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Pulsa Solar water oscillation pumps

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Introduction

FLUXINOS ITALIA of Grosseto, Italy, have pioneered the development of PULSA SYSTEM water oscillation hand pumps which are in the course of revolutionising village hydraulics in developing countries. The level of perfection reached with the hand pumps has enabled the developers to turn their attention to alternative sources of energy. The first result of this original work is the PULSA SOLAR water oscillation pump presented at the 8th European Photovoltaic Conference in May 1988 and at the 6th IWRA World Water Conference in Ottawa in June 1988.

The PULSA SOLAR pumps have all of the brilliant installation and maintenance characteristics of the PULSA SYSTEM hand pumps. They have no parts in relative movement below ground level and can be installed or withdrawn from the bore-hole in just a few minutes using one size 19 spanner. They are so closely related to the PULSA SYSTEM hand pumps that a solar kit comprising an upper element chamber, support structure, DC motor, fly-wheel, crank-shaft and panel array can be fitted onto existing PULSA SYSTEM hand pumps to form a group that can be operated by solar energy and/or by hand. Manual operation is therefore possible at night when there is no sun, when instantaneous sun power (early in the morning or towards evening) is not strong enough on its own to work the pump, or in case of momentary breakdown of the DC motor. PULSA SOLAR pumps can also be operated manually simultaneously with sun power during the day to increase capacity, and can, like the PULSA SYSTEM hand pumps, be used for both horizontal and vertical applications.

Description of the PULSA SOLAR pumps

PULSA SOLAR pumps need an array of 300 Wp (6 x 48 Wp panels). Assuming insolation of 6.5 to 7 KW, and assuming the novel 3 point manual tracking system specially devised for use with the pump is installed, the pumps will supply up to 11 m3 per day at water levels from 5-15 m, 9 m3 per day at 20 m, 7 m3 per day at 30 m, 5 m3 per day at 40 m, and 4 m3 per day at 50 m water level (which guarantees 25 litres/person/day in a village of 200 persons, the original design project of the PULSA SYSTEM hand pumps).

It has been possible to attain these results because of the flexibility offered by the inherent harmonisation characteristics of the PULSA spring rebound inertia system. As there is no mechanical transmission such as rods, it has been possible to develop a simple method for putting the upper and lower parts of the pump into (variable) resonance with each other notwithstanding the natural fluctuations in the direct solar input. PULSA SOLAR can be adpated to larger arrays of solar panels and an increase of capacity attained (always, however, within the 25/litres/minute hydraulic maximum of the pump system) by simply varying the diameter of the pulley mounted on the DC motor, which is coupled directly to the panel array, thus eliminating the need for battery storage systems and inverters.

Applications to village hydraulics in developing countries

Solar pumping systems using electrical alternating current centrifugal pumps connected to a solar array through battery storage systems with inverters are not particularly suitable for solving drinking water supply systems in developing countries because centrifugal pumps often require considerable power on start up and when they get started their capacity is often greater than that of the normal small village bore-hole while the initial investment cost for the solar array and the cost of maintenance of battery systems and inverters are too well known to be discussed in this paper.

PULSA SOLAR pumps offer possibilities to small communities not only of drinking water and water for personal uses but also additional capacity for animal watering and eventually for microirrigation at a revolutionary cost, eliminating at origin, all of the limitations mentioned above with, in addition, the possibility of using the pump installation as a hand pump for additional capacity and in emergencies.

Assessment of cost effectiveness

Projections have recently been developed for PULSA SYSTEM hand pumps, following 42 months of intensive use in Africa, to produce the figures of US $0.405/person/year in a village of 200 persons and US $0.0385 per cubic metre, with a global cost of US $81 per installation per year over a period of 10 years including maintenance services costs and amortisation of all parts subject to replacement at any time, including the costs of the maintenance artisan and of running his means of transport but excluding initial investment costs of the bore-hole, of the pump, of the artisan's means of transport and of civil works and eventual related social or health projects.

PULSA SOLAR pumps use practically the same pump and components. With respect to the hand pump, additional maintenance will come from periodic replacement of the DC motor brushes and of the fly-wheel drive belt, but on the other hand wear and tear of the piston and piston guide system will be less as operation with solar energy ensures a more regular stroke with respect to the violent variations which occur when 200 persons use a hand pump each in his own way.

