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# EXPERIMENTAL TESTING OF MULTISTAGE LINKAGE BASED ECLIPSE GEARBOX FOR WIND MILL APPLICATIONS

**Shrutika Patil, J. G. Patil**
M.E. Student, SGDCOE, Jalgaon(M.S.), India
Associate Professor, SGDCOE, Jalgaon(M.S.), India

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## ABSTRACT

Wind power is currently responsible for about 1:5% of the world's electricity use. Because of this high interest in wind energy, it becomes more and more important to increase the efficiency of wind energy conversion systems (WECS) Such a system consists of a rotor to capture the energy in the wind, a gearbox configuration to speed up the rotational speed of the shaft and a generator to convert the mechanical energy into electrical energy. Blade pitch control is used to control the aerodynamic power captured from the wind. By pitching the rotor blades along their longitudinal axis, the aerodynamic efficiency of the rotor is changed. A disadvantage of using blade pitching below rated speed is that less energy is extracted from the wind, decreasing the efficiency of WECS. Power electronics widely used in the wind turbine industry to improve the performance of wind turbines. The biggest disadvantage of power electronics is reliability. Mechanical components show wear & tear and therefore any failures in these components can be predicted, maintenance can be scheduled before failure occurs. Unfortunately power electronics do not show signs of degrading, therefore failures cannot be predicted and these sudden failures are very expensive to repair.

**KEYWORDS**: Crankshaft, Eclipse gearbox, Reliability of gearbox, Traditional gearbox, Wind turbine.

## INTRODUCTION

Global warming, the increase in the average temperature of the Earth's near-surface air and oceans, is a major issue all over the world. According to the Intergovernmental Panel on Climate Change (IPCC) the majority of the temperature increase is caused by the greenhouse effect [1]. The greenhouse effect refers to the change in steady state temperature of a planet by the presence of an atmosphere containing gas that absorbs and emits infrared radiation. Over three quarters of the greenhouse gas emissions on earth are caused by the combustion of fossil fuels. Renewable energy technologies, such as wind power, solar power, hydropower and biomass, can reduce the emission of greenhouse gases significantly and at the same time reduce the dependency on the oil industry. These two arguments combined make renewable energy a hot item all over the world. The fastest growing renewable energy source is wind power. Wind power is currently responsible for about 1:5% of the world's electricity use [2]. Because of this high interest in wind energy, it becomes more and more important to increase the efficiency of wind energy conversion systems (WECS), also called wind turbines.

### Blade Pitch Control

Blade pitch control is used to control the aerodynamic power captured from the wind. By pitching the rotor blades along their longitudinal axis, the aerodynamic efficiency of the rotor is changed. This change is caused by a modification in the aerodynamic angle of attack. The aerodynamic angle of attack is defined as the angle between the chord line of the rotor blade and the direction of the approaching wind, as seen by the rotor blade. [3]. When decreasing the angle of attack, called feathering, the lift capacity of the blades is reduced and therefore the power captured by the rotor decreases. Conversely, an increase in the angle of attack, with respect to the operational position, will lead to a higher power capture due to a reduction in drag. When the critical aerodynamic angle of attack is reached, the airflow separates at the surface of the rotor blades, limiting the power. This effect is called stall.

Below rated wind speed, the pitch angle can be controlled to change the tip speed ratio. However, application of blade pitch control to follow the desired tip speed ratio is limited by the rate at which the blades can be pitched and the reaction time of the rotor speed to change. A disadvantage of using blade pitching below rated speed is that less energy is extracted from the wind, decreasing the efficiency. For this reason, blade pitch control is generally not used below the rated wind speed. Above rated wind speed, blade pitch control is used to limit the angular speed of the rotor by capturing less power from the wind then available and to protect the system from excessive forces. By pitching the blades, the operating range of the turbine in terms of wind speed is increased. Without blade pitch control, the maximum operating speed would be rated wind speed. Above rated, the dynamic loads on the mechanical components would become too high and the angular speed of the rotor would exceed its maximum. With blade pitch control, the operating range is typically increased up to 25 m/s [3, 4].

