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Comparison of Water Pumping between Pump Driven by Wind Mill and Electric Motor into Brazil

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Abstract. The proposed work consists in the comparison of the application of two systems for the pumping of water. With a pump drive by electric motor and the other by wind mill, in order to demonstrate the efficiency and pay-back of each system. The installation of both projects is simple, having only that consider the lifting height of water for the application of each system, and in the case of using the wind mill, must also be taken into account the average wind speed and the availability of daily even. For the comparison between the two systems presented, became the pumping for a volume of 72,000 liters of water per day, to the heights of 10, 50, 100 and 150 meters, during 6 hours by day and it took into account the price of the installation of the two systems and the cost of electrical energy for the case of pumping with electric motor.
Through the calculations performed, it was found that the installation of wind mill have quicker pay back from the heights of 100m, around four years and 150m around two years, in comparison with the electric motor. Life time the systems is 20 years.

Key words

Pumping of water, wind mill, electrical motor

1. Introduction

The proposed work consists in the comparison of the application of two systems for the pumping of water. With A pump drive by electric motor and the other by pinwheel, in order to demonstrate the efficiency of each system, as well as the sizing of same. It was also verified the financial viability for each system. The installation of both projects is simple, having only that consider the lifting height of water for the application of each system, and in the case of using the pinwheel inclusions, must also be taken into account the average wind speed and the availability of daily even.

2. Materials and Methodology

The system of pinwheel inclusions is composed by a set of paddles, horizontal shaft, which drives the pump and by a tower (Figure 1), where *D* is the diameter of the paddles on the pinwheel inclusions and *H* is the height of pumping, this being the sum of the depth of the well of water and the desired lift height of water. The electrical system of pumping of water is composed of a pump and motor (Figure 2), where V is the valve; *C1*, *C2*, *C3*, *T1*, *T2*, *T3* and *T4* compose the pipe system; *H* is the height of elevation of water, *1* is the box d'less water containing 2/3 of the volume of water to be pumped and *2* is the water box top to store 1/3 of the total volume of water.

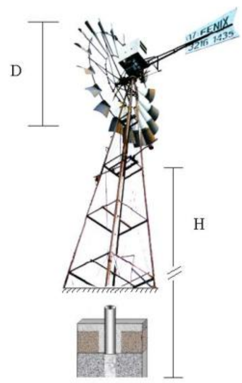

Fig. 1. Structure of the wind mill

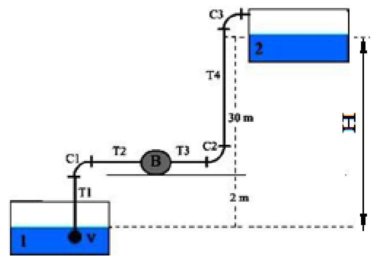

Fig. 2. Schematic of water pumping system with electric motor

Both systems have the pipe, where will the water, a reservoir and the same number of hours of operation. For the wind mill, the scaling uses the lifting height, the total volume of water per day, the availability of wind daily, as well as its average speed. Figure 3 shows the Brazil wind map, which is used as a parameter to check for implementation of pump wind mill in each region.

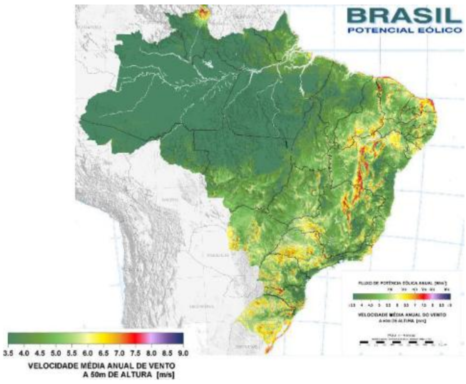

Fig. 3. Brazil wind map (CRESESB, 2000)

For pump driven by electric motor takes into consideration only the height of pumping and the total volume daily. For the comparison between the two systems presented, became the pumping for a volume of 72.000 liters of water per day, to the heights of 10, 50, 100 and 150 meters, during 6 hours by day and it took into account the price of the installation of the two systems and the cost of electrical energy for the case of pumping with electric motor.

