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The Wind Turbine Operated Water Pump

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Abstract: The imminent exhaustion of fossil energy sources, spreading global warming, expanding greenhouse effect , higher need of energy , less availability of power supplies motivates us to use renewable source of energy like wind-energy which is most prominent for our suitable application. Small wind turbines need to be cost effective, loyal, affordable minimum maintenance cost for any average person. It produces costlier electricity than medium and large scaled wind mills, specially in areas where availability of wind sites are less and in self-governing applications.

However, after perfectly sized and used at optimal working climate, small-scale wind mills could be a dependable energy source and produce socio-economically valuable energy not only in developing countries but also in local applications . The small-scaled wind mills have different aerodynamic behaviour than their large-scale wind mills. Poor performance of small wind mills is due to laminar separation and in turns on the rotor blades because of low Reynolds number (Re) resulting from low wind speeds and small rotor capacity.

Low Reynolds number airfoils permits starting at lower wind velocity , increasing the starting torque and thus improving the overall performance of the turbine .Designing of rotor of windmill will includes optimizing the rotor and its components to achieve maximum power coefficient and efficiency . The pitch twist and allotment of chord length are optimized based on conservation of angular momentum and theory of aerodynamic forces on an airfoil. Blade Element Momentum (BEM) theory is first derived then used to conduct a parametric study that will determine if the optimized values of blade pitch and chord length create the most efficient blade geometry.

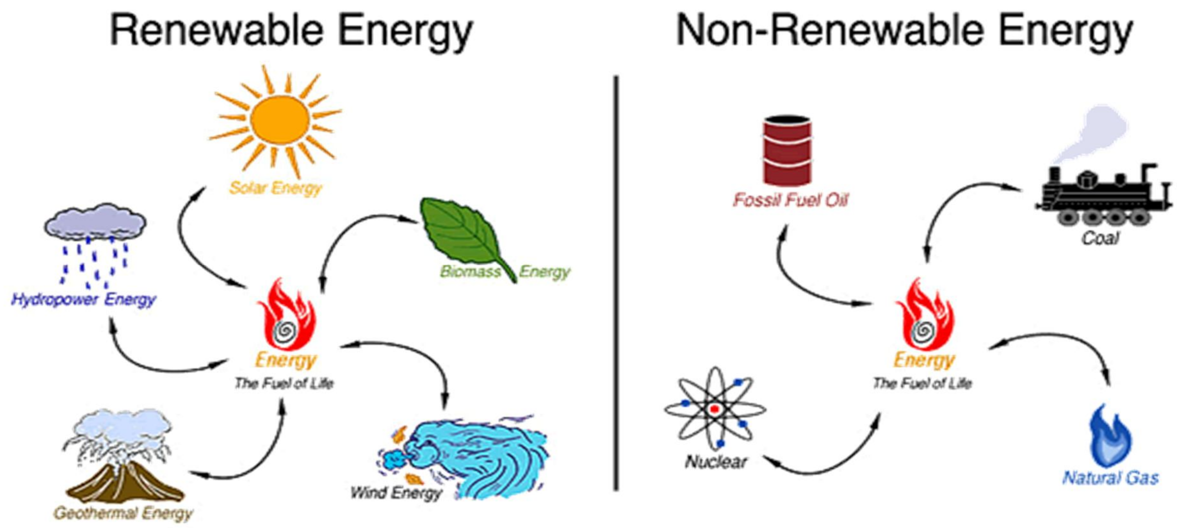
Keywords: Wind pump, Windmill pump, wind operated pump, Water pump, Turbine pump

I. INTRODUCTION

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 [1]. Water supplies like wells, dugouts , rivers can often used 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. A wind pump is nothing but a windmill used for pumping water, either as a source of fresh water or wells. It is one of the earliest methods of utilizing the energy of the wind to pump water.

Popular renewable energy sources making an expandable contribution to the energy supplies in view of encouraging renewable energy sources endowments, limitations and unpredictably supply of fossil fuel , and rise in pressure in environment due to generation of conventional energy. Among the renewable energy resources, the generation of electrical energy & mechanical energy by wind mills has emerged as a feasible and cost-effective option.With the rise in understanding of global warming due to Carbon Dioxide produced by burning of fuels, the use of natural energy resource is coming into picture. Now a day people are started using of natural sources like wind, hydro, solar energy to produce electricity and providing power to the various power-plants. The use of wind mills is one of the most popular methods of using the energy from natural sources. Windmills were used in earlier days to run the pump & pumping the water from the well. Wind mills are not used because they mostly depend on the wind blowing . however, a small scale wind mills can be used to power small home appliances by decreasing the electricity cost and quantity of fuel burnt to produce equal amount of electricity.



A. Objectives

1) To built up small scale wind turbine & to see (study) feasibility of it.
2) To Reduce weight and cost .
3) To design & develop water pump which will cope up with ordinary pump.

B. Need

1) Growing awareness of rising levels of greenhouse gases
2) Global warming
3) Increasing prices of fossil fuels
4) Limited power supplies .
5) Increasing dependency on renewable energy than non renewable source of energy.