**Power Electronics**

Variable speed operation of the generator results in the production of current with a variable frequency. The frequency of the produced current is determined by the electrical angular speed of the generator. For the electrical grid to remain stable, the frequency and phase of all power generating units must remain synchronous within narrow limits. When the frequency of the generator varies too much, in the order of 2 Hz, circuit breakers cause the generator to disconnect from the system, preventing damage to the grid. However, small deviations in the generator frequency can indicate instability in the grid. The grid frequency is not exactly 50 Hz at all times, variations in this frequency directly influence the generator frequency [5].

Power electronics is a technology that is developing rapidly. Higher current and voltage ratings are available, efficiency increases and costs decrease. Therefore, power converters are widely used in the wind turbine industry to improve the performance of wind turbines. However, there are also a number of disadvantages of using power electronics.

The biggest disadvantage of power electronics is the reliability. Mechanical components show wear and tear and therefore any failures in these components can be monitored and predicted, maintenance can be scheduled before failure occurs. Unfortunately power electronics do not show signs of degrading, therefore failures cannot be predicted and these sudden failures are very expensive to repair. Together with high failure costs, power electronics tend to fail quite rapidly because they are very sensitive to voltage spikes [6]. In the wind energy industry about 25% of all failures is due to the power electronics

## EXPERIMENTAL SETUP

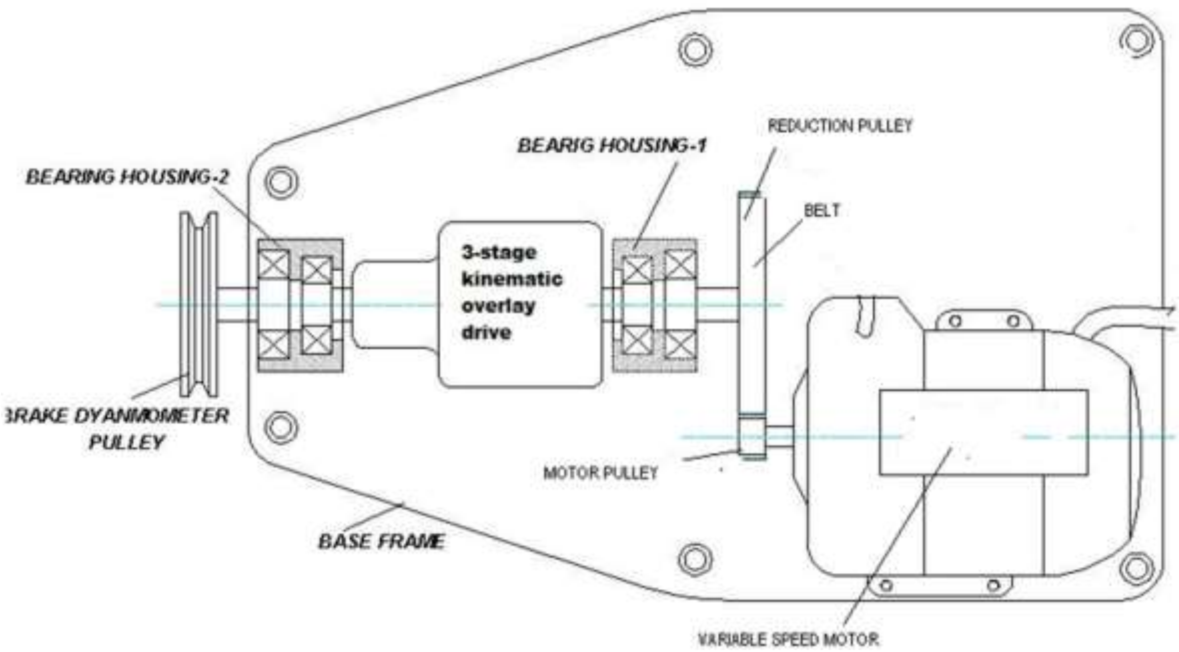


*Figure 1: Test Rig Set Up*

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For testing purpose we take low torque shaft as i/p shaft by using motor and belt input motion is given. Two linkages are in motion through gear and epicyclic gear rotates high torque means output shaft at high torque, various loads are applied and change in rpm is noted.

