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Design, development and fabrication of water pumping system using wind energy

Swapneel D. Rawool
swapneel.rawool@gmail.com
Independent Researcher

Shreyash S. Koyande.
koyandeshreyash62@gmail.com
Independent Researcher

Sagar S. Vaidya
sagarvaidya25@gmail.com
Independent Researcher

Shailendra S. Surve
shailendrasurve001@gmail.com
Independent Researcher

Shubham S. Prasade
shubhamprasade25@gmail.com
Independent Researcher

ABSTRACT

The project consists of designing, and testing the performance of a Lenz vertical axis wind turbine. Due to the increasing environmental and economic cost of fossil fuels, alternative sources of energy are needed. One such source is wind energy. Much of the current wind turbine research focuses on large scale wind turbine. An alternative approach is a small scale wind turbine design specifically to produce power at low wind speed Water is the primary source of life for mankind and one of the most basic necessities for rural development. The rural demand for water for crop irrigation and domestic water supplies is increasing. At the same time, rainfall is decreasing in many arid countries, so surface water is becoming scarce. Groundwater seems to be the only alternative to this dilemma, but the groundwater table is also decreasing, which makes traditional hand pumping and bucketing difficult. As these trends continue, mechanized water pumping will become the only reliable alternative for lifting water from the ground. Diesel, gasoline, and kerosene pumps (including windmills) have traditionally been used to pump water. However, reliable solar (photovoltaic [PV]) and wind turbine pumps are now emerging on the market and are rapidly becoming more attractive than the traditional power sources. These technologies, powered by renewable energy sources (solar and wind), are especially useful in remote locations where steady fuel supply is problematic and skilled maintenance personnel are scarce.

Keywords— *Wind Turbine, Anemometer, Lenz*

1. INTRODUCTION

1.1 Need of the project

Energy from the air can be utilized in multi various ways. It can be tapped directly from air in the form of electrical energy. The contribution of these sources in the total consumption of energy in the world is about 15%. The scope for application of air energy now stands inherently enhanced through intensive research and development carried out all over the world. Air can be directly utilized for the purpose of cooking and drying. By the same time, it can be also used for boiling of water, air heating and refrigeration. Furthermore wind energy can be utilized for driving motors for pollution free riding at this time, where air pollution plays a major problem for environmentalist.

1.2 Problem statement

Energy from the air can be utilized in multi various ways. It can be tapped directly from air in the form of electrical energy. The contribution of these sources in the total consumption of energy in the world is about 15%. The scope for application of air energy now stands inherently enhanced through intensive research and development carried out all over the world. Air can be directly utilized for the purpose of cooking and drying. By the same time, it can be also used for boiling of water, air heating and refrigeration. Furthermore wind energy can be utilized for driving motors for pollution free riding at this time, where air pollution plays a major problem for environmentalist.

1.3 Objective of the project

- To increase awareness of issues of energy and environment by making use of renewable sources easy and wide spread.
- To provide a cheaper way to utilize energy of wind.

- To reduce our country's energy dependence.
- Look for wide scope in agriculture sector mostly in remote areas since they might face shortage of electricity.

1.4 Scope of the project
Wind is an unlimited source of energy. Unlike non-conventional sources of energy, wind energy is clean source. There is no need to dependent fossil fuels and can be installed in less cost.

2. LITERATURE REVIEW
2.1Review of book
Savonius vertical wind turbine: Design, Simulation and Physical Testing (Eddahmani Aymane, Dr. Hassan Darhmaoui, Dr. Naeem Sheikh.)

2.2 Review of research paper
Design and development of windmill operated water pump: Shubham Choukade, Pune University, MIT Academy of Engineering, Pune, India: Water pumping is very important, most basic wide-spread energy needs in rural areas of the world. It has been found that more than half the world's rural population does not have approach to clean water supply. Water supplies like wells, dugouts, rivers can often use for agricultural fields. However, due to limited availability of power supplies or resources some alternate form of energy has to be used to supply water from the source to a point of consumption. Wind energy is an important source of renewable energy that can be used for pumping water in remote locations.

Development of wind powered water pump: I. F. Odesola, L. G. Adinoyi, Department of Mechanical Engineering University of Ibadan, Nigeria: The wind is a clean and plentiful source of energy. Wind Power is the use of wind's force to generate some form of measurable power or work.

