ALTERNATIVE TO EXTRACT WATER THROUGH SOLAR ENERGY

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ABSTRACT

A new device to extract ground water is presented in this study. This device is a pneumatic pump which will be driven by photovoltaic modules. This system: the pneumatic pump and the photovoltaic modules are considered an alternative to the current systems that are made up of a submersible pump which is driven by windmills. At present, the current system is used in those areas located far away from power systems. The main advantage of the system proposed is its low maintenance cost. The operation principle, a constructed model and the experimental results are shown in this study. The results show how feasible is to carry out this proposal considering the advantage mentioned above. As far as its characteristics, common materials and simple technology of the device are concerned, it can be concluded that this device can be applied in other areas of the planet which have similar problems.

INTRODUCTION

Villa Mercedes (San Luis), is located in the central west of Argentina. It is situated in a transition area between the dry pampa to the east and the desert, which extends to the Andes to the west. This area has a dispersed rural population that does extensive cultivation and raises cattle. They need to extract ground water, which is found at about 60 to 80 meters deep, for the cattle and the rural inhabitants. The access to conventional energy systems such as: power system or fuel transportation are not income-producing.

The aeolian mills are one of the methods currently used. They are made up of a pump to extract ground water in the well, a cylinder with piston, a leather gasket and extremely long rods to move the piston. When the mills need to be repaired or maintained, all these characteristics turn to be a great disadvantage; therefore, their cost is high and thus, in numerous cases the system and the activity are abandoned

The purpose of this study is to present an alternative to supply water to isolated areas. Applying this alternative all those problems that are caused by the current systems in this region can be solved. This objective is achieved by a new system of ground water extraction through a pneumatic pump. The energy to make this pump work comes from the solar radiation.

At the same time and in a parallel way this research project studies the following:

1- ***Pneumatic pumping system***: It was fully developed from the research stage to design, testing and complete execution of the system. Continuous developments and modifications were done to improve the efficiency and the reach of this system of water extraction at depth.
2- ***Available solar resource in the area***: The global and diffused solar radiation was determined in

hourly values over an inclined surface. Then, the necessary photovoltaic system was determined according to the foreseen needs and the energetic resources The cost was defined and a comparison was done considering different variables or alternatives stating the economical-technical advantages and disadvantages for each case.

PNEUMATIC PUMP: *Description and Operation*

The pneumatic pump is a device to extract water at a certain depth through compressed air: In figure 1, the compressed air source (1) communicates with the chamber (5) submerged in water by means of a pipe line. There is another pipe line that comes out from this chamber (5) and it goes up to the level of the ground communicating itself with the atmosphere. At the beginning, when the pump is set to work, the chamber and the pipe line are full of water up to a static level (4); water comes into the chamber (5) and to the pipe line (2) through TR1 (6) and TR2 (7) backwater valves because the two-way electro valve that communicates with the atmosphere is open in one part and the part that communicates with the compressed air is closed.
At a certain stage, the way in which the electro valve works is inverted, so the pressure of the compressed air acts on the water found in the chamber (5) and makes it flow towards the pipe line (2) through the TR2 (7). The pressure closes the TR1 valve (6) in the same way. Therefore, the water goes up into the pipe line (2) and at the same time it decreases in the chamber (5) until it gets to the lowest level. Then, the electro valve (3) changes the way it opens and closes, that is to say, the backwater valve is closed (7) by the weight of the water contained in the pipe line (2) and the cycle starts again.