## THE DEVELOPMENT OF GEARBOX

The development of gear box comprises of three stage development:

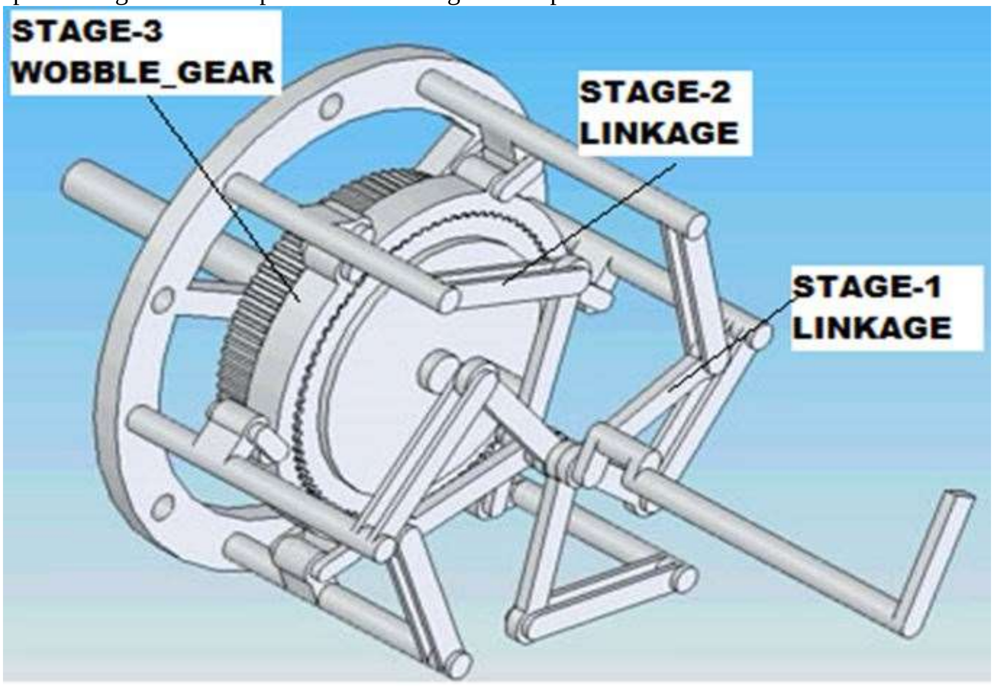


*Figure 2: Layout of Three Stage Kinematic Overlay Gear Box*

**Two Stage Kinematic Linkage Development**

Stage: 1 & Stage-2: Overlay kinematic linkages:

Stage 1 & 2 linkages are four bar kinematic linkages to provide oscillatory input the wabble gear mechanisms used in the third stage. The four bar kinematic linkage comprises of crank connecting rod, oscillator and fixed link. The rotary input to the cranks is converted to oscillatory output and links coupled to the wabble gear will transmit power to the third stage**.**

