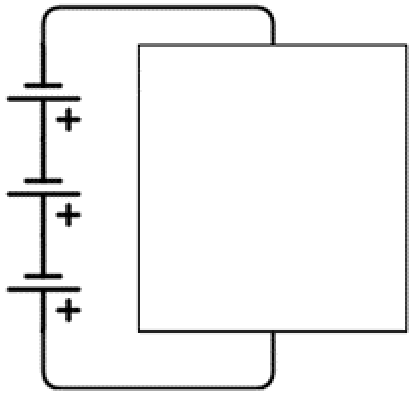

Fig. 3 Circuit Diagram of the Electro Magnetic Clutch

C. Aluminium Sheets and Channels:

Here aluminium sheets are used to make a base for the wind turbine. By Using the aluminium channels the four corners are made to resist the weight of the wind turbine system above on this the aluminium sheets are screwed for a better resistance. It also gives an aesthetic look to the component.

D. Lock Pin:

Lock pin is used for locking the two ends of the shaft. If it is not provided here there might be interruption in the transmission of the two ends. So it is very important to transmit power from the system to the output source.

E. Turbine Blades:

Turbine blades are placed in the top of the arm post. It is placed in the wind so that it can rotate freely and create wind energy. This blade has to be designed in the correct way and exact dimensions so it can transmit power as high as possible.

F. Design of Wind Turbine:

Blade is the most important of the turbine. This blade determines the speed at which the air enters the turbine thus determining the working of the turbine. This blade here is designed in such way that it makes the wind to hit it, thus rotating it even at lower speeds and compatible it at even higher speeds. Thus the design is set and next step is to design the mounting the swept area increases as the blade has a slightly elliptical model.

G. Fabrication:

– Three blades have been fabricated with PVC foam of dimension
– The blades have been suitably tucked in circular base plates of thickness 3mm.
– Circular Base plates have been coupled with the central rod by means of bush.
– It has been coupled with the lower base plate and gear reduction has been connected to it.
– Gear reduction has been connected to Stepper motor so that it generates the electric power
– The turbine shaft is connected to an electromagnetic clutch that has a 24V capacity.
– The electromagnetic clutch is connected to a series battery setup, in order to supply required the required power to the clutch.
– A SPST switch is placed in between the clutch and the battery.
– When power is supplied to the clutch, the turbine blades get engaged to the stepper motor. Thus power is produced. An electric circuit is connected such that the power is stored in a capacitor from capacitor it is connected to a Red-LED.
– Thus when the blade rotates, with clutch engaged, the LED light glows red.
– In the absence of power to the clutch, the LED will not glow, indicating the disengagement of the turbine from the stepper motor.
– Please note that the stepper motor used here have very low losses because of small size, because of this there is no friction. In order to add friction, a rubber band is added to tighten the motor shaft.

H. Dimensions (All Dimensions In Mm):

– The project can fit in to a box of 375*25*600mm

I. Cost Estimation:

1) Mechanical Components:

Material	Quantity	Cost (Rs.)
Aluminium sheet	1	300

Central Channel	1	300
Electromagnetic clutch	1	400
Stepper motor	1	700
Bushes	2	50
HW battery	3	100
Bolts and Nuts	8	50
PVC blade	1	300
Spur gear	2	150
1inch square	4ft	250

Table 1: Cost Estimation

2) Electrical Components:

Material	Quantity	Cost (Rs.)
Switch	1	30
Capacitor	1	30
Diodes	4	40
PCB	1	100

Table 2: Electrical components

V. Conclusion

Therefore a Designed and Fabricated model of an electromagnetic clutch for wind turbine was accomplished after a component Design, Material Procurement, component make Assembly.

This Mode of power Generation using wind as a powering Medium is on any given day a cleaner, greener and a very efficient manner of powering electrical units compared to the other available forms of Replenish able Energy sources and also conventional energy sources as well.

In this present era of severe power crisis in both the nation and globally it is the right time that we realize the potential dead end in fossil powered energy sources and make that shift towards alternative sources so as to lessen the burden on both fossil fuel and also on planet earth.

VI. Future Work

This project can be further expanded to a portable mobile charging equipment. With a help of simple circuit arrangement, we'll be able to make a socket that will supply DC current, when the blades are rotating. This DC current can be utilized for charging our mobile phones, or any other smaller applications, requiring small capacity power.

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