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PERFORMANCE EVALUATION OF HYDROVAC GRAVITY POWER GENERATION SYSTEM

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Abstract: *A unique and novel design of hydro power generation system is presented in this paper. Series of experiments were performed to determine whether power can be produced by utilizing the effect of gravitational pull, atmospheric pressure and the force of suction by allowing a certain quantity of water in a specific shaped tank to fall freely under gravity on a turbine runner to establish automatic suction due to partial vacuum created in the storage tank and weight off set. After carrying out a mathematical modeling, a physical model, was constructed to study various hydraulic effect. The actual model consisted of overhead water tank 8.5 meter high, 60000 liters capacity fitted with a Francis type turbine and an alternator. Penstock pipe of 300 mm diameter size was used to take water from overhead tank to the turbine. Two auxiliary pumps were used to prime the overhead water tank. The tank was provided with 20 suction tubes of 63.3 millimeter diameter size. This power plant was designed to generate 28.6 KW of hydro power on the principal of energy transformation utilizing force of gravity, atmospheric pressure and vacuum. Being the new concept the results obtained exhibited that experimental model required certain improvements to make it feasible with maximum efficiency which are discussed under heading of recommendations. The design concept presented in this paper is an original work in this field.*

Keywords: Hydrovac, Gravity, Vacuum, Suction tubes, OHTRWTSWT.

1. Introduction

Hydro power is the most long-established renewable energy technology. The first water wheels used in irrigation were developed in the far-east over two-thousand years ago. Persian wheel was the first ever hydraulic machine used for this purpose (Rosita Fitch, 2012). Towards the middle of the 19th Century the first water turbines were developed and later it continued till 21st century saw the world's largest hydro power plant- Three Gorges. Keeping in view the various laws of fluid mechanics and natural phenomena (Khurmi, 1970), it was thought that instead of constructing large reservoirs for hydropower, whether combination of universe-lasting gravitational force, atmospheric pressure and vacuum can be utilized effectively to design such a compact system which could produce hydro power or it can yield saving in energy in pumping devices? Hydrovac gravitational power generation is a new concept, utilizing the combined effect of gravitational force, atmospheric pressure and partial vacuum created in a water storage tank.

Evidence was found for similar work in US when a patent was filed for energy producing through a power plant specifically designed and structured for use in association with a natural reservoir of water such as the sea, ocean, lake, river, etc. (Thompson, 1987). An evidence of similar work was also found on the website http://www.info@gravitypower.com accessed on June 2003, which claimed that a study was undertaken in May 1998 on Gravity Power System by National Engineering Lab (NEL) Glasgow Scotland. Siphon type power plants which work on negative pressure are in use in China for last many decades (HRC, 2009).

2. Atmospheric Pressure and Vacuum

Standard atmospheric pressure can lift a column of water in a closed pipe up to height of 10.3 meter (at sea level) if the closed top end of tube is under vacuum (Fig. 1a).

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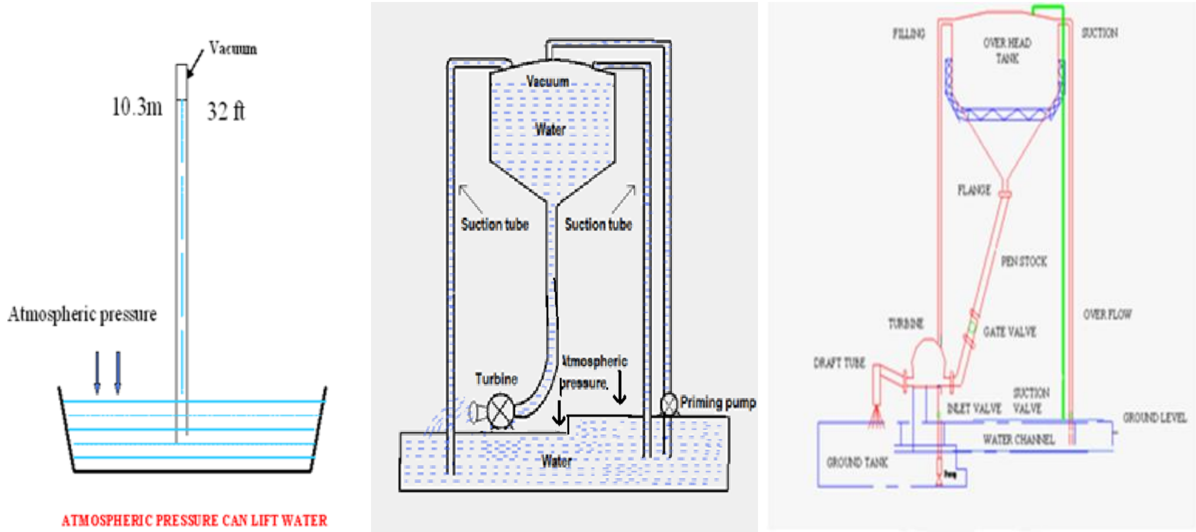
A certain quantity of water when stored in a tank at a head (h) is capable of producing power due to its potential energy. This water will tend to flow down through a nozzle, under the action of gravity and inertia and an instantaneous vacuum will be created at the top of air tight closed tank. This will evolve to establish an automatic suction through a primed suction tube. In this way a considerable amount of energy can be saved in pumping devices and also power can be generated (Fig. 1b).