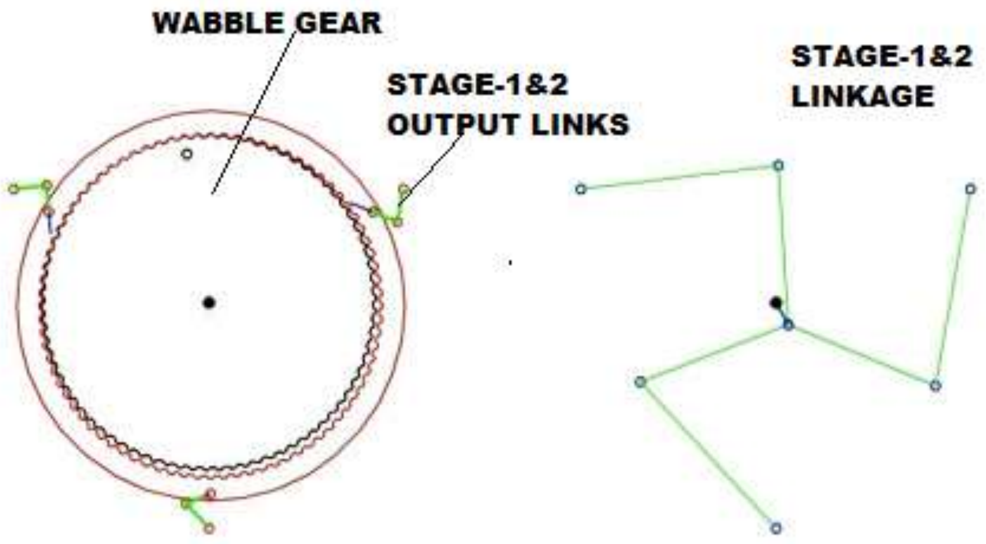


*Figure 3: Eclipse Drive Train*

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## Design of Gears

CATIA is used for design of gears. CATIA is increasingly chosen as the primary 3D design system for many companies, the worldwide demand for CATIA designers is difficult to meet. When you learn to use CATIA you also learn to work with leading-edge technology and play an important role in innovation. You get to put your imagination to work at full-speed because with CATIA there are no boundaries.

CATIA enables the creation of 3D parts, from 3D sketches, sheetmetal, composites, molded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die.

