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Modified Prototype of Wind Powered Water Pump

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Abstract: **India is a country which is abundant in natural resources; the substantial availability of renewable energy sources in the form of solar, hydropower and wind energy can provide opportunities of sustainable energy based development. The Indian government began to pay more attention to wind energy utilization in rural areas. Because the wind energy resource in many rural areas is sufficient for attractive application of wind pumps, and as fuel is insufficient, the wind pumps will be spread on a rather large scale in future**.

Keywords: **natural resources, renewable energy, wind pumps, insufficient fuels.**

I. INTRODUCTION

Energy today has become ultimate need of world. Today every application which has been develop in the world require energy supply for its functioning but population of the world is increasing causes tremendous pressure on the energy and mineral resources leading to their exploitation. More ever the greenhouse gases are increasing due to exploitation of these resources. So we need to focus an alternative solution for this problem. Light, wind, Biomass, water etc. are some of the alternative for this problem. Wind is one of the most clean and highly abundant resources in nature.

So focusing on this concept wind turbine are being developing the world. They are mostly classified as horizontal axis wind turbine and vertical axis wind turbine.

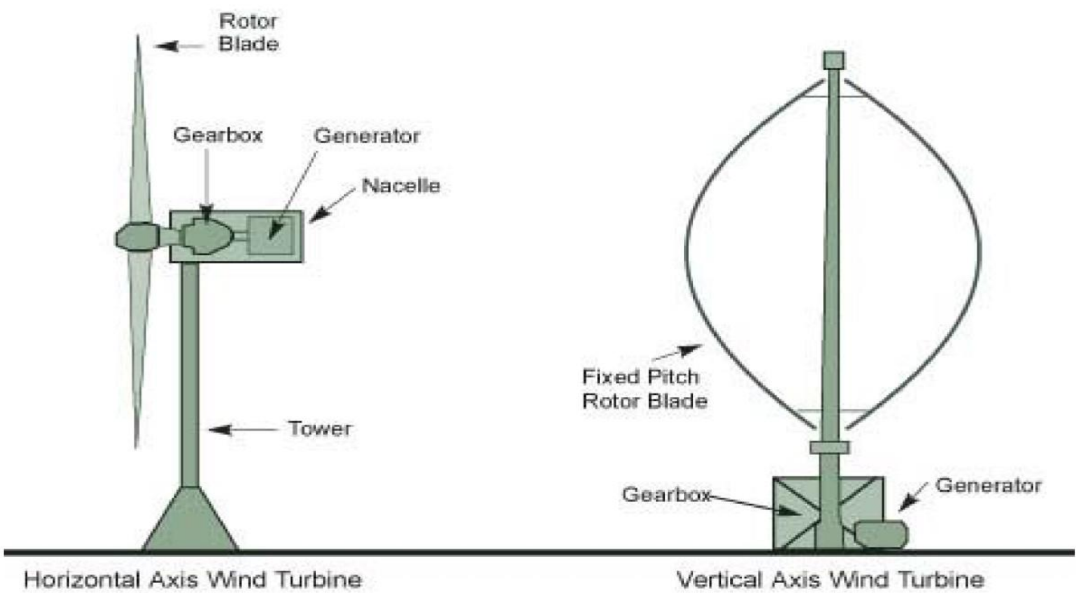

Fig. horizontal axis and vertical axis wind turbine

In horizontal axis wind turbine blades are perpendicular to the horizontal axis of rotation. Both rotor shaft and blades are mounted in the horizontal axis wind turbine require Yaw control mechanism which is used to direct the direction of rotation of blade in the direction of wind pump. This wind turbines are mostly used for high commercial purpose as compare to vertical axis wind turbine. This wind turbine are mostly available in the segment of 350kw, 650kw, 1Mw, 2Mw as so on for commercial purpose.

Vertical axis wind turbine are as important as horizontal axis wind turbine from commercial point of view. Vertical axis wind turbine are developed in world and they have the advantage over horizontal axis wind turbine with absence of Yaw control system. Due to absence of Yaw control system it acts as Omni direction (it accept wind from all direction). VAWT need not to be directed in the direction of wind flow. It can be rotated in any condition with different variable wind flow, here the Darrius wind turbine is discussed below.

With the spinning of Darrius wind turbine, the rotor blades of turbine also move in circular path in forward direction creating positive angle of attack. Resultant force act on the line of action. The rotor rotate as force is projected inward past the turbine axis leaving the positive torque to the shaft. The angle of attack changes as per the direction of wind flow. The rotor spin regardless of wind speed. Thus energy is obtained from the torque and speed due to the rotation of rotor shaft. More ever the concept of lift and drag is totally neglected in VAWT.