Design and development of wind power water lifting pump mechanism: Hayder Kadhim Khashan, Department of Mechanical Engineering VIT Pune: There has also been an increase of wind power use in developing nations as a source of electric power, or as mechanical energy to pump fresh water from wells. Due to the strides taken in high-strength fibre material technology, variable-speed electric generators, and the experience gained through continued development of wind technology, the cost and difficulty of construction of wind power has significantly decreased to provide more feasible and affordable wind powered machinery.

Design and fabrication of pedal operator reciprocating water pump: Sermaraj M., M.A.R.C.E.T, This project focused on modeling, design and control of pedal operated water pumping, with emphasis on lightweight, portable appliances. An innovative method of minimizing manual stress and thus reliably stabilizing the pumping was also presented

3. PROPOSED WORK
- Literature Review.
- Design consideration and design of wind turbine.
- Preparation of CAD model and drafting.
- Corrective action and Redesign.
- Manufacturing of wind turbine, setup an electric parts and assembly.
- Testing of Project.

4. METHODOLOGY
4.1 Selection of material
After planning a particular machine or mechanism, it becomes very essential to select proper material considering and referring to its strength from machine design data book. To prepare any machine part, the type of material should be properly selected, considering design, safety and following points.

The selection of material for manufacturing our project "Water pumping system using wind energy using wind energy" for engineering application is given by the following factors:
- Availability of materials.
- Suitability of the material for the required components.
- Suitability of the material for the desired working conditions.
- Cost of the materials.
- Aesthetic view
- Weight of the material

4.2 Materials properties
- **Strength:** It is the ability of a material to resist the externally applied forces without Breaking or yielding.
- **Stiffness:** It is the ability of a material to resist deformation under stress. The modulus of elasticity is the erasure of stuffiness.
- **Elasticity:** It is the property of material to regain its original shape after deformation when external forces are removed.
- **Malleability:** The ability of a material to be reshaped in all directions without cracking our technology technician demonstrates the 'malleability' of a material by heating a piece of mild steel until it is red hot. He then beats it with a large forging hammer to reshape it. Because of the high temperature it reaches while heating the steel becomes malleable, it can be reshaped permanently. It often heats up steel, because he likes the color and it matches his complexion after he has run up the stairs.

- **Toughness:** A characteristic of a material that do not break when exposed to a blow or under a sudden shock. Our technology technician demonstrates the 'toughness' of a material by hitting a piece or material to see if it will break or shatter. It has been known to test authentic Chinese Ming Dynasty pottery with the same technique. This is why he is often arrested in Museums and has been banned from the local Antique dealers.
- **Hardness:** The ability of a material to resist scratch, wear and tear and indentation. Our technology technician, dressed in a kilt, slides along the floor to see if it will scratch. It will be considered too hard wearing if it resists scratching.
- **Fatigue Ratio:** The dimensionless fatigue ratio of the stress required to cause failure after a specific number of cycles to the yield stress of a material. Fatigue tests are generally run through 10^7 or 10^8cycles. A high fatigue ratio indicates materials which are more susceptible to crack growth during cyclic loading.

4.3 Mild steel

Table 1: Contents

Carbon	0.20 % - 0.25 %
Manganese max	0.8%
Sulphur, max	0.05%
Phosphorus, max	0.05%
Iron	Remainder

5. CAD MODEL

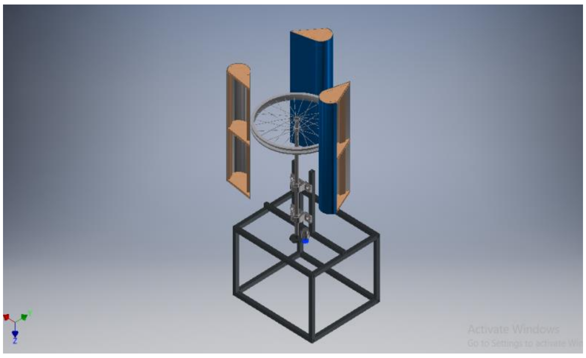

Fig. 1: Cad mode

6. CALCULATIONS

6.1 Blade

Kinetic energy of air in motion given by,

$$(\text{Kinetic Energy/Unit Volume}) = 0.5\rho V^2 \quad (1)$$

$$\text{Volume} = A\times V\times t$$

$$M = \rho\times A\times V \quad (2)$$

We get,

$$KE = 0.5\times\rho\times A\times V3 \quad (\text{Watts})$$

Where (ρ = 1.225 kg/m^3)