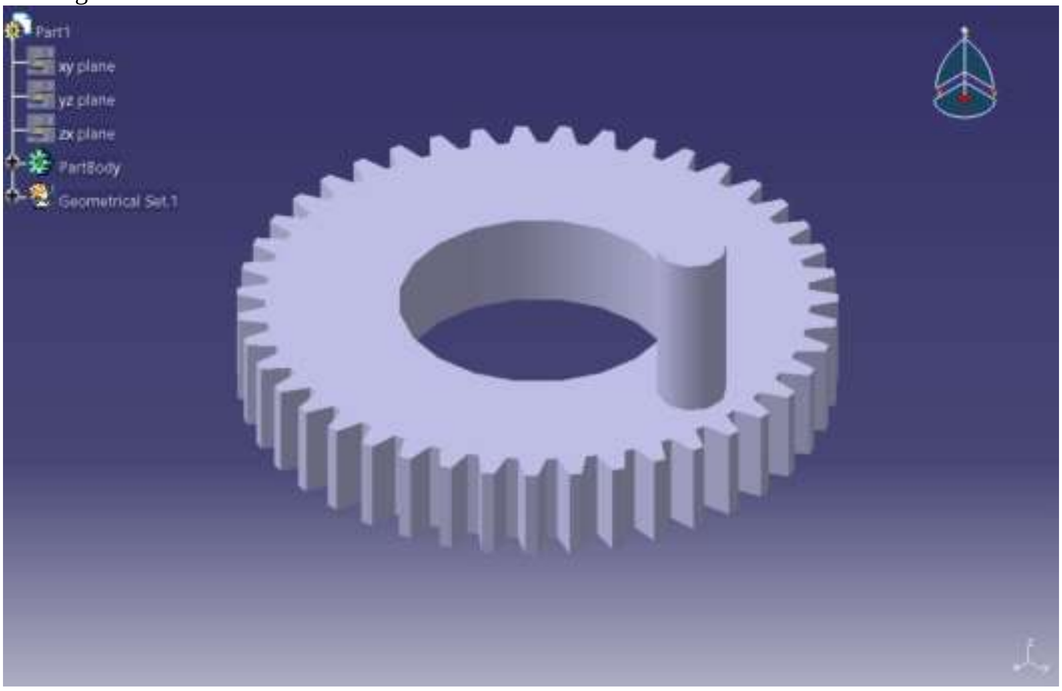


*Figure 4: Design of Internal Gear*

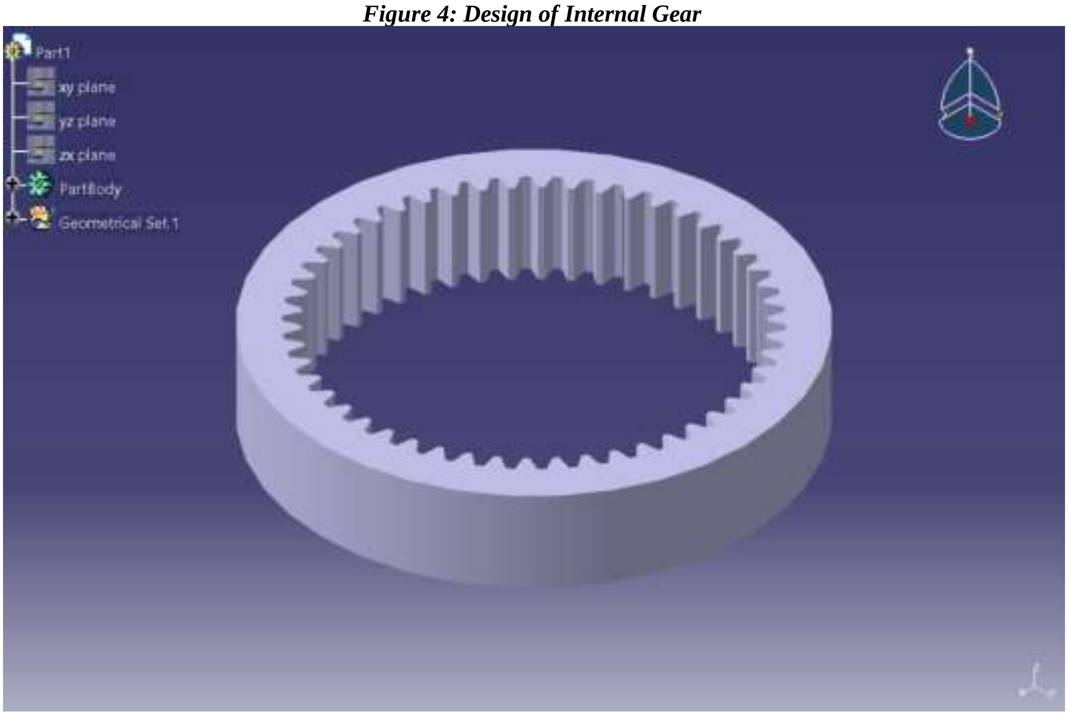


*Figure 5: Design of External Gear*

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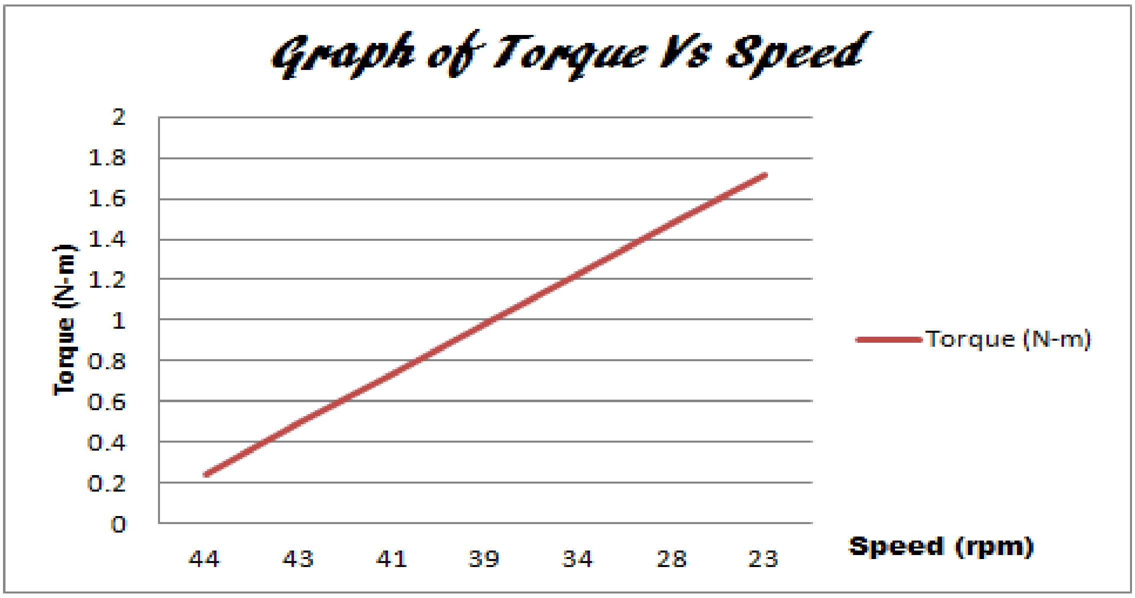
## TEST RESULT

***Table 1. Result Table***

| SR NO | LOAD (gms) | SPEED (rpm) | TORQUE (N.M) | POWER (watt) | efficiency |
|---|---|---|---|---|---|
| 1. | 0.5 | 44 | 0.24525 | 1.130177 | 22.60355 |
