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DESIGN AND FABRICATION OF SOLAR POWERED FLOATING PUMP

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Abstract: *The current paper works on sustainable energy pumping system. It involves in a design of pump which is freely floating on the surface of water/fluid which displaces from its original position depending upon the control. The solar floating pump consists of a floatation unit that is made of high density thermocoal. The housing unit consists of a pump system that consists of an impeller connected to a 12V DC motor, which is powered by a solar power system. The solar power system used consists of water proofed solar panels that is in a closed circuit with the motor. The results which are obtained are validated with the existing pump design. The overall work concentrates mainly on stability, power generation and the discharge. Dimensionless number is calculated to predict the type of flow at the exit.*

Keywords: *sustainable energy, discharge, power, pump efficiency, Reynolds number.*

I. Introduction

The conventional energy resources mainly are coal, oil and gas. But hydro and renewable energy sources play an important role in developing countries like India where solar energy available abundantly and sufficiently [10]. The energy is divided into two categories as: commercial and non-commercial. The most important commercial energy is electricity others are petroleum products and coal. The commercial energy form depends on industrial, agricultural, transport and commercial development in the modern world [6, 7]. The energy which is not available in the commercial market is called non-commercial energy e.g. Firewood, cattle dung, agricultural waste, solar energy, animal power for transport and wind energy. The non-commercial energy which can be harnessed without release of harmful pollutants called renewable energy for e.g. solar power, wind power, geothermal power, tidal power, and hydroelectric power etc [1]. The floating Photovoltaic system is a new method of solar-energy generation utilizing water surface available on dams, reservoirs, and other bodies of water. This method has an advantage that allows efficient use without bringing damages to the environment [2].Recently, the market for solar energy is expanding due to introduction of the renewable portfolio standard (RPS). Thus, vigorous research is held on alternatives against the lack of sites to install overland PV systems. This method has an advantage that allows efficient use of nation's soil without bringing damages to the environment, which the pre-existing PV systems cause when it is installed in farmlands or forests. Until 2012, Korea applied renewable energy certificate (REC) value of 1.0 to floating PV systems similar to general PV systems. However, recognizing the technological value and necessity of floating PV systems, Korea has announced that the REC value will be 1.5 for floating PV systems, the same value as building integrated photovoltaic system (BIPV), from the year 2013. There is a need to search of renewable or virtually inexhaustible energy for the human development to continue. The renewable energy is generally electricity supplied from sources such as wind power, solar power, geothermal energy hydro power and various forms of biomass [6]. The above work involves in design and fabrication of floating pump which is driven by the sustainable energy i.e. solar energy harnessed by the photovoltaic cells. The entire system is stabilized by flotation unit which is portable.

II. Related Study

Mitsuo Uno et.al [1] focused on the impeller construction, on contact driving method and performance of a newly developed shiftless floating pump with centrifugal impeller. The drive principle of the floating impeller pump used the magnet induction method similar to the levitation theory of the linear motor. In order to reduce the axial trust by the pressure difference between the shroud and the disc side, the balance hole and the aileron blade were installed in the floating pump impeller. Considering the above effect, floating of an impeller were installed in the floating impeller. Considering the above effect, floating of an impeller in a pump was realized. Moreover, the performance curves of a developed pump are in agreement with the general centrifugal pump, and the dimensionless characteristic curve also agrees under the different rotational speed due to no mechanical friction of the rotational part. Young-Kwan Choi [2] verified the superiority of floating PV system through comparison analysis of generation amount by 2.4kW, 100kW and 500kW floating PV system installed by K-water and the cause of such superiority was analyzed. Also, effect of wind speed, and waves on floating PV system structure was measured to analyze the effect of the environment on floating PV system generation efficiency. Shiv Lal [3] used 2hp DC motor with 2200W (10 panels of each 225W) have been used for discharge 30 m water head. The maximum discharge logged 163litre/minute between 11AM to 2PM at PV power output between 75 to 85W/m^2 and the system is operating approximately 8 hours in the of November of the winter season. The full day discharge has found 70995 litres and it is more than the average discharge given by the manufacturer at 50m depth. It is revealed that PV array based water pumping system is suitable and feasible option for off-grid and drip irrigation system. Dave Umang Y [4] worked on solar reciprocating pumping systems is believed to be applicable to many remote and domestic irrigations applications without access to electricity relaying diesel power and having insufficient wind for pumping and to be cost competitive, locally manufacturable alternative to photovoltaic. This system consists of solar collector, battery, motor, crankshaft, reciprocating pump, valve, and tank. B. Eker [5] explained solar powered water pumping system which is made up of two basic components. These are PV panels and pumps. The smallest element of a PV panel is the solar cell. Each solar cell has two or more specially prepared layers of semiconductor material that produce direct current (DC) electricity when exposed to light. This DC current is collected by the wiring in the panel. It is then supplied either to a DC pump, which in turn pumps water whenever the sun shines, or stored in batteries for later use by the pump. The aim of this article is to explain how solar powered water pumping system works and what the differences with the other energy sources are.