$$A = \frac{\pi}{4}\times D^2 (\text{m}^2)$$

Put D = 0.102m

Hence,

$$A = 0.0087 \text{ m}^2$$

$$\text{Available Wind Power (P)} = \frac{\rho\pi D^2 V^3}{8}$$

Trail 1 of velocity 1.94 m/s------ P = 0.0097 Watts

Trail 2 of velocity 3.33m/s-------P = 0.0167 Watts

Trail 3 of velocity 4.17m/s-------P = 0.020 Watts

Tip Speed Ratio (TSR)

$$TSR = (\text{Blade Tip Speed}) / (\text{Wind Speed})$$

$$TSR = (1.94/4.17) = 0.47$$

Frontal Area

$$\text{Frontal Area} = (0.163\times 0.53) = 0.086 \text{ m}^2$$

6.2 Dynamo (generator)

$$\text{Power (P)} = V\times I$$

$$P = 12\times 0.5 = 6 \text{ watts.}$$

$$\text{Power (P)} = \frac{2\pi NT}{60}$$

$$6 = \frac{2\pi\times 100\times T}{60}$$

$$T = 0.57 \text{ N/m.}$$

For 50 RPM

$$\text{Power (P)} = \frac{2\pi NT}{60}$$
$$P = \frac{2\pi \times 50 \times 0.57}{60}$$
P = 2.98 watts.

For 100 RPM

$$\text{Power (P)} = \frac{2\pi NT}{60}$$
$$P = \frac{2\pi \times 100 \times 0.57}{60}$$
P = 6 watts.

For 150 RPM

$$\text{Power (P)} = \frac{2\pi NT}{60}$$
$$P = \frac{2\pi \times 150 \times 0.57}{60}$$
P = 8.95 watts.

6.3 Battery

Time required charging the battery,

$$\text{Charging time of battery} = \frac{\text{Battery Ah}}{\text{Charging current}}$$

Where, Charging current = $\frac{P}{V}$

For P = 2.98 watts

$$\text{Charging time of battery} = \frac{7}{2.98/12}$$
Charging time of battery = 28.18 ≈28 Hrs.

For P = 6 watts

$$\text{Charging time of battery} = \frac{7}{6/12}$$
Charging time of battery = 14 Hrs.

For P = 8.95 watts

$$\text{Charging time of battery} = \frac{7}{8.95/12}$$
Charging time of battery = 9.38 ≈9 Hrs.

6.4 Pump

6.4.1 Voltage consumption rate by pump,

(H= head of the pump)

$$\text{Voltage consumption of pump} = \frac{\text{I.V. of battery} - \text{F.V. of battery}}{\text{Time}}$$

For H = 20 feet

$$\text{Voltage consumption of pump} = \frac{12 - 11}{1}$$
Voltage consumption of pump = 1 V/hr.

For H = 15 feet

$$\text{Voltage consumption of pump} = \frac{12 - 11.25}{1}$$
Voltage consumption of pump = 0.75 V/hr.

For H = 10 feet

$$\text{Voltage consumption of pump} = \frac{12 - 11.8}{1}$$
Voltage consumption of pump = 0.2 V/hr.

6.4.2 Pump Discharge,

$$\text{Discharge (Q)} = \frac{3960 \times \text{WHP}}{H}$$

Where, H = Head of the pump.

$$60 = \frac{3960 \times \text{WHP}}{4}$$
WHP = 0.06 watts.

For H =20 feet

$$Q = \frac{3960 \times 0.06}{20}$$
Q = 11.88 Lit/hr.

For H = 15 feet

$$Q = \frac{3960 \times 0.06}{15}$$

Q = 15.8 Lit/hr.

For H = 10 feet

$$Q = \frac{3960 \times 0.06}{10}$$

Q = 23.76 Lit/hr.