| 2. | 1 | 43 | 0.4905 | 2.208983 | 44.17966 |
| 3. | 1.5 | 41 | 0.73575 | 3.15936 | 63.18719 |
| 4. | 2 | 39 | 0.981 | 4.006993 | 80.13985 |
| 5. | 2.5 | 34 | 1.22625 | 4.366595 | 87.33189 |
| 6. | 3 | 28 | 1.4715 | 4.315223 | 86.30446 |
| 7. | 3.5 | 23 | 1.71675 | 4.135422 | 82.70844 |

## GRAPHS OF TORQUE, POWER, EFFICIENCY VS SPEED



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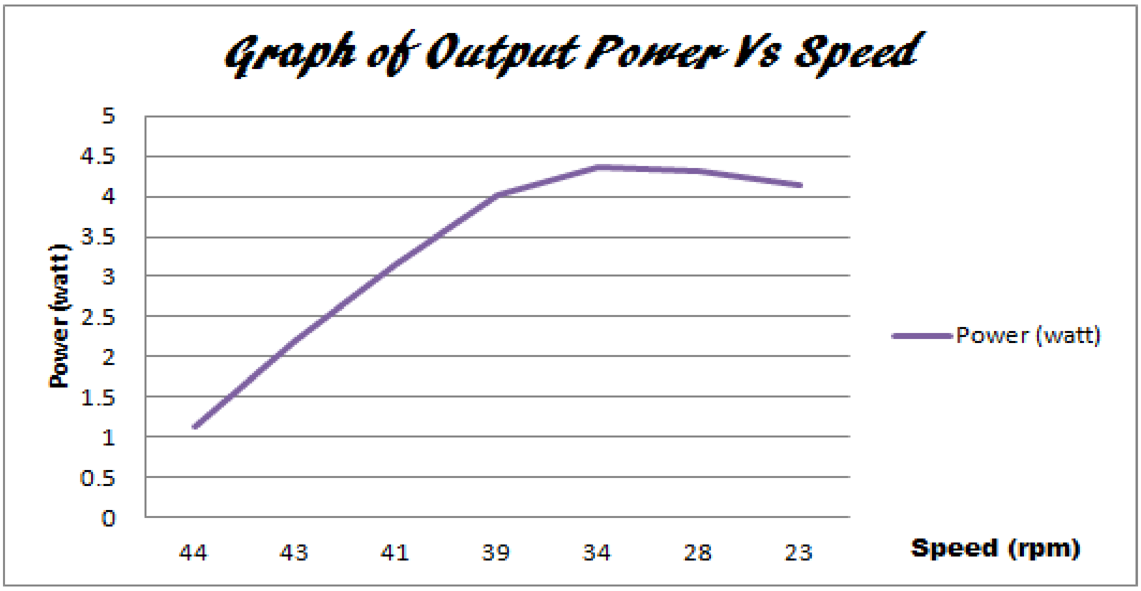