The maintenance structure at one single level (a travelling artisan able to cover on his own on a systematic preventive maintenance basis several hundred installations) and a three-tier spare parts distribution structure (artisan's kit, local stock, national stock) will be applicable to the PULSA SOLAR as for the PULSA SYSTEM hand pumps with the same maintenance structure and parts stocks for both types of pump.

Initial additional capital investment cost

The initial capital investment cost will, of course, be greater for the PULSA SOLAR as against the PULSA hand pumps, the difference being to the order of US $3850. Taking life spans for modern solar panels as being 20 years minimum, the initial capital input differential (excluding financial costs such as hypothetical interest) would thus produce US $3850 divided by 20 years to give US $192.5 per year, which would mean in a village of 200 persons US $0.9625 per person per year. This capital cost input need not be to the charge of the community as within the framework of an ESA (External Support Agency) project it would normally be included in the global cost allowance, and would mean just a few percent extra on the global value of the project.

The concept of progressive investment

The concept of progressive investment applied with PULSA SYSTEM hand pumps (starting with a single pump, then putting a double, then a triple pump down the same bore-hole) is still further enhanced by the introduction of the PULSA SOLAR, because a PULSA SYSTEM hand pump already on a borehole can be subsequently "solarised" in a second phase by fitting on to it the solar kit which serves to transform the handpump into a combined solar and/or hand pump unit, either as the second phase of an ESA financed project or by way of collection over a few years of funds by the villagers themselves for this purpose.

Conclusions

The recurrent maintenance cost onus on the beneficiary village will be the same as that for the PULSA SYSTEM hand pumps and amounts to US $0.50 (maximum) in a village of 200 persons, and the additional investment cost differential is US $0.9625 per person per annum in a village of 200 persons, for the privilege of using solar energy for the pumping of drinking water and water for personal uses, and eventual surplus water for animals and microirrigation purposes.

Pulsa Solar Indicative Technical Specifications

Working principle: exploitation of the characteristics of oscillating water columns
Above-ground: piston, shaft, flywheel, DC motor. No parts in relative movement below ground level
Connecting pipe: one single 1 1/4" H.D. flexible polyetheylene pipe, nominal pressure 16 bar, 40 mm external diameter, 28.8 mm internal diameter, joined to the upper pump body and to the flexible element chamber by means of standard rapid couplings
Fly-wheel axis: height from ground : 1 m
Fly-wheel diameter: 1.4 m
Nominal speed: 90 rpm
Motor: 48V DC - 1500 rpm connected directly to the solar modules with the exclusion of battery and inverter systems
Transmission: type A trapezoidal belt
Suction height: 0-50 m+ (water temperature not greater than 30°C)
Direct start up without current surge
Average life of piston seal: 12+ months
Time for replacing piston seal: maximum 15 minutes
Size and movement of piston: piston diameter 100 mm; stroke length 4-5 cm
Bearings: two 80 mm and one 110 mm lubricated sealed bearings with life of 10+ years

Installation: 300 Wp with insolation 6 1/2KW, capacity at 20 m water level: 9 m3 per day
Optional use as a hand pump