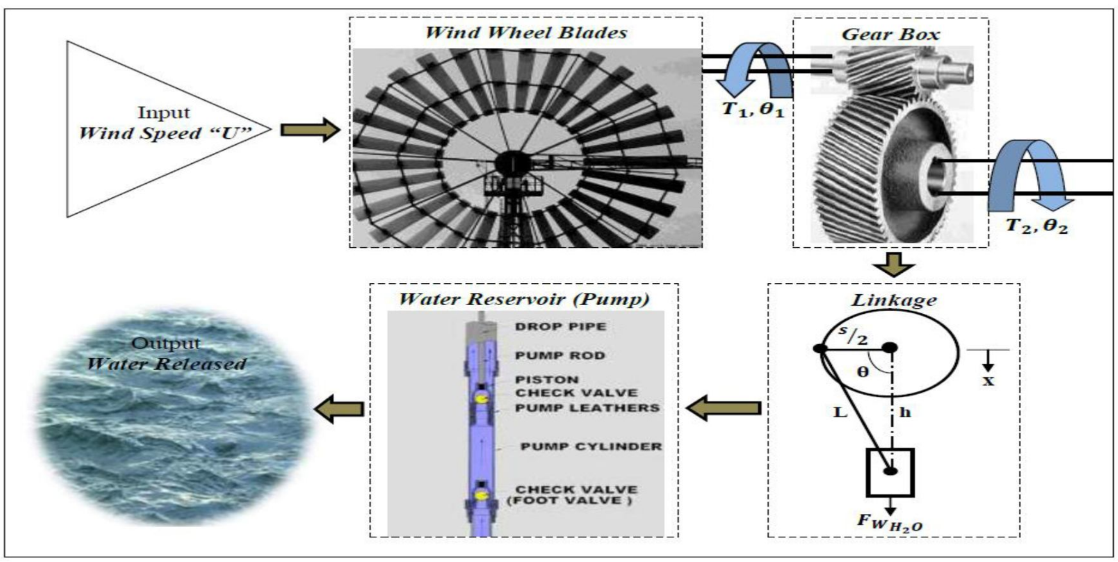
C. Scope Of Project

1) Cascading of Solar and Wind energy for running specific application like waterpump etc.
2) Wind energy can be used for electricity or power generation.
3) Efficiency or power output of pump can be improved by optimizing blade parameters such as blade thickness ,blade length , blade profile , number of blades etc.

D. Methodology

1) Analytical study
   a) Research Papers
   b) Formulas
   c) Empirical Relations
2) Design of small wind turbine blades
   a) Blade angle
   b) Blade height
   c) Blade thickness
   d) Blade length
3) Experimentation with small wind turbines .
4) Measure velocity , power , discharge , torque , head etc.
5) Use the energy produced from small wind turbines for suitable application like pumping water etc.

E. Concept Of The Project



II. LITERATURE REVIEW

The viability of a windmill is greatly affected by its location. The site must have sufficient wind power to move the windmill and also be away from obstructions that might cause turbulence.

The speed of wind for a given location is not constant and thus the climatic condition of the site should be examined for over on a year and recorded on a wind map which is then used to analyze the suitability of the site.

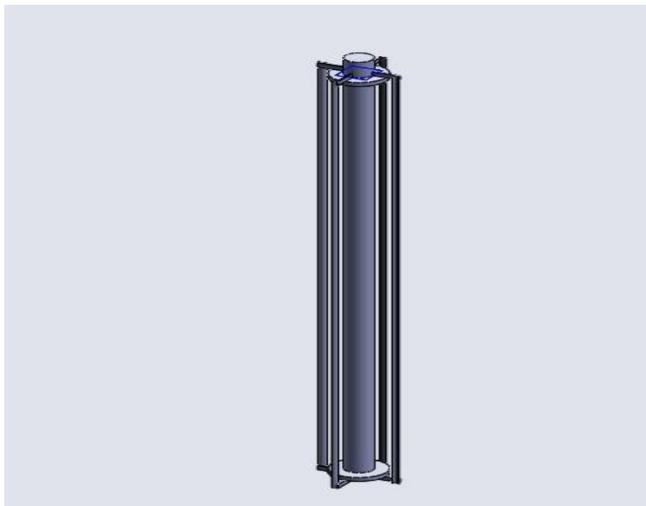
To avoid distractions, most windmills are located on hilly areas or the rigs are tall enough to ensure the rotor is far above the obstacles. The site of our windmill had been identified and there was no need for selection of another site. However we did an analysis on the site to determine its suitability and the findings were as follows:

The winds speed of Nairobi varies from 3m/s to 4m/s and these were the maximum and minimum wind speeds recorded from January to December in the year 2013, hence the site is suitable.

The location of the windmill is strategically away from tall buildings and trees and therefore minimal obstruction of the wind

A. Types Of Wind Turbines

1) *Vertical Axis Wind Turbine:* The vertical axis wind turbine (VAWT) is used for domestic purpose and low volume of production. VAWT requires low cost investment and less space for the installation compared to HAWT. The rotational axis of vertical axis wind turbine is perpendicular to the direction of wind. It can produce electricity at low wind speed. The maintenance of vertical axis wind turbine is quite easy compared to horizontal axis wind turbine. The efficiency of VAWT is optimal so it cannot be utilize for larger volume of production. The main advantages of VAWT compared with HAWT are generation of electricity at ground level and the way of installation is simple.