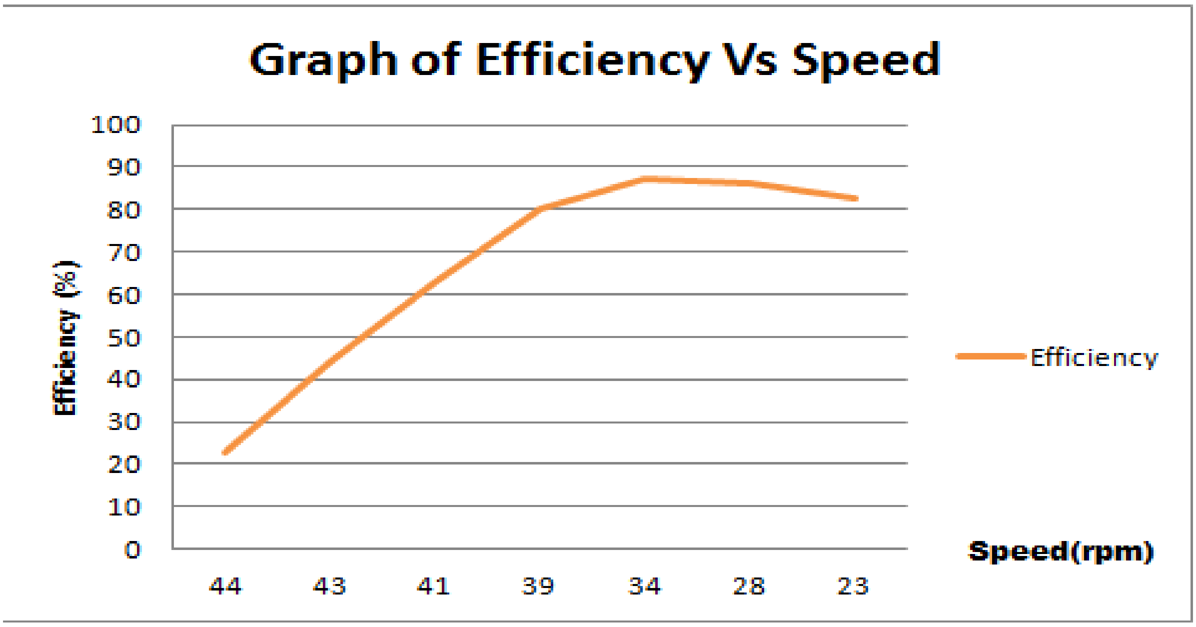


## CONCLUSION

This work has presented a powerful method of enhancement of windmill applications by designing multistage linkage based eclipse gearbox. Performance of windmill increases as well as the power and efficiency is also increases.

- The torque increases with the decrease in the output speed indicating that the device will slow down slightly if the load is increased.
- Power Output indicates a rising trend up to 39rpm output speed and then slightly drops indicating that the operating range of the device is below 40 rpm to obtain maximum power output from the device.
- Efficiency indicates a rising trend up to 39rpm output speed and then slightly drops indicating that the maximum efficiency operating range of the device is below 40 rpm to obtain maximum efficiency from the device.

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