Designing a spiral pump for irrigation

by L.C.A. Naegel, J.G. Real and A.M. Mazaredo

New experiments on an old idea have determined the ideal conditions for achieving maximum efficiency from a spiral pump.

THE SEARCH FOR cost-effective pumps is a top research priority worldwide. Studies to develop models which can be powered by renewable energy sources, which can pump water to a higher head than the pump structure itself, and which can be built out of available materials by local craftsmen have produced two types of stream-driven pumps: the coil and the spiral pump.

The coil pump and the spiral pump work on the same principle, but the designs differ significantly. In the coil pump, flexible tubing is wound concentrically around a drum or floating framework.[1,2] The major drawback of the coil pump is that the size of the drum limits the pump's use in narrow irrigation canals. A simpler inclined coil pump with an internal coil for low head applications also exists.[3]

The second option is the stream-driven spiral pump, invented originally in 1746 by H.A. Wirtz[4,5] and re-invented by P. Morgan[6] in 1984. The pump consists of a flexible plastic hose coiled spirally on the same axis and plane, so that each loop of the hose differs in diameter from the next, and the whole device resembles a large wheel with the axis parallel to the water surface (see Figure 1). The pump is partially submerged in the stream and the wheel is rotated by the streamflow, so that alternating plugs of water and air are scooped into the intake tube. The large diameter of the pump makes hand-turning easy during decreased streamflow. To increase the water intake into the pump, and therefore the efficiency, a scoop has to be attached. The end of the hose leads into the rotating axle, and by means of a water- and pressure-tight swivel, the water moves into the stationary water-delivery pipe. The swivel is similar to an oil seal used commonly in cars, and can be made locally in a workshop. During water delivery, the individual plugs in each of the loops of the hose are forced against the head, resulting in the build-up of a differential pressure in each of the loops of the spiral.

To test its efficiency, prototypes of the spiral pump with 2.0m overall (wheel) diameters were constructed at the University of the Philippines at Los Baños, using different tube materials and tube diameters (1.91, 2.54, 3.81, 5.08 and 7.62cm), different speeds of rotation, and different total heads.

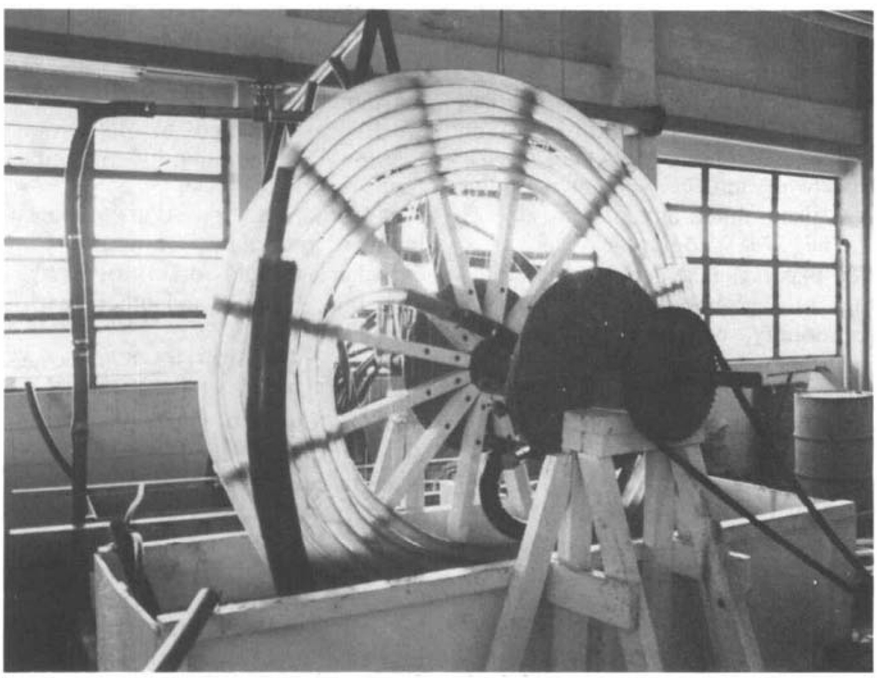


Figure 1. A spiral pump being tested in the laboratory.

Nearly 1600 individual tests were done. It was established that the pump was most efficient (over 50 per cent) with a high head, a slow rotational speed, a smaller-diameter tube, and with a scoop of 100 to 120 per cent of the outer coil volume.