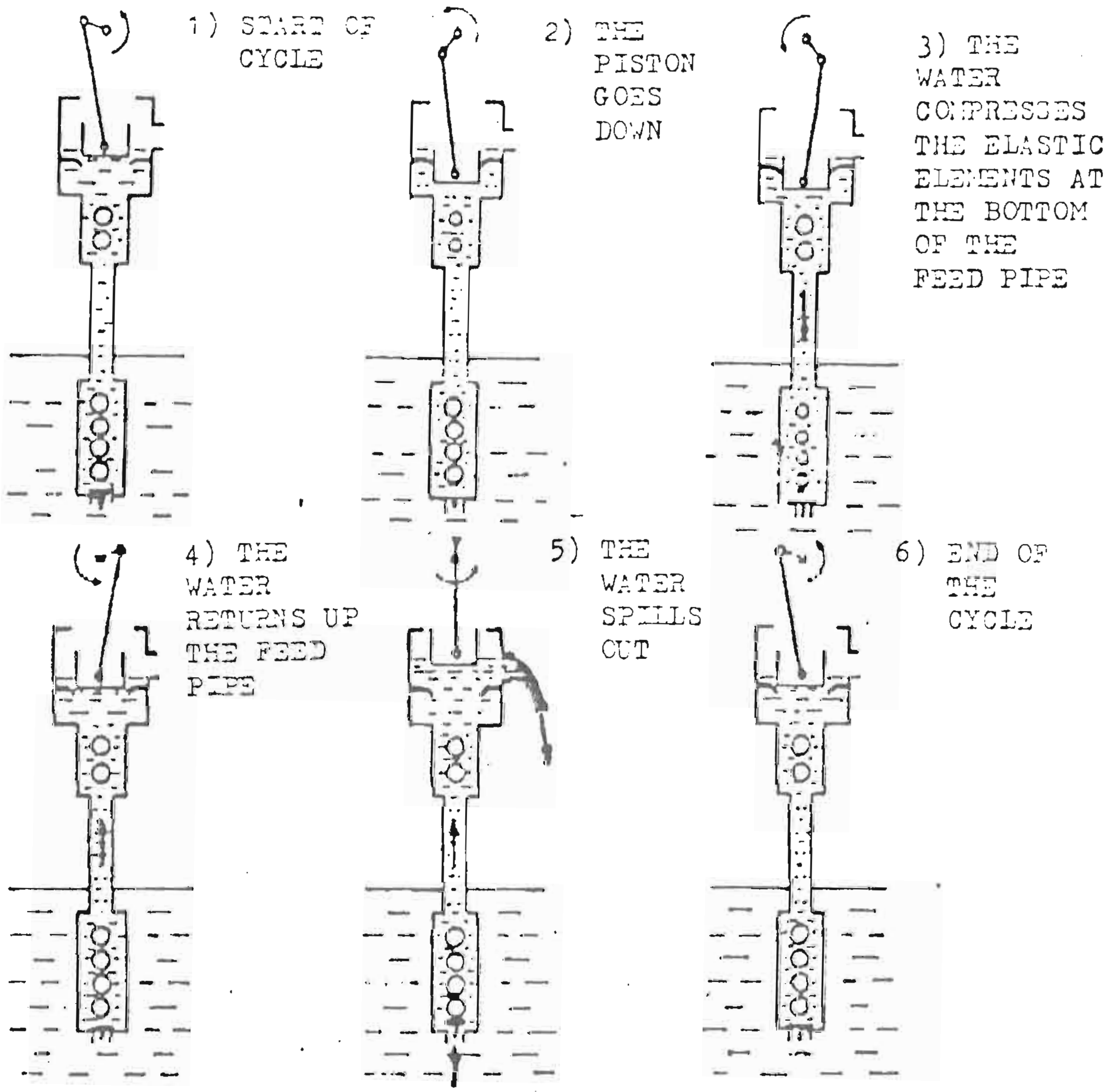
References

The development of PULSA SOLAR pumps is the original work of the authors.

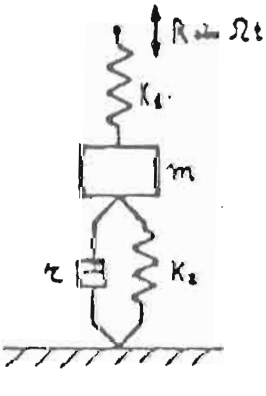
Hohmeyer O. Social costs of energy consumption. Springer Verlag, Berlin-Heidelberg, 1988.

Cabraal A. A comparative assessment of photovoltaics, handpumps and diesels for rural water supply. 6th IWRA World Congress on Water Resources, Paper 99A, IWRA, Ottawa, 1988.

PULSA SOLAR - PUMPING CYCLE



PULSA SOLAR - SIMPLIFIED PHYSICAL MODEL



R = crank radius
K_1 = elastic constant upper springs
m = water mass in pipe
k_2 = elastic constant lower springs
r = various losses
Ω = angular speed of crank
$\omega = \sqrt{k_2/m}$ system pulsation