III. Methodology:

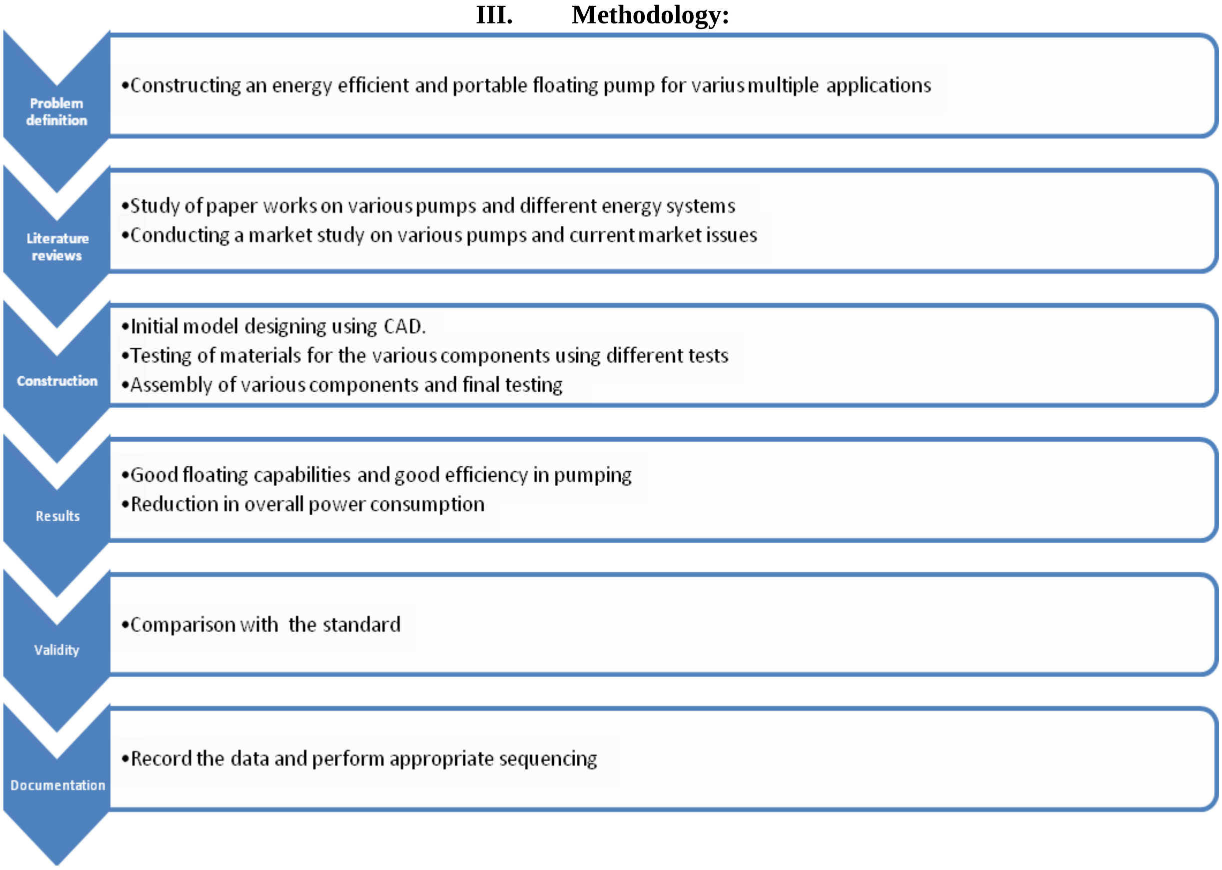

Figure 1: Methodology involved in the design and fabrication of floating pump

The above project begins with the problem definition which focus on design and fabrication of sustainable energy floating pump. It involves in collection of the data which are supporting the above work. Initial model was built in CAD before building the actual model. The model was built according the appropriate dimensions. Entire system undergoes testing to determine the discharge and efficiency of the system. Experimental results are compared with the existing results similar to the work. Finally the entire work is documented for further use. The following expressions are used to obtain pump characteristics.

The head of a pump can be expressed in metric units as:

$$h = ((p_2 - p_1) / (\rho\ g)) + (v_2^2 / (2\ g)) \quad (1)$$

The output power or the power required to lift the water

$P_{Water} = Q\ \rho\ g\ h$ (2)

The Power developed by the shaft

$P_{Shaft} = 2\ \pi\ NT$ (3)

Pump efficiency, *η (%)* is a measure of the efficiency with which the pump transfers useful work to the fluid.

$\eta = P_{water} / P_{shaft}$ (4)

Reynolds number to predict the type of flow is calculated using

$Re = (\rho VD/\mu)$ (5)

IV. Construction and working:

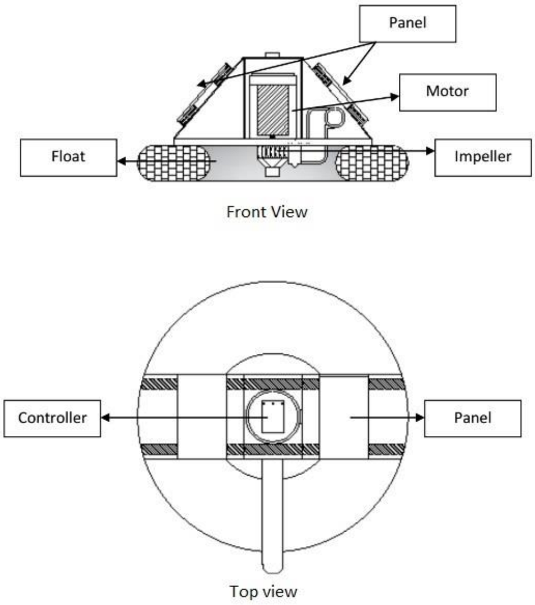

Figure 2: 2D view of solar powered floating pump