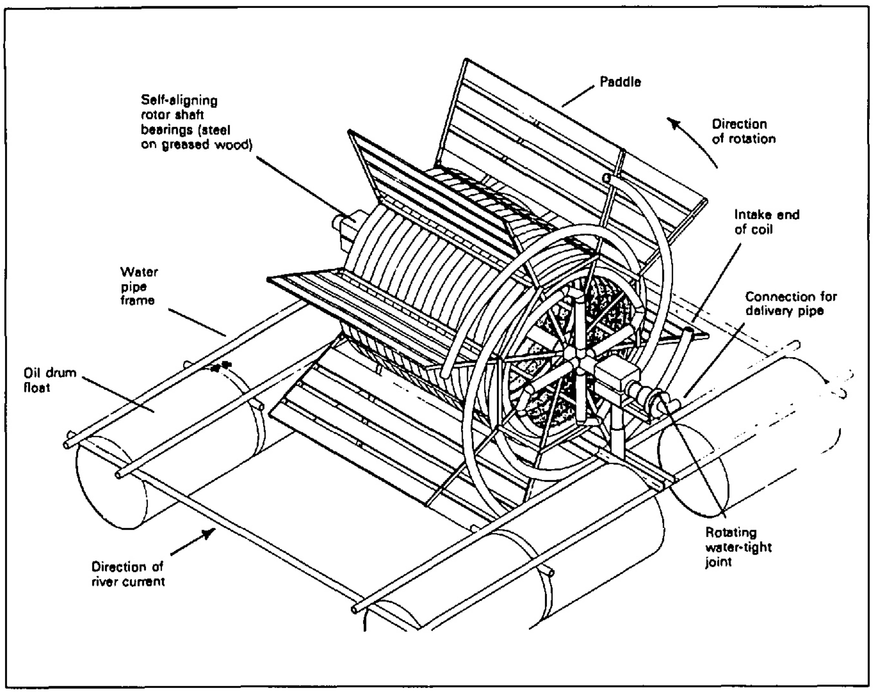
An interesting observation was that regardless of the depth of immersion of the wheel into the water, and the design of the water intake scoop, it was not possible to fill the outer coil with water to more than 50 per cent of the volume of the outer coil, a fact first described by Olinthus Gregory in 1815.[7]

Field tests

Field tests of the Los Baños model were conducted in co-operation with the Abra River Irrigation Project (ARIP). ARIP is a large irrigation project in the province of Abra, about 400km north of Manila, and is helped financially by Misereor. Abra is one of the poorest provinces in the Philippines, where the average area of land per family is less than half a hectare. In the past, rainfed (dryland) fields could be planted with crops (such as rice) only during the rainy season, which lasts about six months. To increase agricultural production the Abra river was tapped, and a diversion canal was constructed which now feeds several thousand hectares of agricultural fields. The fields situated above the irrigation canals, however, do not benefit from this new development. The field tests were initiated because of the strong interest shown by farmers for cost-effective pumps that could supply water to these disadvantaged fields.

Spiral pumps with outer diameters of 2.5m, 4.0m and 5.0m were constructed and installed at different sites going into the main diversion canal. The canal was 3m wide and the water depth fluctuated from 1.2m to 1.6m. At a velocity of about 1.59 m/sec, approximately 7.5m^3 of water was passing through the canal per second.

To make the most efficient use of a given streamflow, the size of the paddles should be adjusted accordingly. In this case the paddle size of 0.5 ×0.8m was increased to 1.2 ×0.8m, which resulted in a



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much faster rotating of the wheel and an increase in delivered water.

The pumps were running without major problems for nearly four months from February 1990, and the field tests had to be interrupted only because of the rainy season.

The tube diameter used, the height of the water delivery, and the water volume scooped into the tube resulted in varying speeds of rotation of the wheel, and thus different volumes of delivered water. These results agreed with the formulae obtained from the previous laboratory tests.

In view of the successful operation of the pumps and the readiness of the farmers to accept this new technology, the Abra River Irrigation Authority is planning to install more pumps in the main irrigation canal. This will make possible intensive vegetable production on fields situated above the irrigation canal.

Although the amount of water supplied per minute is less than a conventional gasoline or diesel-driven pump would provide, this is made up for by the continuous, free-of-cost day and night operation of the pump. An additional advantage of the pump is that the maintenance requirements are minimal, consisting mainly of cleaning and checking, and repairs can be carried out by local craftsmen.

Cost comparisons

The main drawback at the moment is that the pump is expensive because each one is built individually. Comparing the actual cost price of a factory-produced Japanese gasoline pump (about 6000 pesos) or diesel-driven pump (about 12 000 pesos), an individually built spiral pump is more expensive (about 14 000 pesos). The axle, the tube material and the swivel are the main cost factors, but a group could mass-produce the axle and the swivel, thereby lowering the price.

Considering the high efficiency of the pump at high heads and slow speeds of rotation, its non-use of fossil fuel and its adaptability to existing natural conditions (i.e. where a strong streamflow stream in narrow rivers or irrigation canals is available), spiral pumps are an excellent alternative, in particular for developing countries without their own oil resources.

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Acknowledgements

This research project was financially supported by GATE/GTZ, Eschborn, Germany. The axle and the swivel were manufactured by DESCO, Manila. The project was initiated through the great hospitality of the UPLB College of Engineering where the laboratory tests were conducted. The field tests were successfully completed through the active co-operation of the Abra River Irrigation Authority (through Fr E. Reinhardt and Mr Darwin Onel).

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Water for irrigation is now within reach, even from this narrow canal.