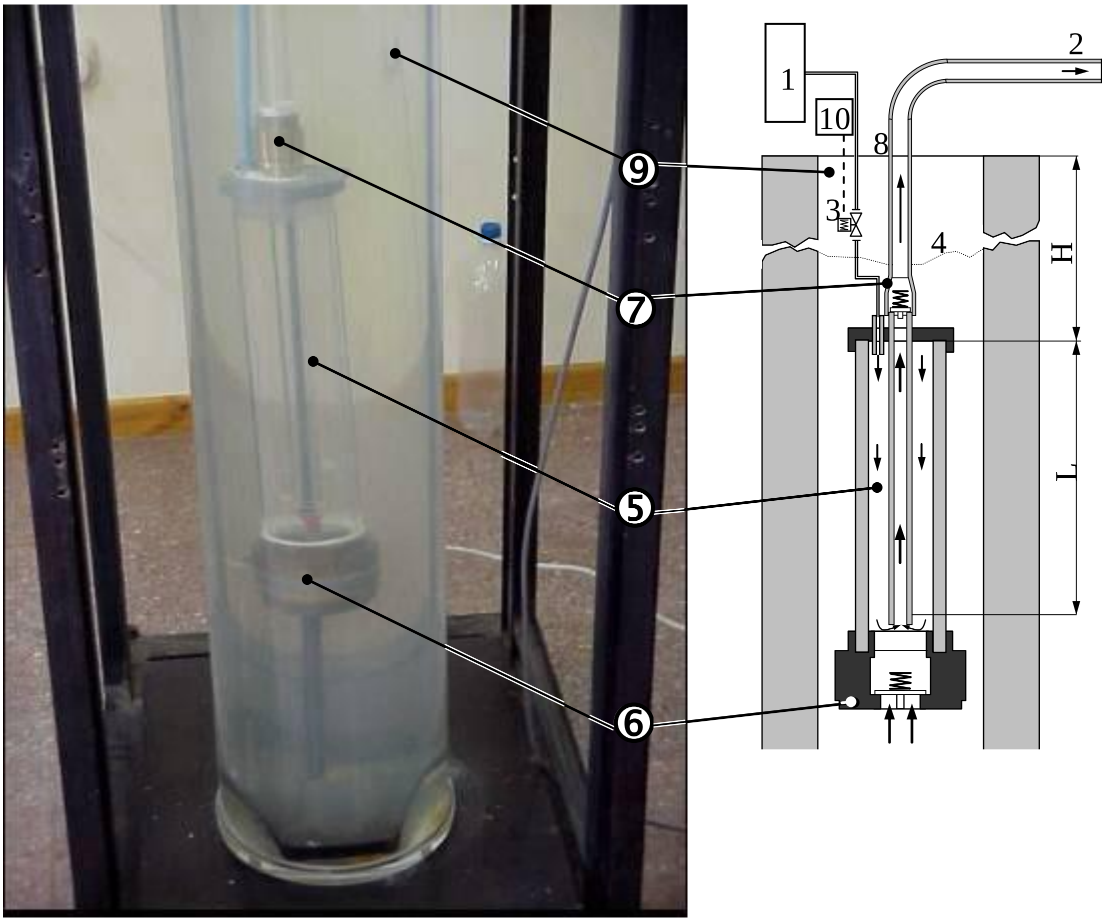

Figure 1. *Photo and sketch of the simple pneumatic pump.* Where: (1) Air compressed source; (2) Water outlet; (3) AB electro valve; (4) Level of water; (5) Chamber; (6) TR1 Backwater valve; (7) TR2 Backwater valve; (8) Level of ground; (9) Drill; (10) Automatic control of the AB electro valve.

Tests and results

Eleven tests were performed with the first prototype. They are shown in Table 1. Then, thirteen new experiences were done using the same prototype, but this time different depth values up to thirty meters were considered, so as to do tests, measurements and to observe the chamber loading and unloading time operation according to the level of water in the well and the working pressure. When the experiences were finished, it was found the loading time for the different parameters which are stated below: (the level of water was measured over the highest part of the chamber)

- **level 1** elevation 0,00 m – loading time 3,00 s
- **level 2** elevation 0,50 m – loading time2,50 s
- **level 3** elevation 1,00 m – loading time 1,20 s.
- **level 4** elevation 1,50 m – loading time 1,00 s
- **level 5** elevation 1,75 m – loading time 0,90 s

A significant decrease of the loading time was observed. Then, a test was done on the level four with an elevation of 1.5 m having a loading time of 1 sec. and a height between one and thirty meters and it was found that for the same extraction pressure and height there was an increase in the extraction flow of 750/850 liters of water per hour with a chamber of 38 cm^3.

TABLE 1

Characteristic values of the pump operation for the first eleven experiences to oneself elevation of 0,5 meters of water above the bomb.

Where: H [m]: depth; CC [l]: flow for cycle; C [l/h]: flow; P_t [atm]: work pressure (relative); Ec [W-h]: energy for cycle; E_l [W-h/l]: energy for liter; T [sec]; time of each cycle; T_p [sec]: passive time of each cycle (doesn't surrender water) and T_a [sec]: active time of each cycle (surrenders water).