The entire unit consists of the floatation unit and housing unit. The floatation unit consists of two solar panels which is connected to a battery is placed inside a housing. The motor is connected to the impeller generating 1600rpm; it is connected to a 12V battery which is being continuously charged by the solar panels. The housing unit is attached to a floatation unit with the help of two supports rods which is capable of holding 120 Kg. The two five volt solar panels installed on the device generates power which is sufficient to charge the batteries. When power is supplied to the motor it rotates the impeller at high speeds hence causing a pressure difference inside the impeller chamber. This pressure difference drives the water through the inlet and pump it through the outlet at greater velocity. The entire housing is supported by the flotation unit which keeps the system in equilibrium position in dynamic condition. Figure 2 shows the two dimensional view of the floating pump panel which is used to pump the water. All the individual elements are shown with their appropriate position. Figure 3 shows the actual set up built for experimentation.

Figure 3: Fully fabricated solar powered floating pump

V. Results and discussions:

Table 1: Characteristics of floating pump

Sl.No	Input Power (HP)	Head (m)	Torque(N-m)	Discharge(litre/min)	Speed of rotation (rpm)	Shaft power (Watts)	Pump Efficiency (%)
1	0.25	0.75	0.576	20.5	1500	90.47	48.52
2	0.5	1	0.99	22.5	1800	180.95	48.51
3	0.75	1.25	1.235	24.5	2100	271.5	48.51
4	1	1.5	1.441	26.5	2400	361.9	48.51
5	1.25	1.75	1.599	28.5	2700	352.1	48.51