3. Description

The basic mechanism is illustrated in Fig. 1c. A certain mass (m) of water is stored in an air tight overhead tank. When water will be flowing out of the delivery line (penstock) under gravity, theoretically the vacuum or negative pressure will be created on the top portion of this tank and two different situations can be encountered here:



a) *b)* *c)*

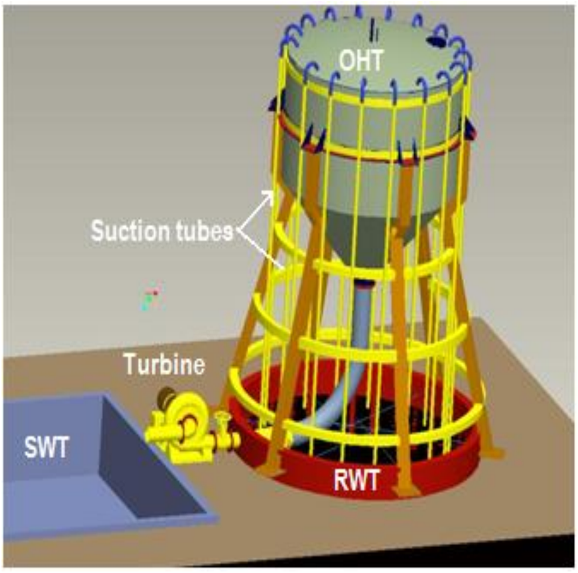
Fig. 1: Hydrovac Gravity Power System uses atmospheric pressure and vacuum to lift water.

Under one situation, the "*water will not flow at all*". Once the vacuum on the top portion of tank is created and valves of the suction pipes are closed, "the system may be *vacuum locked*", and this flow will not be established till the time air or some other fluid is injected in the tank. This situation can be observed in water bowzers and oil tankers where air has to be injected inside through vent plugs for smooth discharge at outlet.

Under other situation, when main outlet valve of penstock is open, water from gravity tank will flow out through turbine under free or forced flow condition and if the valves of already primed suction pipes are also open, negative pressure or vacuum on the top portion of tank will be created. If intensity of this negative pressure is sufficient enough to suck the water through already primed suction pipes and if the outlet flow pressure of water is greater than the atmospheric pressure, water will start flowing from gravity tank and will be sucked back into gravity tank through suction pipes submerged in water. Pressure of water at outlet can be managed to be greater than the atmospheric pressure if a specially designed gravity tank with minimum surface friction is used (Fig. 2). Intensity of negative pressure will depend upon a few critical values like tank height, tank diameter, type of bends & internal friction of suction tubes, rate of discharge from main tank and nozzle diameter. This way water can be lifted up to a specific height without consuming power or utilizing minimum power as compared to conventional water lifting system.

4. Methods

Two concrete water tanks of capacity 44,000 liters in round shape suction tank (RWT), 1.52 m deep just below the main overhead steel tank (OHT) and 60,000 liters in square shape discharge tank (SWT), 1.15 m deep respectively were constructed on two meter deep reinforced concrete raft foundation (Haruyuki, 2004). An overhead steel tank (OHT) of 60,000 liters capacity was manufactured for storage of water at 8.5 meter height (as it is a lower limit for atmospheric pressure to support a water column in Islamabad, being 10.3 meter at sea level). Overhead tank was mounted on a hexagonal steel structure bolted on a 2 meter deep concrete raft foundation (Poulos, 2005), (Fig. 2).



a)

b)

Fig. 2: Computer aided design and testing of working model.