2) *Horizontal Axis Wind Turbine:* The horizontal axis wind turbine (HAWT) is widely used for higher volume of production which requires huge investment and occupies more space for the installation compared with vertical axis wind turbine (VAWT). The rotational axis of horizontal axis wind turbine is parallel towards the direction of wind in order to generate electricity. It requires large tower and blade to install and the transportation cost is nearly 20% of the equipment of the cost. Highly skilled labors are required to install the horizontal axis wind turbine. The production cost is low

When generating higher volume of electricity. The efficiency of horizontal axis wind turbine is high than the vertical axis wind turbine. The horizontal axis wind turbines are most suitable for sea shores, hill tops etc.

B. Research papers

1) *Mohammed Hadi Ali [1]:* Has carried out experimental comparison and investigation of performance between two and three blades Savonius wind turbine. Due to this purpose, two models of two and three semi-cylindrical blades were designed and fabricated from Aluminum sheet, with having an Aspect ratio of (As = H/D =1), the dimension is (H = 200 mm height and diameter D = 200 mm). These two models were assembled to have overlap zero (e = 0) and a separation gap zero (e' = 0). Subsonic wind tunnel is used to investigate these two models under low wind speed condition, which shows that maximum performance at (λ = TSR = 1) and a high starting torque at low wind speed, and also gives reason for three bladed rotors is more efficient than the two blades, that by increasing the number of blades will increase the drag surfaces against the wind air flow and causes to increase the reverse torque and leads to decrease the net torque working on the blades of Savonius wind turbine.
2) *N.H. Mahmoud [2]:* Has conducted an experimental analysis by using, wind tunnel experimental setup, the experimental results shows that -Three bladed Savonius rotors are more efficient than the three and four bladed Savonius rotors. The rotor with end plates gives higher efficiency than the without end plates. Blades having overlap ratios are better than the blades with without overlap ratios. By increasing Aspect Ratio Coefficient of performance (Cp) will also increase.
3) *Javier Castillo [3]:* Has carried out that, three-bladed design is more efficient than a four-bladed rotor; a low solidity (σ≥4)wind turbine may present self-starting problems as rotor efficiency. CP also decrease at low tip speed ratio, so optimum tip speed ratio is 2.5-3 for H-rotor. He also conclude that Larger radius turbines are more efficient than small turbines at same rotational speed as the tangential airspeed increase leads to smaller angles of attack, bigger Reynolds numbers and thus bigger blade lift coefficients.
4) *U.K. Saha, S. Thotla, D. Maity [4]:* Has conducted that, power coefficient Cp of Savonius rotor depends on number of stages. When number of stages increased from one to two, the rotor shows better performance characteristics, however the performance get degraded when the number of stages become three. These may be increased in inertia of rotor. So the optimum number of stages for Savonius rotor is two. It also concludes from the experimental evidence that a two- blade system gives optimum performance. For two blade two stage Cpis about 30%, V=6-8 m/s.
5) *T. Letcher[5]:* Has carried out experiment in three separate directions Computation Fluid Dynamics (CFD) modelling, generator design and materials/manufacturing process. With the experimental data collected during this project, It was concluded that the power output of combined setup is higher than the single Savonius and Darrieus rotor.
6) *M. Abid, K.S. Karimov[6]:* Experimental study concluded that, combination of NACA 0030 airfoil and Savonius rotor provided the functions required for a starting mechanism. The Savonius and Darrieus blades should have different assemblies to perform effectively. Savonius and Darrieus blades were observed responsible for the low start up speed and high rpm, respectively. Furthermore, the blades with NACA 0030 airfoil provided the high thickness which resulted in an increase in the self-start capability of the turbine. The power output of turbine is around 14 Watt at 5 m/s velocity.
7) *S.M. Rassoulinejad-Mousavi, M. Jamil [7]:* In this paper attempt was made to measure performance of individual H- Darrieus and combined Savonius-H-Darrieus rotor for three different conditions. Conclusion has been summarized from the experimental study that, Combined H-Darrieus and Savonius rotor shows self-starting ability at low wind speed 3m/s. When H-rotor placed at top of S-rotor than, power output (24 Watt) is maximum compare to S-rotor at middle of H-rotor (20 Watt).It has been found that in the case that the two turbines (H-rotor and savonius) are combined, higher performance is acquire in compare with H-rotor. The authors concluded that Combining both savonius and H-rotor with each other makes an effective wind turbine which has better self-starting ability besides higher power coefficient.
8) *Shrikant G. Gawade, D.S. Patil[8]:* Has conducted comparative study of a single stage Savonius with combined Savonius- 3 blade Darrieus. For maximum power output NACA0021 blade profile for H-rotor is taken in to consideration. From experimental study it was concluded, the maximum power co-efficient for Savonius is around 16% while for combined Savonius- H rotor maximum power co-efficient is 39% which is much more improved towards power production.
9) *R. Gupta, K.K. Sharma [9]:* Has studied about the performance of a two-stage two-bladed configuration of the Savonius rotor. Experiments were conducted in a subsonic wind tunnel. The parameters studied are overlap, tip speed ratio, power coefficient (Cp) and torque coefficient (Ct). Optimized Overlap ratio was used to generate maximum performance of the rotor. The study showed that maximum Cp of 0.25 was obtained at 20% overlap condition. Similarly power and torque coefficients decrease with the increase of overlap from 0% to 16.2%.