#	H [m]	P_t [atm]	C [l/h]	CC [l]	E_c [W-h]	E_l [W-h/l]	T [s]	T_p [s]	T_a [s]
1	1,0	0,8	372	0,38	0,093	0,24	3,7	2,5	1,2
2	1,0	1,2	384	0,38	0,098	0,28	3,5	2,5	1,0
3	1,0	1,5	398	0,38	0,102	0,30	3,4	2,5	0,9
4	1,0	2,0	420	0,38	0,123	0,32	3,2	2,5	0,7
5	6,4	1,2	327	0,38	0,143	0,40	3,5	2,5	1,0
6	6,4	2,0	410	0,38	0,176	0,46	3,3	2,5	0,8
7	6,4	3,0	415	0,38	0,200	0,52	3,2	2,5	0,7
8	6,4	4,0	427	0,38	0,186	0,53	2,9	2,5	0,4
9	13	2,0	334	0,38	0,220	0,58	4,0	2,5	1,5
10	13	3,0	384	0,38	0,270	0,71	3,6	2,5	1,1
11	13	4,0	404	0,38	0,310	0,81	3,4	2,5	0,9

TABLE 2

Characteristic values of the pump operation for thirteen experiences at level 2 (L2) and level 4 (L4).

	H[m]	P_t[atm]	C[l/h] L2	C[l/h] L4	E_t[Wh/l]	T [sec] L2	T[sec]L4	T_a [sec]
1	1	0,8	372	630	0,24	3,70	2.20	1,20
2	1	1,2	384	684	0,28	3,50	2.00	1.00
3	1	1,5	398	720	0,3	3,40	1.90	0,90
4	1	2	420	804	0,32	3,20	1.70	0,70
5	6,4	1,2	327	684	0,4	3,50	2.00	1.00
6	6,4	2	410	760	0,46	3,30	1.80	0,80
7	6,4	3	415	804	0,52	3,20	1.70	0,70
8	6,4	4	427	977	0,53	2,90	1.40	0,40
9	13	2	334	567	0,58	4.00	2.50	1,50
10	13	3	384	652	0,71	3,60	2.20	1,10
11	13	4	404	720	0,81	3,40	1.90	0,90
12	20	4	330	594	0,75	3.80	2.30	1.30
13	30	6	320	559	0.98	3.95	2.45	1,45

This increase of the extraction flow is due to the decrease of both the loading and the unloading time. It is not only important to know exactly the loading time of the chamber which is submerged in the water found in the well but it is also important to know its exhaust time which also depends on the compressed air pressure. Having in mind these values, a programmable logic controller is programmed (PLC SIEMENS LOGO 230RC 6 inlets 4 outlets) to control the electro valve. The results for the different experiences are shown in Table 2.

Advantages and conclusions of the pump

The main advantage of the pump is that it does not have complex or mobile parts submerged, except two simple backwater valves. The compressor is its most complex part and it is located at the ground level, so it can be easily accessed to maintain. Both its structure and its operation are very simple: According to the results of the tests and as it was foreseen, it can be mainly concluded that the pump as a whole works properly, that is to say, every single part works correctly, and it has been also proved that if the chamber is submerged more deeply, the loading time is reduced and the flow is increased. It can be observed that the pressure for extractions at 30 meters varies between 4 and 6 Kg/cm^2, and at a higher depth it increases significantly.

PHOTOVOLATAIC SYSTEM: *Description and operation*

In Figure 3, a global sketch to extract water at depth applied in a dispersed rural area is represented. The electric power generation is obtained through photovoltaic modules which load the batteries by means of a voltage regulator; then an inverter DC/AC is used to generate compressed air and tension is given to a PLC to control the compressed air electro valves, which open and close. To determine the photovoltaic system, the above mentioned steps were considered: the use of a system of ground water extraction through a pneumatic pump and the determination of solar resources for a specific area in the country (V. Mercedes/San Luis/Argentina).