Rigging angle-

It is angle between rotor blades and adjoin structure.

Yaw control system-

It is system used in horizontal axis wind turbine to direct direction of turbine blade in direction of wind flow.

Rotor blade-

Rotor blade used in VAWT robust in construction connected from top to bottom in adjoining assembly. This turbine blade is symmetric in nature to create positive angle of attack in direction of wind flow.

Electric generator-

Mechanical work is obtained from rotation of turbine blade due to high speed wind and further converted to the torque leading to generation of electricity.

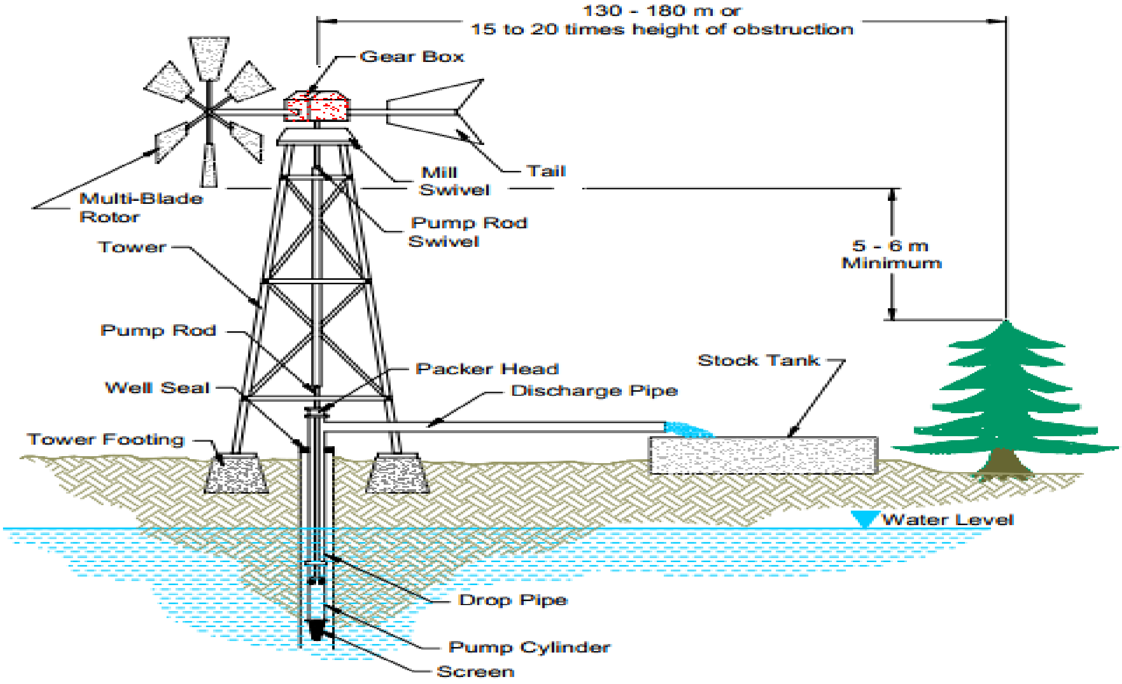

Fig: Wind operated water pump

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Moreover wind mill could also be used for irrigation purpose along with generation of electric power, so the concept of horizontal wind powered water pump developed in the world. Rotor blades rotate in the direction of wind flow and motion is transmitted to the pump via gears drives mechanism and connecting rod. The upward and downward movement of piston takes place in the water pumping. With the upward movement of piston vacuum is created leading to the suction of water from the source. Thus water is pumped out and the real motto of this technology to obtain the electric power and pumping of water is obtained.

II. MATERIAL SELECTION

Material selection plays very important role for design and fabrication of any prototype. Material selected should have optimum and reliable properties as per requirement of variable environmental condition. Commercially many material with high strength and rigidity are available in the market.

COMMONLY USED MATERIAL IN WIND TURBINE BLADE:

From the past time wood was primarily used for making wind turbine blade. Wood has high rigidity but is possess low stiffness, so it has limitation of bending. Due to this region it lost its potential for manufacturing of wind turbine blade with advancement of technology related to wind turbine. With the further research alloy steel was preferred for manufacturing wind turbine blades, but it is excessive weight brought various problem for turbine assembly. Moreover it has low fatigue resistance and high cost another material which proved to be useful for manufacturing wind turbine blade was polymer matrix composite and is used still today. Composite are proving good material for manufacturing the turbine blades but they are suffering in mechanical properties due to limitation of resin transfer.