For the analysis of the time of payback for the application of the system of the wind mill regarding the application of the electric motor there was calculated the price of installation and maintenance of both systems and to the value of the cost found for the electric motor there was added the cost of the electric energy spent during the time used for the comparison.

For the comparison between the two systems presented, became the pumping for a volume of 72,000 liters of water per day, to the heights of 10, 50, 100 and 150 meters, during 6 hours by day and it took into account the price of the installation of the two systems and the cost of electrical energy for the case of pumping with electric motor.

The Table 1 presents the price of the kit of the towers of 10, 50, 100 and 150 meters with shovels of diameter of 3,5 meters of tower 15m of height and his costs for implementation.

Table 1 – Relation of the initial cost of the implementation of weathercocks for the heights of 10, 50, 100 and 150 meters

PUMPING HEIGHT (m)	10	50	100	150
VALUE OF TOWER (US$)	4,251.60	4,251.60	4,251.60	4,251.60
VALUE OF COUNTER-WEIGHT (US$)	733.94	733.94	733.94	733.94
ASSEMBLY OF (US$)	1,100.92	1,100.92	1,100.92	1,100.92
VALUE OF COUNTER-WEIGHT (US$)	188.07	940.37	1,880.74	2,821.10
TOTAL	6,274.53	7,026.83	7,967.20	8,907.56

For the calculation of the cost of implementing the electrical motor is necessary to obtain the engine power and the value of the flow of the water pump to be coupled to the engine to the pumping of the same volume of water to different heights.

The volume of water to be pumped is of 72.000 liters during 6 hours per day.

• Pumping to lift height of 10 m

The flow rate (Q) is given by the equation (1).

$$Q = \frac{V}{h \times 3{,}600} \qquad (1)$$

Being V is the volume of water in m³ to be pumped and h number hours at which the engine will cause the pumping.

$$Q = \frac{72{,}000}{6 \times 3{,}600}$$

$$Q = 3.33 \times 10^{-3} m^3/s$$

Or

$$Q = 12 m^3/hora$$

This flow will be the same for all the heights of pumping, because it is related only to the quantity of water to be pumped and the amount of hours of pumping per day.

The pump power (P_B) is given by the equation (2).

$$P_B = \frac{\rho Q H}{75 \eta_B} \qquad (2)$$

Being ρ is the specific mass of the liquid to be pumped (in case we'll use the ρ of drinking water that is equivalent to 1000 kg/m³), Q is the flow rate, H the height of pumping and η_B yield the hydraulic pump, which reaches up to the value of 53 % .

$$P_B = \frac{1{,}000 \times 3.3 \times 10^{-3} \times 10}{75 \times 0.5}$$

$$P_B = 0.88 CV$$

The engine power (P_m) is given by the equation (3).

$$P_m = \frac{P_B}{\eta_m} \qquad (3)$$

Being η_m is the output of the engine. For a conventional engine income relate to the powers of the hydraulic pumps as shown in Table 2.

Table 2 - The Ratio of the output of the engine with the power of hydraulic pump

PUMP POWER (CV)	1.0	12.5	Above de 15.5
ENGINE PERFORMANCE	0.7	0.8	0.9

Using the data of Table 2, determines the power of the engine.

$$P_m = \frac{0.88}{0.7}$$

$$P_m = 1.26CV$$

• Pumping to lift height of 50 m

To pump power (P_B) is given by the equation (2).

$$P_B = \frac{1{,}000 \times 3.3 \times 10^{-3} \times 50}{75 \times 0.5}$$

$$P_B = 4.4CV$$

The engine power (P_m) is given by the equation (3). Using the data of Table 2, determines the power of the engine.

$$P_m = \frac{4.4}{0.8}$$

$$P_m = 5.5CV$$

• Pumping to lift height of 100 m

To pump power (P_B) is given by the equation (2).