10) *S. Brusca, R. Lanzafame[10]:* This experiment work looks at designing a vertical-axis wind turbine to maximize its power coefficient. It has been seen that the power coefficient of a wind turbine increases as the blade's Reynolds number rises. By experimental study it was found that the ratio between blade height and rotor radius (aspect ratio) influences the Reynolds number and as a consequence the power coefficient. It has been highlighted that a turbine with a lower aspect ratio has several advantages over one with a higher value. The advantages of a turbine with a lower aspect ratio are: higher power coefficients, a structural advantage by having a thicker blade (less height and greater chord) and greater in-service stability from the greater inertia moment of the turbine rotor.
11) *Richard m. keslo et al. [11]:* Conducted that performance variation of leading edge for distinct airfoil profiles. Anexperimental screening has been undertaken to determine the impact of sinusoidal leading-edge protrusions on the performance of two NACA airfoils with different aerodynamic characteristics. Force measurements on full-span airfoils with manifold combinations of tubercle amplitude and wavelength expose that when compared to the unmodified equivalent, tubercles are more beneficial for the NACA 65-021 airfoil than the NACA 0021 airfoil. The authors concluded that NACA 0021, which has maximum thickness at 30% of the chord, increased lift performance in the post stall domain.
12) *Franklyn Kanyako et al. [12]:* Has carried out that highlighted the progress made in the development of aerodynamic models for forecasting the performance of straight-bladed, fixed-pitch vertical axis wind turbine blade profiles. An improved blade element momentum algorithm using a hybrid database was built to survey the solidity of the turbine, by analysing the effect of blade chord, radius, and number blades at different tip speed ratios. The authors have done 2-D numerical investigation to compare the performance prediction scope of the CFD and mathematical model. The authors concluded that negative and/or minimum Cp and torque are generated at lower tip speed ratios, which indicate that NACA 0015, NACA 0018, and NACA 0021 airfoils are not self-starting. Nevertheless, NACA0021 has shown to have better starting performance than the other two airfoils due to its intimate section.
13) *Micol Chigliaro [13]:* The authors concludedthat a nominal reduction of overall rotor performance with the enlargement of its shaft diameter.From this study, concludes that aerodynamic blade profile NACA 0012, NACA 0015, NACA 0018, NACA 0021, NACA 0025, NACA 0063 are advisable for Darrieus rotor. Many researchers have used these blade profiles for wind applications using other solidities and other models. It has been also observed from literature survey that blade profile NACA 0021 has batter starting function due to its thickness. It has been also observed that Combining both savories and H-rotor with each other makes an effective wind turbine which has better self-starting ability besides higher power coefficient.

III. TYPES OF WIND TURBINES

There are two types of wind turbines. One is Vertical axis wind turbines and the other is horizontal axis wind turbines**.** We also know that there is sufficient wind to satisfy much of humanity's energy requirements – if it could be gathered effectively and on a large scale.

1) *Vertical Axis Wind Turbines (VAWT):* Vertical axis wind turbines **(**VAWTs) which may be powerful, practically simpler and significantly cheaper to build and maintain than horizontal axis wind turbines **(**HAWT**s**). They have advantages, such as they are always facing the wind, which might make them a important for cheaper, cleaner renewable resources of electricity. VAWTs might even be critical in problems like currently facing electricity producers and suppliers. Moreover, cheaper VAWT's which may provide an alternative to destruction of the rain forest for the growing of bio-fuel crops.

Vertical axis wind turbines (VAWTs) in addition to being simpler and cheaper to build, it has the following advantages:

a) They are always facing the wind hence no need to escort for the wind.
b) Have greater surface area for energy storage hence can store more energy.
c) Are more efficient in stormy or breezy winds.

Can be installed in locations like on roofs, along highways, in parking lots.

- Can be scaled more easily from milliwatts to megawatts.
- Can be significantly less expensive to produce as they are inherently simpler .
- Can have low maintenance downtime as mechanisms are at or near ground level.
- Produce less noise due to low speed hence less noise.

2) *Horizontal Axis Wind Turbines (HAWT):* Horizontal-axis wind turbines (HAWT) has the rotor main shaft and electrical generator at the top of a tower, and may be pointed into or out of 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.

Some advantages of HAWT are –

a) Variable blade pitch which gives the blades of turbines the optimum attack angle. Allowing the attack angle to be adjusted gives greater control, so that turbine can stores the maximum amount of wind energy for the day and season time .
b) High efficiency, since the turbine blades always move perpendicularly to the wind, collecting power through the whole rotation. All vertical axis wind turbines, and most airborne wind turbine designs, include various types of reciprocating actions, requiring surfaces of the airfoil to backtrack against the wind for part of the cycle. Backtracking against the wind give rise to inherently lower efficiency.
c) The taller tower base provides access to stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the speed of the winds can increase by 20% and the output power by 34%.