7. STRESS ANALYSIS

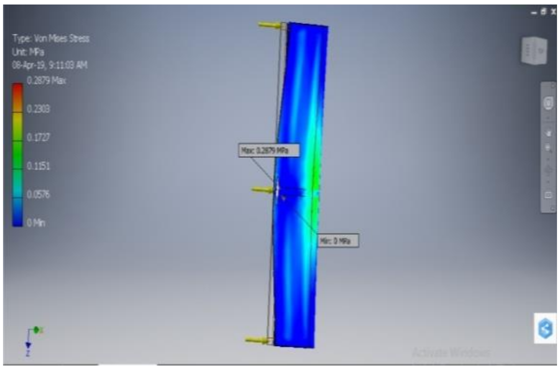

Fig. 2: Stress

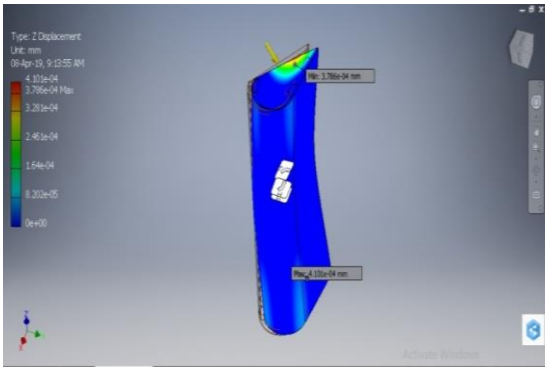

Fig. 3: Displacement

Table 2: Von misses stress on blade

Min von mises stress	0 MPa
Max von mises stress	0.2879 MPa
Min Displacement	3.786e-04 mm
Max Displacement	4.101e-04 mm

8. RESULTS

8.1 Power generation

Table 3: Power generated

S. no	Wind speed (Km /hr.)	Dynamo RPM	Power generated (Watt)
1	10	50	2.98
2	12	100	6
3	15	150	8.95

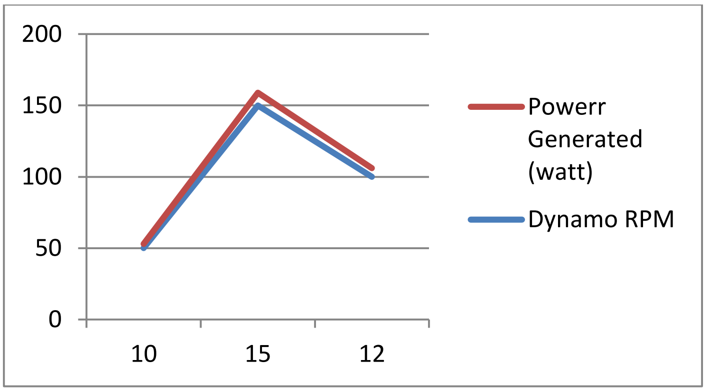

Fig. 4: Wind speed vs. power generated

From the data gathered for different wind velocities, power generated and revolutions per minutes of dynamo could be evaluated. Result 1 shows increase in power as wind speed increases. We have used CAD model and ansys to get respective deformations.

8.2 Voltage consumption and discharge by pump

Table 4: Voltage consumption and pump discharge

S. no	Head of pump (feet)	Voltage Consumption (V / hr.)	Pump Discharge (Lit / hr)
1	10	0.2	23.76
2	15	0.75	15.8
3	20	1	11.88

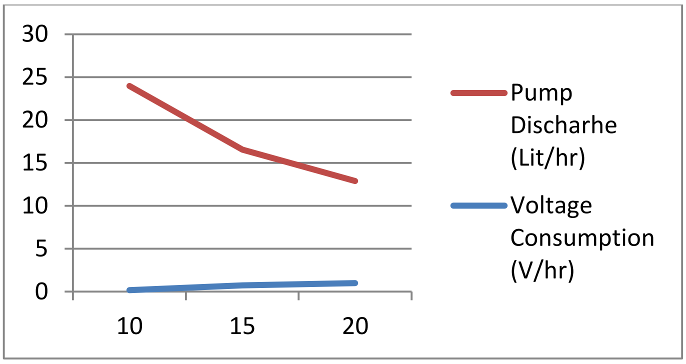

Fig. 5: Head (feet) vs. voltage consumption and pump discharge

Result 2 shows that as the distance increases, the voltage required for the pump increases. While on other side, the discharge decreases with increase in distance in terms of feet.

9. CONCLUSION

In the modern period of rapidly developing technology the design of this vertical axis wind mill generator can be able to full fill certain amount of energy requirements. All materials used are locally available and at a low cost making the model economically viable. In villages, this wind mill can be used for pumping of water when there is no power supply the ease of construction and design modification of the vertical Windmill pump meant that the system is well suited for technological transfer to rural-based community groups. Although it is capital intensive, these technologies will be one of the most cost effective renewable energy wind pumps in terms of the cost per water pumped in very low wind regimes.

10. REFERENCES

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