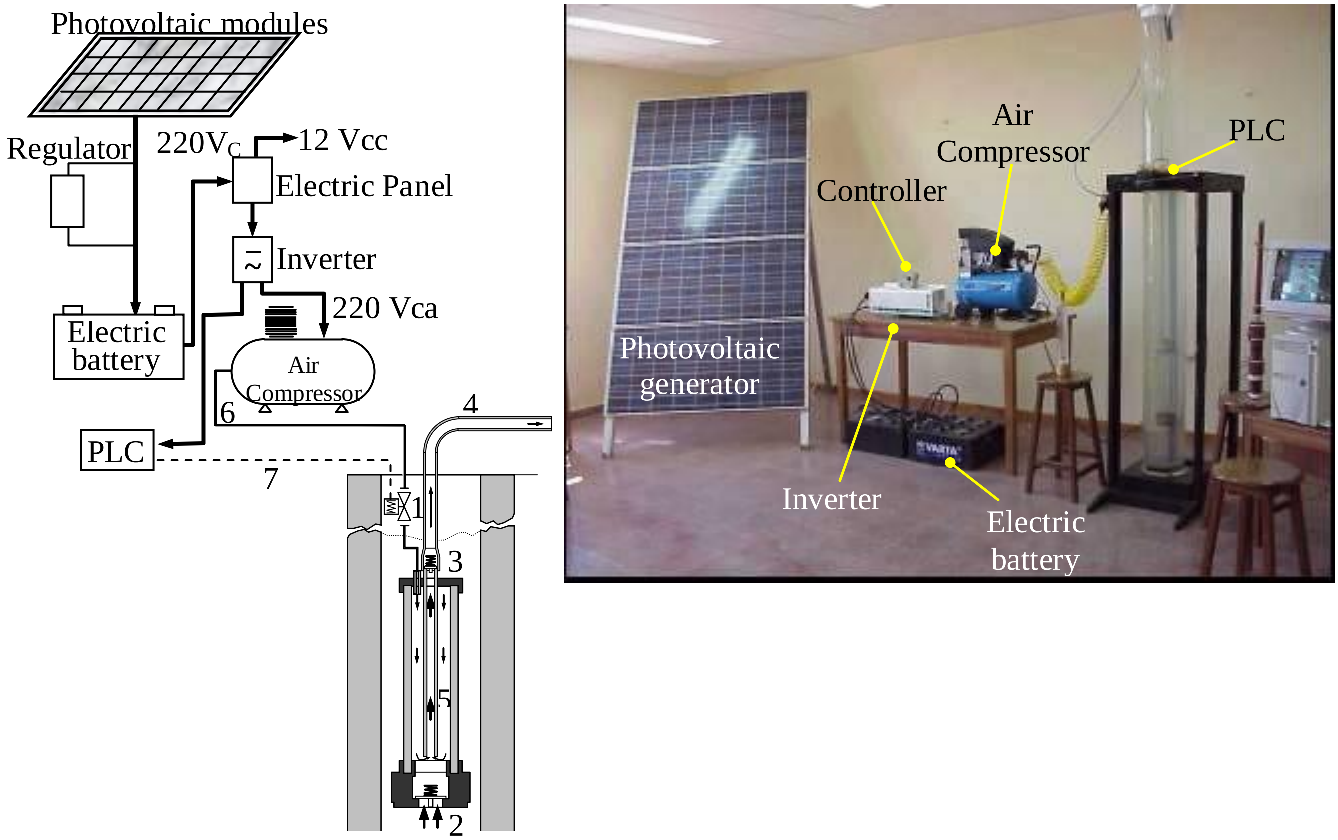

Figure 3. *Photo and sketch of the water pumping through compressed air system in one of the stages integrated with the electric generation through solar energy.* Where: (1) Compressed air electro valve; (2) 2 ½” Backwater valve, (3) ¾” backwater valve; (4) ¾” Pipe; (5) Chamber 1; (6) ¾” Pipe line for the compressed air and (7) Control electric circuit of the electro valve

The purpose of this project is to assess this alternative to supply drinking water specifically to an isolated area using solar energy in economical terms. Besides, a technical-economical comparison with other power and traditional systems was performed so as to offer potential customers a tool to help them decide whether the adopted system to supply water is convenient.

CONCLUSIONS

It was proved that the proposed system of the pneumatic pump is capable of extracting water at depth and it was checked that the pump can be energetically fed by means of photovoltaic modules.

The main advantage of the pump is that it does not have complex or mobile parts submerged, except two simple backwater valves. The compressor is its most complex part and it is located at the ground level, so it can be easily accessed to maintain. Both its structure and its operation is very simple.

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