FEW MATERIALS USED IN WIND TURBINE BLADES DUE TO THEIR SPECIFIC CHARACTERISTICS:

POLYESTER RESIN-

Polyester Resin is most commonly used material in industry. This material is most preferred for manufacturing turbine blade as it shows better water resistance ability, its mechanical properties could be improved with the help of suitable catalyst accelerator and additives. Polyester is chemically resistant but sometimes become brittle where certain shock load is applied. When turbine blade reaches to certain level while rotation well before its ultimate strength cracks start to appear. Thus it is poor to handle high fatigue stresses, due to these small cracks water, moisture is well able to penetrate or adsorbed in the material decreasing its mechanical strength.

EPOXY RESIN-

Epoxy resin is another most wide and suitable material for manufacturing turbine blades. It possess superior properties in terms of load carrying ability, resistance to environment degradation highly adhesiveness, and tensile strength of 85Mpa and Young’s modulus of 10.5Gpa. It causes low viscosity and low shrinkage capacity thus maintaining good dimensional tolerances.

VINYL EASTER RESIN-

This resin had good chemical structure due to which it shows improved shock loading capacity. It has high stiffness, rigidity, water and chemical resistance, inspired operate good physical and mechanical properties. It is less popular as found to be having adverse effect of human health.

THERMOPLASTIC-

Matrix here is having good fatigue strength abrasion but, it has problem of disposal techniques which include in land fill, recycling, incineration etc.

ARAMID FIBRE-

It is also material which possess the properties suitable for manufacturing of turbine blade. It has a high specific strength and available in the bright golden filament.In spite of its such accident properties t is susceptible to water in grace, ultra violet ray erosion, sand erosion, insect collision due to this limitation its impact in manufacturing of wind turbine blades is decreases.

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CARBON FIBRE-

It is one of the material which has proved to be most suitable material from the manufacturing point of view in every application in the developed world. Carbon fibre available in three different categories high strength, intermediate module, ultra-high module. It has highest strength in tension and compression can possess very high resistance to fatigue, creep and corrosion. In spite of this most suitable optimum and reliable properties it proves to be less feasible due to its high cost.

HIGH SUITABILITY OF POLYPROPYLENE MATERIAL-

We discussed many material for manufacturing of our prototype but it has some limitations; so to overcome this limitations with the material of high mechanical, physical, chemical properties we selected property material.

PP Plastic material has high chemical and corrosion resistance that it has inert nature with less reactivity towards corrosive chemicals. It is light in weight with high rigidity to overcome sudden high shock loading. It has high tensile strength so that it can overcome sudden fatigue stresses and avoid forming of cracks and pores. It has excellent abrasion resistance properties which prove to be helpful for working of wind turbine in adverse environmental conditions with high wind speeds. It has low moisture absorption properties as cracks and pores are avoided due to high ultimate tensile strength. It is easy to use and cut due to which it can be fabricated in any required shape. It has excellent thermal insulation and dielectric properties due to which our prototype can be protected against sudden lighting taking place moreover it has flame retardant property thus proves to be lifelong material, hence due to all this excellent properties it proves to be the most optimum material for turbine blade.

III. PERFORMANCE PARAMETER

POWER AVAILABLE IN WIND-

P = $\frac{1}{2}\rho A v^3$

Where,

P = Power available in wind

ρ = Air density in kg/m^3

r = Radius of blade in m

A = Cross sectional area of blade in m^2

TORQUE-

T = $\frac{\text{power}}{\text{angular speed}} = \frac{P}{\omega}$

Where,

T = Torque of shaft in Nm

P = Power available in wind in Watts

ω = Angular velocity in rad/sec

TIP SPEED RATIO-

$\lambda = \frac{4\pi}{n}$

Where,

λ = Tip speed ratio

n = Number of blade

FORCE ON BLADE-

F = $\rho A v^2$

Where,

F = Force act on blade in N

ρ = Air density in kg/m^3

A = Swept area in m^2

v = Air velocity in m/s

DRAG FORCE ACTING ON BLADE-

$F_D = ½\rho A v^2 Cd$

F_D = Drag force acting on blade

ρ = Air density in kg/m^3

A = Swept area in m^2

v = Air velocity m/s

Cd = Drag force coefficient

LIFT FORCE ACTING ON BLADE-

$F_L = ½\rho A v^2 Cl$

Where,

$F_L =$ Lift force acting on blade in N

ρ = Air density in kg/m^3

A = Swept area in m^2

v = Air velocity m/s

EFFICIENCY-

$\eta = \frac{Pt}{Pw}$

η = Efficiency

Pt = Power in turbine in Watts

Pw = Power in wind in Watts

IV. COMPONENTS OF WORKING HORIZONTAL WIND OPERATED WATER PUMP

BLADE:

Blades are most important components in turbine assembly as it capture wind. Blade positioning and orientation plays a very important role as it decides the intensity of air captured by the turbine blade. So looking for this point of view to optimize our turbine efficiency we experimented two different types of blade.