A 300 mm diameter intake Francis type turbine was fitted on a Penstock. The diameter of the runner was 300 mm which was designed to give 50 kW at a head of 40 meters, (Fig. 2b).

4.1. Suction tubes

Twenty x 63.3 mm diameter mild steel suction pipes were fitted over the top cover of main overhead tank. These suction pipes were submerged in the lower round water tank. The purpose of these suction tubes was to suck the water from round shaped ground level reservoir (RWT) under siphon action (shown in Fig. 2).

5. Results and Discusssions

Priming of the system: System was primed and a separate open end air vent tube was installed having an open end at height of 1.5 meter above the roof level of main tank which indicated the priming of the system. Total volume of the overhead tank and penstock was 69000 liters. The total time for priming the Overhead tank (OHT) and Round water tank (RWT) with one centrifugal pump of 2 kilowatt power was recorded as 108 minutes.

Measurement of rate of discharge through turbine: Actual discharge from turbine was measured by calculating the actual volume of water coming out from turbine in a unit time (Fig. 3).

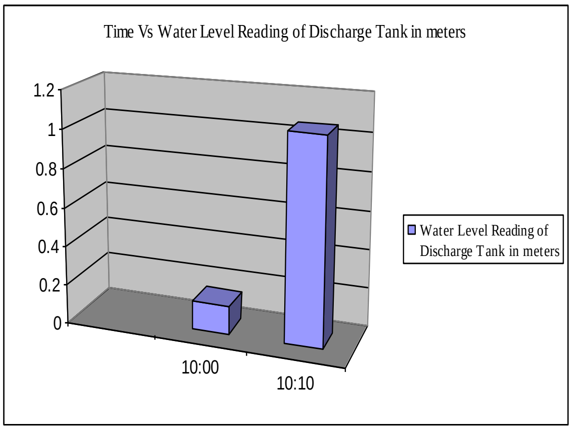


Fig. 3: Time verses water level reading.

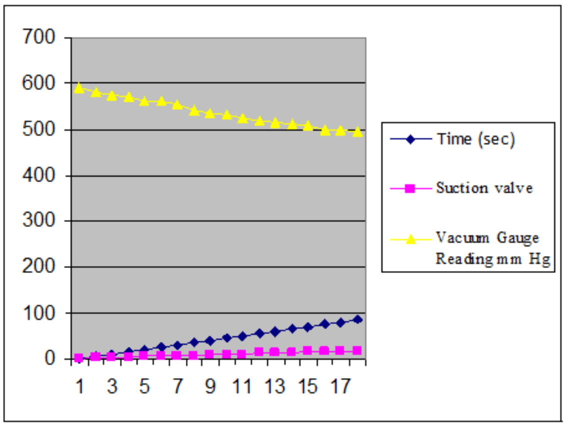


Fig. 4: Vacuum vs Suction valves.

Effect of opening suction valves: System was primed and Turbine valve was opened and system was taken to maximum limit of negative pressure (595 tor), then each suction valve was opened one after the other. Effect of opening 1 to 18 suction valves shown gradual decrease in the reading of negative pressure. Decrease in negative pressure may be due to minor leakage in the system or the phenomena of formation of vapours under intense negative pressure in the main overhead tank. Actual maximum power produced by the system was observed as 7.2 kW with voltage rating of 240 volts AC and current rating of 30 amperes for 45 minutes under controlled flow conditions.

6. Conclusion

Further research is required, which should be integrated with investigations including computational fluid dynamics (CFD) analysis based on friction less material of piping like HDPE, raised water level in base tank and air vent at throat of penstock and evaluation of various types of turbines with different performance characteristics.

7. Recommendations

Following are the recommendations:

- Francis turbine with 225 mm intake diameter may give positive results. It may be the most suitable option for present study.
- HDPE pipe and HDPE valves may be the best option to minimize friction losses.
- Trial with an additional 10 kW size motor may be used as starter to enhance the negative pressure (from 595 mm Hg to 610 mm Hg) in the main tank which can be disengaged after the suction is established.
- A sand filled float may be induced in the round water tank (RWT), which will increase the water level in the base tank and ultimately will increase the pressure at the base of suction tubes.
- Water level at the base tank can be increased by increasing the height of walls of RWT which will result in reduction of suction head.
- The water coming out from the draft tube can be reversed into the RWT if the suction is established.
- Air vent pipe at the throat of penstock will enhance the discharge pressure at turbine which may result in increase of vacuum inside the main tank.

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