$$P_B = \frac{1{,}000 \times 3.3 \times 10^{-3} \times 100}{75 \times 0.5}$$

$$P_B = 8.8CV$$

The engine power (P_m) is given by the equation (3). Using the data of Table 2, determines the power of the engine.

$$P_m = \frac{8.8}{0.8}$$

$$P_m = 11CV$$

• Pumping to lift height of 150 m

To pump power (P_B) is given by the equation (2).

$$P_B = \frac{1{,}000 \times 3.3 \times 10^{-3} \times 150}{75 \times 0.5}$$

$$P_B = 13.2CV$$

The engine power (P_m) is given by the equation (3). Using the data of Table 2, determines the power of the engine.

$$P_m = \frac{13.2}{0.8}$$

$$P_m = 16.5CV$$

To match the calculated values of powers and flow found to commercial values, we used the Submerged Motor Pumps 4" Series SUB 50 and SUB 100 of the company "Schneider Motobombas". The Tables 3 and 4 show the ratio of costs for the installation of the electrical motor, containing values of pumps selected to meet the calculated (being that the electric motor is already attached to the pump system), the accessories needed for the installation and the price of the energy spent by the system during the period of 1 year (adopting the cost of electrical energy the being of US$ 0.15 per kWh)

Table 3 - The Ratio of the initial cost of the implementation of the electrical motor for the heights of 10, 50 meters

PUMPING HEIGHT OF 10 m	VALUE (US$)	PUMPING HEIGHT OF 50 m	VALUE (US$)
PUMP SUB 50 - 20S4E5	871.55	PUMP SUB 50 – 75S4E18	1,146.79
CABLES	25.23	CABLES	36.70
PIPES	5.05	PIPES	25.23
INITIAL COST	899.08	INITIAL COST	1,208.71
COST OF ELECTRICAL POWER	364.62	COST OF ELECTRICAL POWER	1,367.34

Tabela 4 – Relação do custo inicial da implementação do motor elétrico para as alturas de 100, 150 metros

PUMPING HEIGHT OF 100 m	VALUE (US$)	PUMPING HEIGHT OF 150 m	VALUE (US$)
PUMP SUB 50 – 100S4E24	1,834.86	PUMP SUB 100 – 150F6E15	2,603.21
CABLES	68.81	CABLES	77.98
PIPES	50.46	PIPES	75.69
INITIAL COST	1,954.13	INITIAL COST	2,756.88
COST OF ELECTRICAL POWER	1,823.12	COST OF ELECTRICAL POWER	2,734.82

To calculate the payback time of installation of the pinwheel inclusions in relation to the electrical motor, was subtracted from the cost of installation of the pinwheel inclusions the cost value of installation of electrical motor and divided them if this value by the cost of electrical energy consumed by the engine during the period of 1 year, resulting in years of payback, these calculations were made for the various heights analyzed.

3. Results

Through the design of each system, it was obtained the respective costs of installation, as shown in Table 5.

Table 5 – The initial cost for installation for the two pumping systems

WIND MILL PUMP		ELECTRIC MOTOR PUMP		
HEIGHT (m)	INITIAL COST (US$)	HEIGHT (m)	POWER (CV)	INITIAL COST (US$)
10	6,2748.54	10	2.0	899.08
50	7,026.83	50	7.5	1,208.71
100	7,967.20	100	10.0	1,954.13
150	8,907.57	150	15.0	2,756.88

Using the data in Table 5 and adopting the cost of electrical energy as being of US$ 0.15 per kWh. It has been calculated that the time to pay back, in US$ dollars (October 2013), with the use of wind mill pump compared with the pump driven with electric motor, as shown in Table 6.

Table 6 - Estimated time to pay-back of wind mill pump and electric motor pump.

PUMPING HEIGHT (m)	PAY BACK (years)
10	15
50	5
100	4
150	2

4. Conclusion

Through the calculations performed, it was found that the installation of pump wind mill of pay-back is faster for height of 150m. However, due to the useful life of the pinwheel inclusions be greater than 20 years, it is also economically viable up to height of 10m.

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