First blade we used is cup in shape of PVC plastic material for manufacturing of our turbine blades. Intensity of wind captured increased as turbine blade poses the cup shaped which proved to be helpful for generation of required mechanical work leading to generation of electric power and water pump. But it has a limitation of being comparatively light, as per the size and shape of prototype to be handled under different variable condition with different wind speed.

So to overcome this limitation and use suitable and optimum material for turbine blade according to prototype design requirement we found Polypropylene plastic material.

Fig. Polypropylene plastic material blade

Polypropylene plastic material is light in weight but possess high strength and rigidity as compared to PVC plastic material. Moreover it can be easily fabricated to the aerodynamic shape as per the requirement of prototype. Due to aerodynamic shape been provided with help of PP material, efficiency of the overall system improves according to Betz limit.

CRANKSHAFT:

Fig. Crank Shaft

Another most important component for the smooth functioning of prototype is crankshaft. Crankshaft should poses high strength, rigidity and toughness due to these requirement they are manufactured by casting and forging production techniques. Crankshaft is component connected between the turbine blade and connecting rod. With the rotation of turbine blade, certain mechanical motion is obtained which is transmitted to the crankshaft leading to rotary motion of connecting rod with piston in the pumping assembly.

CONNECTING ROD:

Fig: Connecting rod

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Connecting rod is long slender component between crankshaft and piston assembly via sew-saw mechanism. Mechanical motion obtained from the crankshaft for the reciprocation of piston rod in pumping assembly is transmitted via connecting rod. Connecting rod should have high ultimate tensile stress, resistance for the bending, fatigue stresses so it should be manufactured by casting and forging production techniques.

SEW-SAW MECHANISM:

Fig. Sew-saw mechanism

Sew-saw mechanism is the basic principle for reciprocation of piston in pumping assembly is achieved by sew-saw mechanism. Blade rotate further leading to the rotatory motion of crankshaft. This rotatory motion is further transmitted in the form of transverse motion for the reciprocation of piston rod in pumping assembly.

PUMPING ASSEMBLY

Pumping assembly is the most important sub system of prototype as it carry out work of pumping of water here in the pumping assembly we use a single acting reciprocating piston. Due to sew-saw mechanism piston moves upward and downward in pumping assembly with the upward movement of piston in pumping assembly vacuum is created in pump. Due to this vacuum suction of water takes place for the commercial use from the required given outlet.

ALTERNATOR:

From the developed prototype, alternator plays an important role from the electric power generation point of view. Alternator is provided on the back side of prototype. Alternator is connected to the connecting rod via small shaft. With the rotatory motion of the crankshaft, mechanical motion is transmitted to the alternator by the small shaft through its rotation. Due to rotation of the alternator shaft, electromagnetic flux is generated in the alternator assembly leading to the development electromotive force which produce electric power.

WORKING ASSEMBLY:

Fig: Assembly of wind powered water pumping

Horizontal wind powered water pump proves to be hybrid system for generations of electricity and pumping of water for the commercial purposes.

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Polypropylene plastic blades rotate with the intensity of wind bombarded on it. Due to rotation of turbine blades mechanical motion is transmitted to the crankshaft leading to its rotatory motion. This rotatory motion of crankshaft is further transmitted to the piston of pumping assembly via sew-saw mechanism and connecting rod. The motion of piston is between the top of dead centre and bottom of pumping assembly. When the piston is at the top dead centre, vacuum is created in pumping assembly. This leads to suction of water for required commercial purpose. Moreover from the electricity generation point of view alternate shaft is connected to the crankshaft. With the rotatory motion of crankshaft, electromagnetic flux is produced in alternator leading to generation of electric power.