A. Characteristics & Specifications Of Windturbines

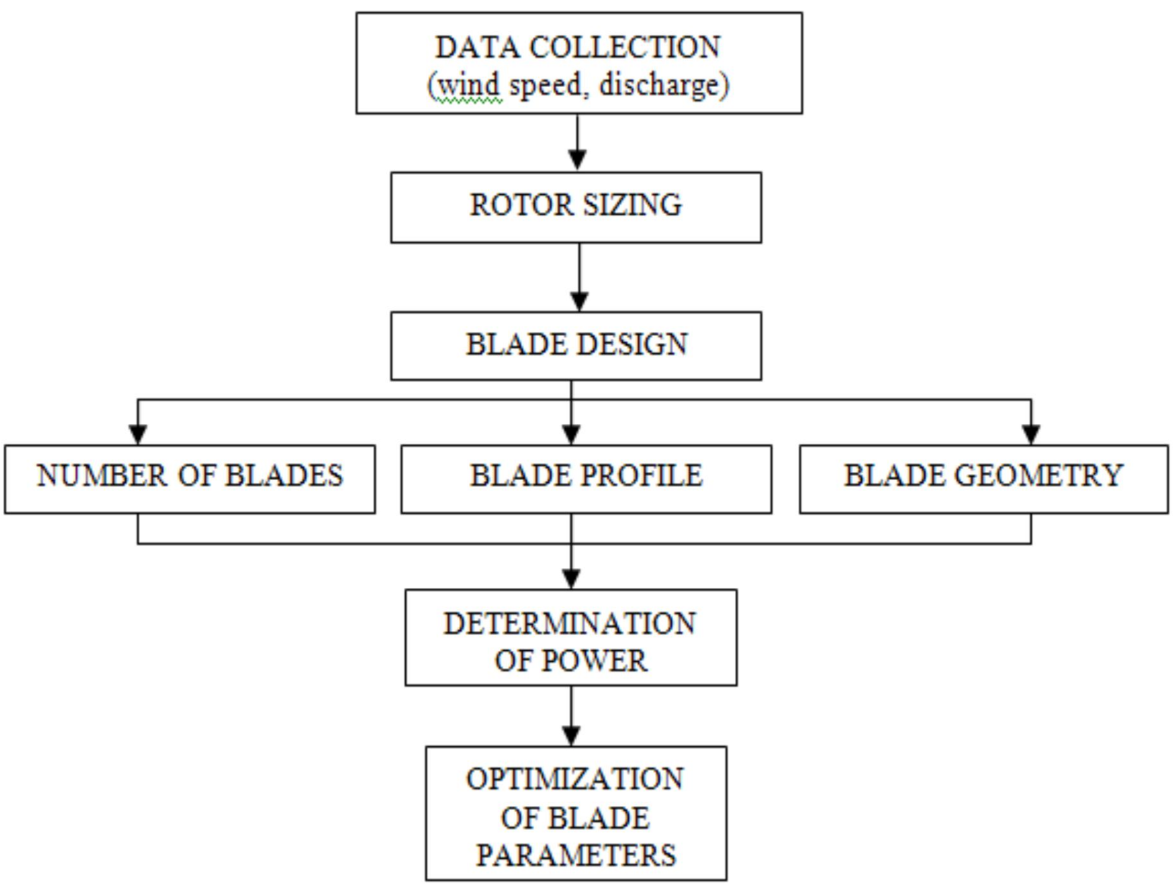
1) *Wind Speed:* This is very important to the productivity of a windmill. The wind turbine only produces power with the wind. The wind rotates the horizontal or vertical axis and causes the generator shaft to sweep past the magnetic an electric current. b) Blade Length:- This is important as the blade length is proportional to the swept area. Larger blades have a greater swept area and thus catch more wind. Because of this, they may also have more torque. c) Base Height:- The height of the base affects the windmill immensely. If the windmill is higher, it will become more productive as the altitude increases due to which increase in winds speed. d)Base Design:- Some base design may be more stronger than others. Base is most important during the construction of the windmill because not only they support the windmill, but also they are subjected to their own weight and the drag of the wind. If a tower having weak base is subjected to these elements, then it will definitely collapse. Therefore, the base must be identical to ensure a fair comparison.

B. Requirements For Placing

1) *Site Selection Considerations:* The power available in the wind increases rapidly with the speed; hence wind energy conversion machines should be placed in areas where the winds are strong & endless. The following point have to be understand while selecting site for Wind Energy Conversion System (WECS).
2) *High Annual Average Wind Speed:* The wind velocity is the most important parameter. The power in the wind Pw, through a given X – section area for a uniform Velocity of wind is given as : Pw = KV3 (K is constant) It is important, because of the cubic dependence on velocity of wind. small increases in V affect the power in the wind **E.g**. doubling V, increases Pw by a factor of 8.
3) *Availability of Wind V (t) Curve at the Proposed Site:* This availability of wind curve help us to determine the maximum energy in the wind and hence it is desirable to have average speed of wind V such that V ≥ 12-16km/hr i.e. (3.5 – 4.5 m/sec).
4) *Wind Structures at the Proposed Site:* Wind notably near the ground is turbulent and gusty, & changes rapidly in direction and in velocity. This separation from homogeneous flow is called as ―the structure of the wind‖.
5) *Altitude of the Proposed Site:* It affects the air density and thus the power in the wind & hence a useful WECS electric power o/p. The wind tends to have higher velocities at higher altitudes.
6) *Local Ecology:* If the surface is naked rock it may mean lower hub heights hence lower cost of structure, if trees or grass or venations are present. All of these tends to destructure the wind.
7) *Nearness of Site to local center/Users:* This criterion decreases length of transmission line, hence losses & costs.
8) *Nature of Ground:* Ground condition should be such that the foundations for WECs are secured, surface of ground should be stable.