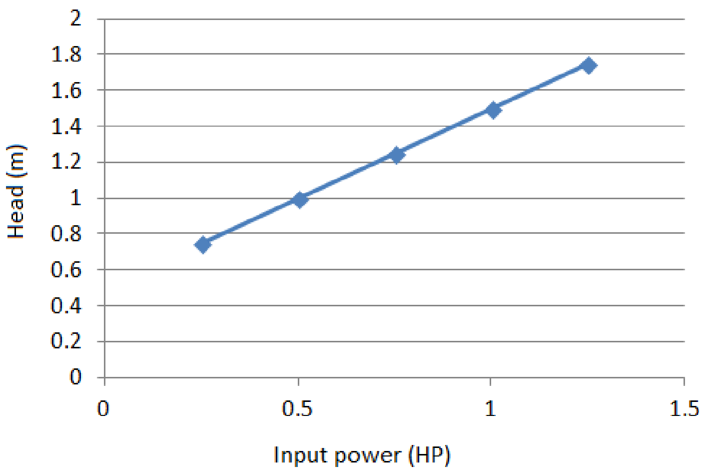

Figure 4: Variation of Water head with the input power

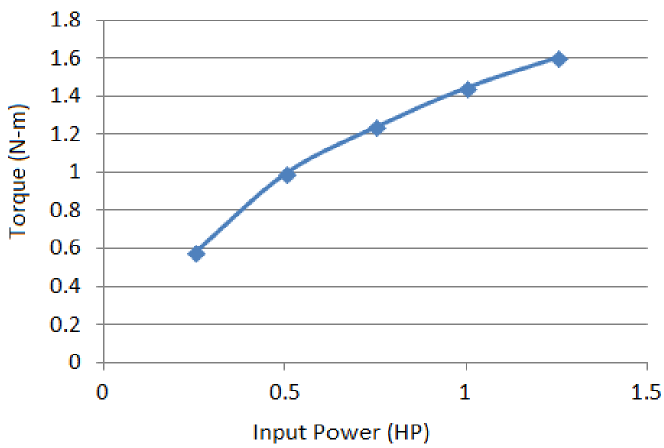

Figure 5: Variation of impeller torque with the input power

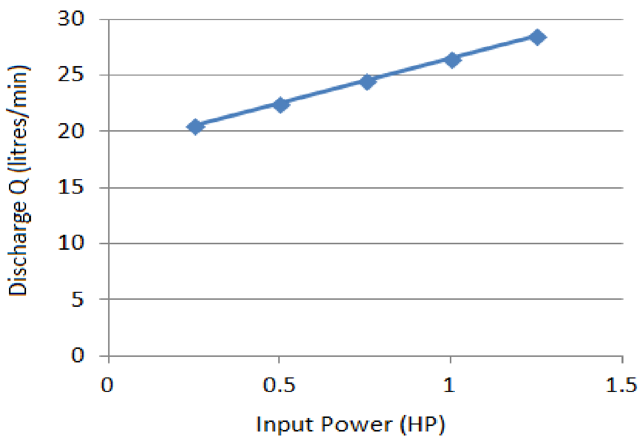

Figure 6: Variation of water discharge with the input power

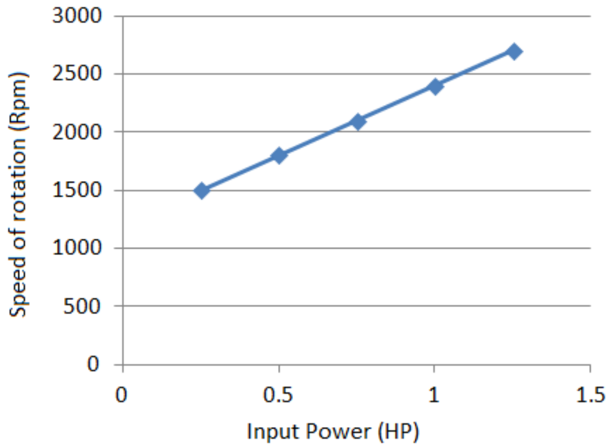

Figure 7: Variation of speed of rotation with the input power

From the figure 4, 5, 6 & 7 shows the variation of water head, torque, discharge and speed of rotation with input power, which shows that all the parameters varies linearly with the input power.