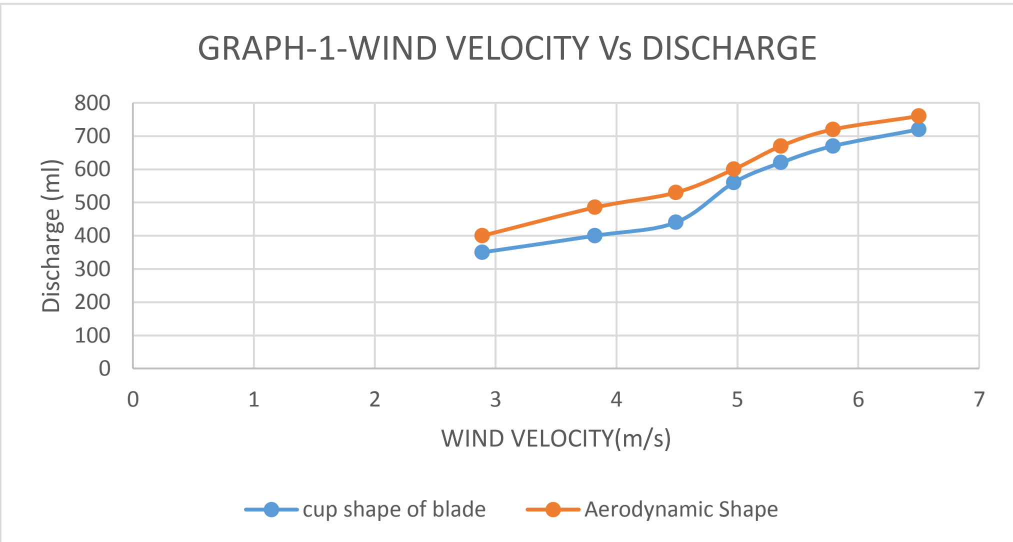
V. RESULTS

Table. Result table of aerodynamic shape of blade

Sr. No.	Wind Velocity (m/s)	Water Discharge (ml)	Head (m)
1	2.89	400	0.8
2	3.82	485	1.0
3	4.49	530	1.5
4	4.97	600	1.8
5	5.36	670	2.5
6	5.79	720	3.0
7	6.5	760	3.4

Table. Result table of cup shape of blade

Sr. No.	Wind Velocity (m/s)	Water Discharge (ml)	Head (m)
1	2.89	350	0.5
2	3.82	400	0.7
3	4.49	440	1.0
4	4.97	560	1.5
5	5.36	620	1.8
6	5.79	670	2.3
7	6.5	720	2.5



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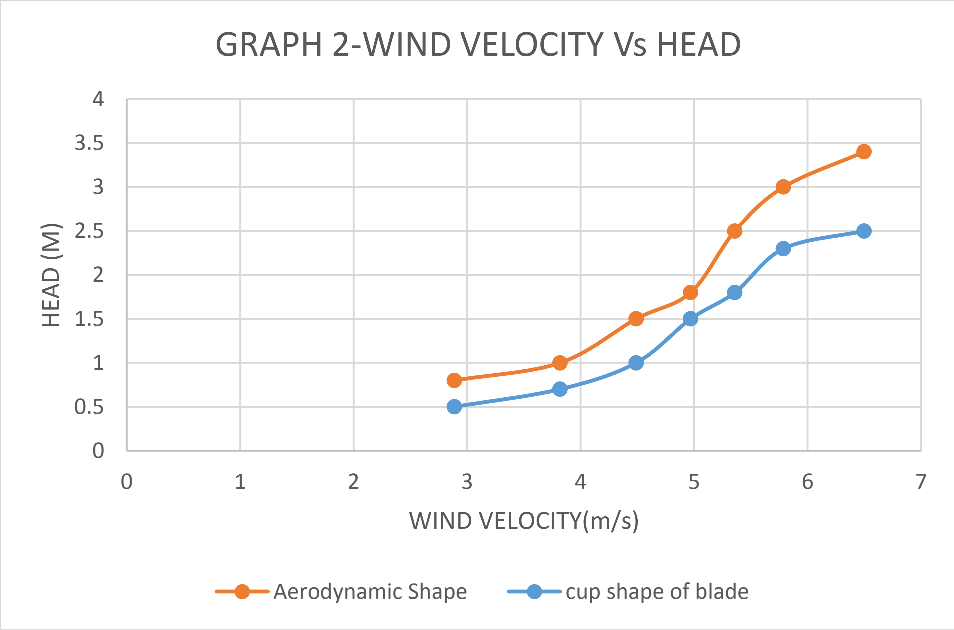

VI. CONCLUSION

From the prototype design, it can be concluded that, the **total torque** of the windmill is **3.27 N-m** and this is sufficient to sustain the desired **flow rate** of **2.35 lit/min** with a **maximum head** of **1.5 m** at **45 rpm** and also to overcome other barriers to motion.

The **numbers of blades** used is **3** with **a total surface area of 1.8381 m^2** and this gives a **solidity of 0.8**, the minimum value of solidity for a windmill and therefore ensures conformity with the standard specifications.

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