IV. DESIGN PROCEDURE

Steps in designing rotor of small wind turbines are as follows:



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V. MATERIAL CONSIDERATION FOR WINDMILL

The efficiency of a wind mill changes thus for good output it is important to check material and its property for different material the property are shows in Fig (Table).

Property	Aluminum Extrusions	Molded Plastic	Wood	Vinyl (Polyvinyl Chloride)
Strength (Tensile)	Very good mechanical properties.	Wide variation in properties from 0.08 to 8 tensile strength of aluminum extrusions for glass filled compounds.	Good compressive properties, variable with the species of wood and moisture content.	Low mechanical properties.
Density	Lightweight about 1/3 that of copper or steel.	Very lightweight about 60% the weight of aluminum.	Very lightweight about 1/3 the density of aluminum.	Very lightweight about 60% the density of aluminum.
Strength	Very Good.	good.	good.	good.
Formability	Easily formable and extruded in a wide variety of complex shapes including multi-void hollows.	Easily formed or molded into complex shapes.	Poor; cannot be routinely formed.	Easily formed or molded into complex shapes.
Electrical Conductivity	Excellent; twice as efficient as copper, used in bus bar and electric connector applications.	Poor; used as an insulator, high dielectric capability.	Poor; cannot be used as an electrical conductor Usually cannot be employed as an insulator.	Poor; electrical and thermal insulating characteristics.
Thermal Conductivity	Excellent; ideal for heat exchanger applications.	Poor; low coefficient of thermal (heat) transfer.	Poor.	Poor.
Finishing	A finishes can be applied including mechanical and chemical prefinishes, anodic coatings, paints and electroplated finishes.	Color can be integral with material as well as plated, painted, and hot stamped.	Paint and stain coatings can be employed.	Color can be integral with material.

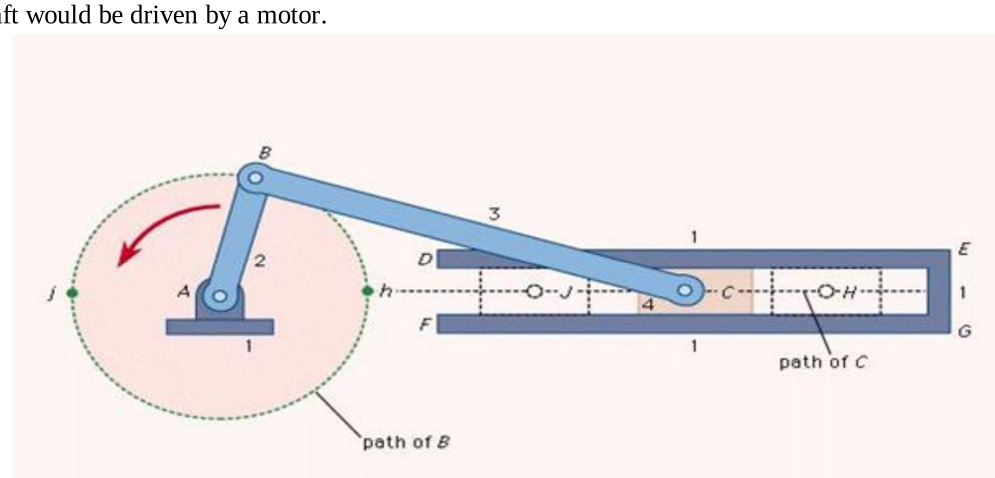
VI. CONSTRUCTION DETAILS

A. Vertical Axis Wind Turbine

Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically. Important advantages of this arrangement is that the turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where the wind direction is highly variable, for example when integrated into buildings. The key disadvantages include the 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.