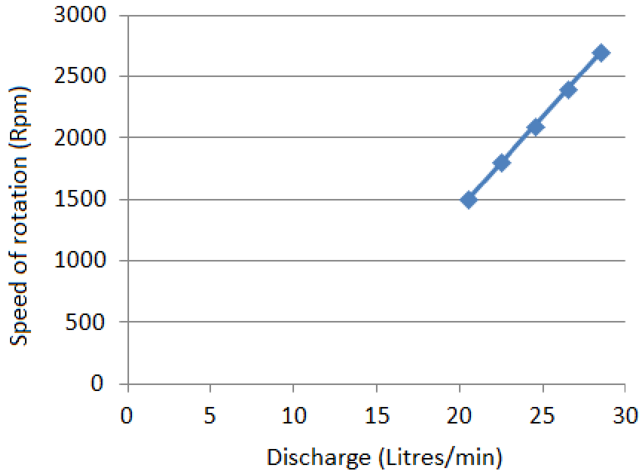

Figure 8: Variation of speed of rotation with the water discharge

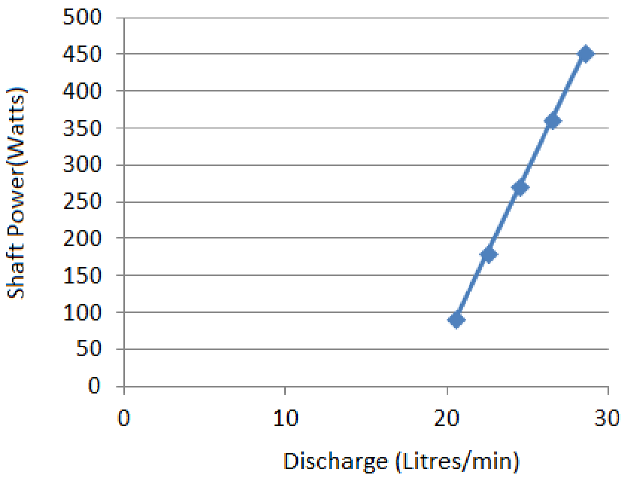

Figure 9: Variation of shaft power with the water discharge

Figure 8 & 9 shows the variation of impeller rotation and shaft power with the discharge of water. Both the parameters increases linearly with water discharge. Efficiency is defined as the ratio of output shaft power to the input power to drive the system. According to table 1, the efficiency of the pump is 48.51% irrespective of the change in inlet condition.

Table 2: Dimensionless number variation with pump parameters

Sl.No	Density of fluid (kg/m^3)	Velocity of fluid (m/s)	Diameter(m)	Discharge(litre/min)	Speed of rotation (rpm)	Dynamic Viscosity (Pa-s)	Reynolds Number
1	1000	0.47	0.03	20.5	1500	8.94e-4	15842.69
2	1000	0.53	0.03	22.5	1800	8.94e-4	17865.16
3	1000	0.57	0.03	24.5	2100	8.94e-4	19213.48
4	1000	0.62	0.03	26.5	2400	8.94e-4	20898.87
5	1000	0.67	0.03	28.5	2700	8.94e-4	22584.26