B. Slidercrank Mechanism

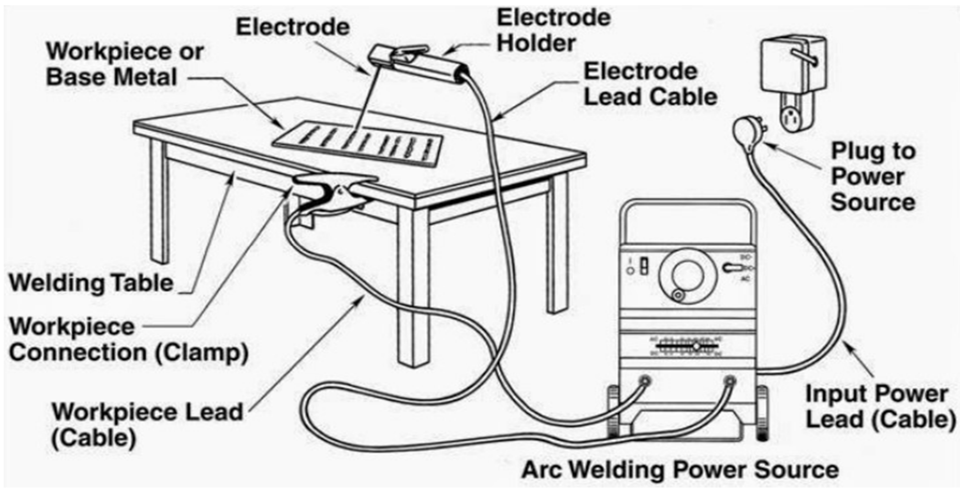
Arrangement of mechanical parts designed to convert straight-line motion to rotary motion, as in a reciprocating piston engine, or to convert rotary motion to straight-line motion, as in a reciprocating piston pump. The basic nature of the mechanism and the relative motion of the parts can best be described with the aid of the accompanying figure, in which the moving parts are lightly shaded. The darkly shaded part 1, the fixed frame or block of the pump or engine, contains a cylinder, depicted in cross section by its walls DE and FG, in which the piston, part 4, slides back and forth. The small circle at A represents the main crankshaft bearing, which is also in part 1. The crankshaft, part 2, is shown as a straight member extending from the main bearing at A to the crankpin bearing at B, which connects it to the connecting rod, part 3. The connecting rod is shown as a straight member extending from the crankpin bearing at B to the wristpin bearing at C, which connects it to the piston, part 4, which is shown as a rectangle. The three bearings shown as circles at A, B, and C permit the connected members to rotate freely with respect to one another. The path of B is a circle of radius AB; when B is at point h the piston will be in position H, and when B is at point j the piston will be in position J. On a gasoline engine, the head end of the cylinder (where the explosion of the gasoline-air mixture takes place) is at EG; the pressure produced by the explosion will push the piston from position H to position J; return motion from J to H will require the rotational energy of a flywheel attached to the crankshaft and rotating about a bearing collinear with bearing A. On a reciprocating piston pump the crankshaft would be driven by a motor.



VII. FABRICATION TECHNIQUES

A. Arc Welding

Arc welding uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is sometimes protected by some type of inert or semi-inert gas, known as a shielding gas, and/or an evaporating filler material. The process of arc welding is widely used because of its low capital and running costs The following gauge lengths of electrodes are used in this process 8, 10&12mm. The number of electrodes used in this fabrication is around 40-45 electrodes.



B. Metal Cut Off Grinder

This Is a Grinder Which Is Use in for Cutting A Metal Sheet , Metal rod..etc. This Machine Are Work On Alternating current. The Metal Cut Off Grinder are having Large Cutting Tool Called Cutting grinder Which Is use for cutting of stainless steel alloy cast iron metal sheet metal rod etc….this blade is made of steel.

C. Surface Grinder

This is a hand grinder which is used for finishing the welded material; this grinder is easy to handle. This Grinder Are work on a alternating current. This grinder are having grinding blades which is use for finish rough surface then sharp edges…etc. The blade made up of abrasive material, mild steel cast iron, etc.

VIII. CONCLUSION

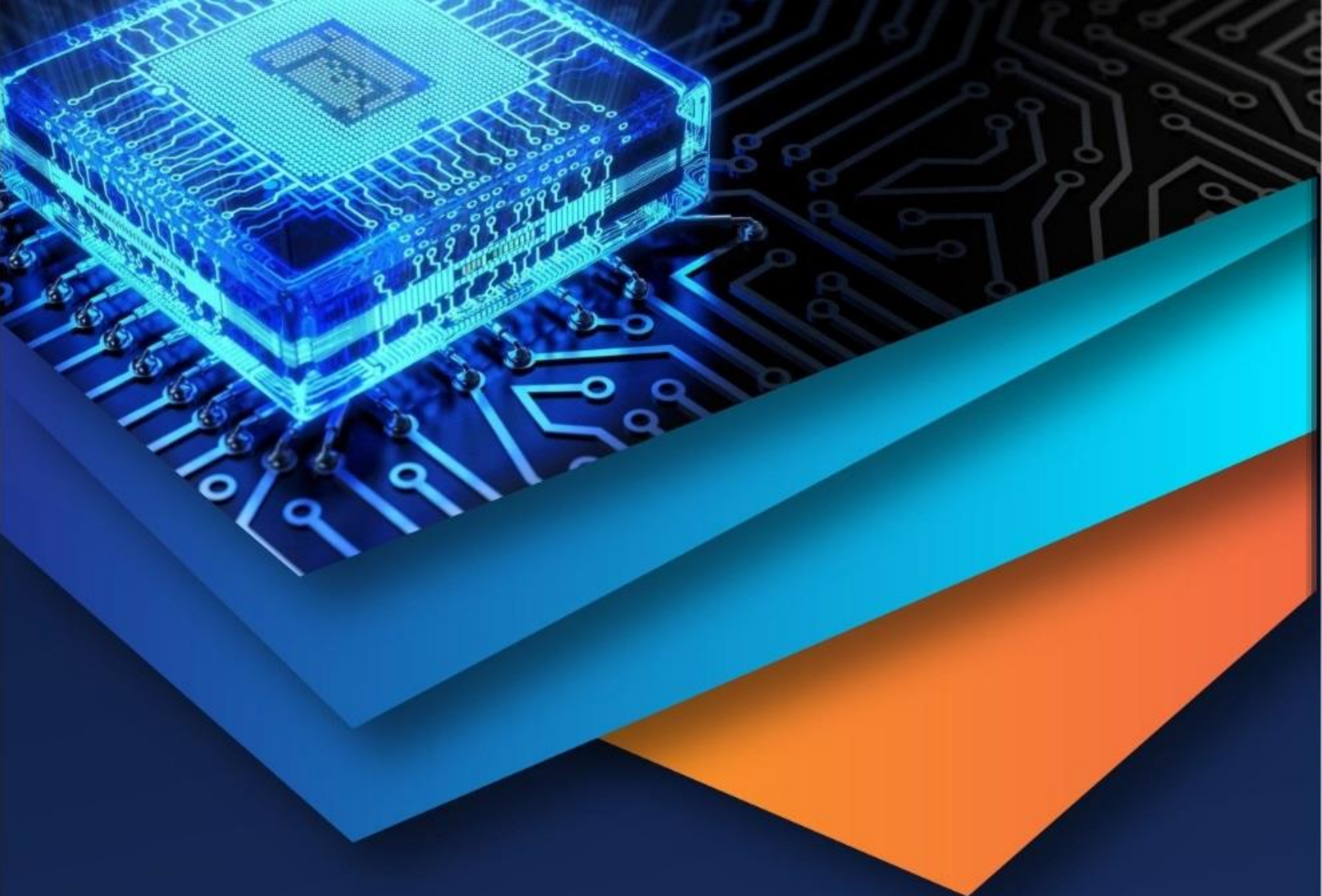
We design make project which run successfully. Our wind turbine generates average 7.2 watt power in one mi, Our pump discharge 600 ml water in one minute. The goal of project is accomplished from the requiresanalysis and fabrication of prototype that is utilization ofwind power to pumping water and generate electricity. In our design, we used a horizontal axis windmill with 3 blades and we generate power from windmill and store In battery and use that power to drive the pump.