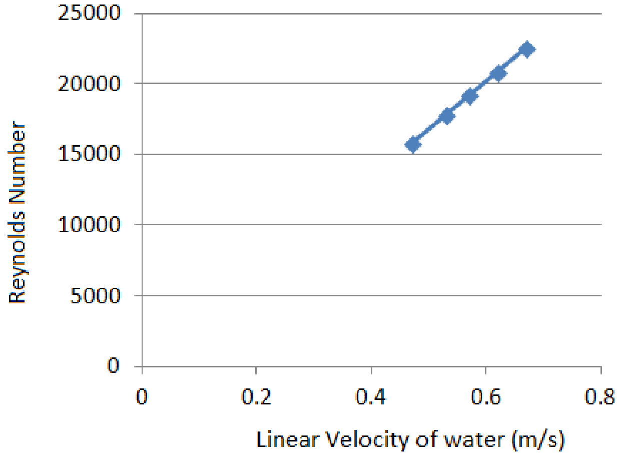

Figure 10: Variation of Reynolds number with the velocity of water

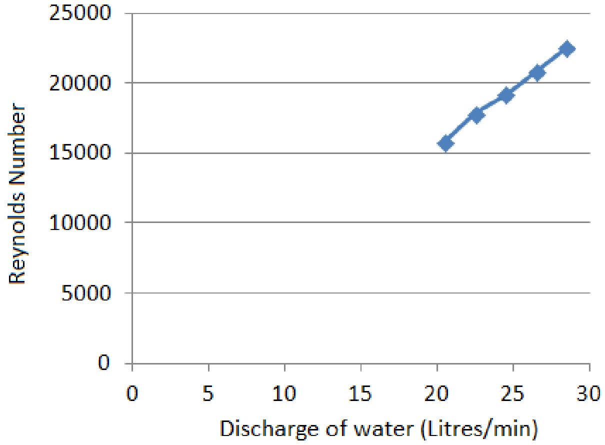

Figure 11: Variation of Reynolds number with the water discharge

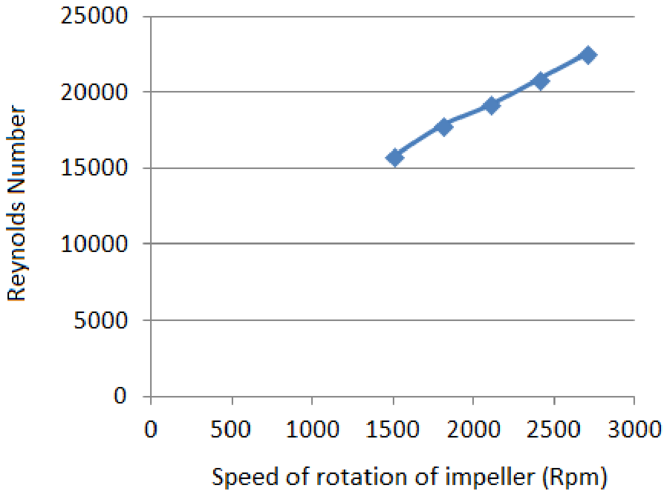

Figure 12: Variation of Reynolds number with the impeller rotation

Figure 10, 11 & 12 shows the variation of Reynolds number with linear velocity of water, discharge of water and the speed of rotation of the impeller. Above graph shows that the dimensionless number varies linearly with the pump parameters. The value of the Reynolds number which is calculated and shown in table 2 signifies that the above flow of the water at the outlet is turbulent. The results which are obtained is validated with [4, 5] it is found out that it is matching with its conclusions and results.

VI. Conclusions:

Using sustainable energy the power was generated to drive the floating solar pump, which is able to discharge 20 liters per min of the fluid using the prototype. The above designed system was in the state of perfect equilibrium during the dynamic condition. The efficiency of the overall pump is found to be 48.5 %. From the experimentation it is proved that shows the variation of there is a rise in water head, torque, discharge and speed of rotation with the input power. Also the result indicates that there is an increase in the variation of impeller rotation and shaft power with the discharge of water. Dimensionless analysis is carried out by calculating Reynolds number, which showed that flow which takes place at the outlet is turbulent. The dimensionless number varies linearly with the linear velocity of water, discharge of water & speed of rotation of the impeller.
The above work can be further improved by the determination of appropriate weight and improve discharge, efficiency with optimum selection of components (materials).The addition of wireless mobility system helps to position the system accurately. Adding filtration unit to the avoid debris, water bodies and there by prevent the choking of the impeller. A mathematical model can be developed by considering the thermal parameters like heat transfer coefficient and thermal conductivity. Various temperature and pressure at different points can be determined. Further the work can be applied to pump the oil or undesired fluid from the surface of the water to support filtration technique. The above system produces enough energy to run the entire system efficiently therefore it can be implemented in rural areas.

Nomenclature:

h = total head developed (m)
$\mathbf{p_2}$ = pressure at outlet (N/m^2)
$\mathbf{p_1}$ = pressure at inlet (N/m^2)
ρ = density (kg/m^3)
g = acceleration of gravity ($9.81 m/s^2$)
$\mathbf{v_2}$ = velocity at the outlet (m/s)
$\mathbf{P_{Water}}$ =Power output (W)
$\mathbf{P_{Shaft}}$ =Power input (W)
Q= Discharge (m^3/s)
D=diameter, m
μ= Dynamic Viscosity, Pa-s

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