A. Future Scope

By keeping solar panels to rotate the wind mill we can pump easily where no power consumptions is required to pump the water. Efficiency or power output of pump can be improved by optimizing blade parameters such as blade thickness, blade length, blade profile, number of blades etc.

REFERENCES

[1] Mohammad Hadi Ali, ‘‘Experimental Comparison Study For Savonius Wind Turbine of Two & Three Blades At Low Wind Speed”,International Journal Of Modern Engineering Research (IJMER) Vol.3 Issue 5, Sep-Oct .2013 PP -2978-2986.
[2] N.H.Mahmoud, A.A El-Haroun, E.Wahba,M.H.Nasef‘‘AnExperimental Study on improvement of Savonius rotor performance”, AlexandriaEngineering Journal (2012)51, 19-25.
[3] Javier Castillo, ‘‘Small-Scale Vertical Axis Wind Turbine Design”,December2011.
[4] U.K. Saha S.Thotl, D.Maity, ‘‘Optimum Design Configuration Of Savonius rotor Through Wind Tunnel Experiments”, Journal of WindEngineering and Industrial Aerodynamics 96 (2008) 1359– 1375.
[5] T. Letcher, ‘‘Small Scale Wind Turbines Optimized for Low Wind Speeds”, The Ohio State University, Columbus, OH.
[6] M.Abid,K.S.Karimov,H.A.Wajid,F.Farooq,H.Ahmad,O.H.Khan, ‘‘Design, ‘Development and Testing of a Combined Savonius and DarrieusVertical Axis Wind Turbine”,Iranica Journal of Energy& Environment,ISSN:20792115.
[7] S.M.Rassoulinejad-Mousavi, M.Jamil, M.Layeghi, ‘‘Experimental Study of a Combined Three Bucket H-Rotor With Savonius WindTurbine”, World Applied Sciences Journal 28(2):205-211, 2013,ISSN 1818-4952.
[8] Shrikant G. Gavde, Prof. D.S.Patil,‘‘Comparative Study Of A Single Stage Savonius With A Combined Savonius-Three BladedDarrieus”,International Journal For Technological Research In Engineering Volume 2,Issue 6,February-2015 ISSN(online): 2347-4718.
[9] R.R.Gupta,R.Das&K.K.Sharma, ‘‘Experimental Study of a Savonius –Darrieus Wind Machine”,International Conference On RenewableEnergy For Developing Countries-2006.
[10] S.Brusca, R.Lanzafame, M.Messina ‘‘Design of a Vertical-Axis Wind Turbine: How The Aspect Ratio Affects TheTurbine’sPerformance”,International Journal Energy Environment Engineering(2014)5:333-340.
[11] Anurag Kumar, AlokNikhade, “Hybrid Kinetic Turbine Rotor”,International Journal Of Engineering Science And Advance Technology,ISSN:2250-3376, Volume-4, Issue 6, 453-463.
[12] Darrieus G.J.M, “Turbine having its rotating shaft transverse to the flow of current”, US patent no. 1.835.018,1931.
[13] Richard M. Kelso, “Performance Variations of Leading-Edge for Distinct Airfoil Profiles”, AIAA Journal, Vol.49, No.1, January 2011.



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IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

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