PRACTICA
Foundation

Report

Production and testing of an animal driven deepwell pump

foto: Testing animal driven pump in the vicinity of Butajira

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About this report

This report has been produced as one of the outputs of the project 'Production and testing of an animal driven deepwell pump in Ethiopia'. This project is financed by JICA Ethiopia and executed in cooperation with the Ethiopian Water Technology Centre (EWTEC). Other outputs that have been produced in the context of this project are:
- One working prototype of the Animal driven deepwell pump installed in the vicinity of Butajira;
- A set of production drawings of the pump as installed in the field;
- A CD-ROM with photo and video material of the production, installation and testing of the pump as well as soft copies (pdf and AutoCAD 2005 and LT) of the workshop production drawings.

This report contains information about the background of the project, the objectives of the project and the project approach as can also be found in the project proposal. Further in this report, the course of action during production, installation and testing of the pump is described. Also included is information about the costs of the pump and recommendations about monitoring, evaluation of the installed pump and continuation with animal powered pumping in Ethiopia.

Background

Ethiopia has many areas where the groundwater is deep and where it is difficult to lift the water by hand pump. Also where large quantities of water are required (e.g. where many people depend on one borehole, cattle watering or irrigation), the capacity of hand pumps is often insufficient. In such cases mechanised pumps can be used (diesel or petrol engine) but they have the disadvantage of requiring fuel and maintenance and are apt to breakdown.
The use of animals for driving pumps can be a good alternative to using engines and fuel. It is cheap and has the potential to be sustainable. Four prototypes of animal driven pumps have been build and installed in Niger, back in 1985. The technology worked but there has been no follow-up and Practica has no information on the user satisfaction of these pumps.
To the knowledge of Practica there have been very few, if any, successful introductions of deepwell animal driven pumps. The reasons for failure were often too high cost, complicated equipment or impractical operation. On the social level there may be the feeling by the users that animal driven equipment is regress rather than progress and users may not want to adopt it for that reason. Considering however the potential advantages of animal driven deepwell pumps in combination with the habit of using animal power in Ethiopia, an experiment with such a pump can be worthwhile.

Objectives

The overall objective of the project is to gain experience with an animal driven deepwell pump in Ethiopia and so to evaluate the potential of these pumps for large scale introduction. This includes the following steps:
- Optimising the existing design for animal traction deepwell pump and testing by means of a prototype model in the Netherlands;
- Production of drawings of the pump for production of a prototype in Ethiopia;
- Providing supervision and training to a local workshop on the production and installation of the animal driven deepwell pump;

- Installation of the pump at a test location;
- Monitoring of the pump on technical performance and social acceptance.

Design criteria

For the design of the animal driven deepwell pump, the request from JICA was to use a piston pump instead of a rope pump. The pump should be designed to be operated by horse instead of a donkey. The maximum depth from which this pump should lift water is estimated to be around 80m. At this depth the discharge (using a horse) should be about 0.25 l/s.
The design of the pump has been based on these criteria. As the test well in Butajira is only 18m deep, with a static water level at 17m, the design of the pump has been adapted to lift water from 17m only. The discharge at 17m is estimated at 0,9 l/s using a horse and a pump stroke of 2m.

The course of action

The implementation of the project has taken 5 week, of which 1 week preparation in the Netherlands, 2,5 weeks production in the EWTEC workshop and 1,5 weeks installation and testing on site in Butajira.

Production

During production of the pump, no serious problems have been found. The availability of the materials for production in Addis Ababa is good, although some materials took some time to find. The material for the foot valve seating, piston, piston ring and piston guide is solid PVC. This material was brought from the Netherlands. No details are known about the availability of solid PVC material in Addis Ababa. The material used for the guide rolls is solid Delrin (POM) plastic. This was also brought from the Netherlands. No details are known about the availability of Delrin plastic material in Addis Ababa. If not available, other options / design for these parts have to be considered for these parts.
The most difficulties were found with the alignment of the bronze bushings of the central pole. After some experimenting, it was found that simple bronze pipes and fittings can be used to produce these bushings.
Many parts have to be produced on the lathe. This requires special skills and is time consuming. During production, 1 person has worked for some 1,5 weeks to produce the different parts on the lathe.

EWTEC workshop
The production of the pump was done in the workshop on the EWTEC premises. Although the workshop is well equipped for production of prototypes (good machinery), there is currently no routine in production. The workshop is mainly used for training purpose. The tools needed to use the machines (cutters for the lathe, drill bits) were not readily available and had to be borrowed or purchased. Other machines (lathe) were not working at all and had to be repaired. For future project when production of a prototype is involved, it is recommended to check the machines in advance and purchase basic equipment needed to operate the machines.
Contrary to earlier experiences of PRACTICA staff with poor motivation of the personnel, I have experienced full support of all the staff. Earlier experiences with slow and complex procedures for purchasing materials and tools are still valid. Working with a separate budget for the project solved most of these difficulties, however, in case of purchasing of

tools and machine parts (which was not included in the budget), the procedures can slow down the project.

Installation

Before going to the field, a first installation of the pump was done at the EWTEC test site, on a borehole. During this installation the following problems were encountered:
- Lack of anchoring of the structures to the ground; with no concrete blocks in the ground, it was not possible to pump. This gave some good indications about the importance of heavy ground anchors;
- Stretch of the rope; when using normal 10mm PE rope, we noticed a lot of stretch in the rope. As the stretch will reduce the effective pump stroke, a lot of energy is lost. The rope was replaced by a 5mm steel cable;
- Problems with removing the piston; when installed, extracting the piston from the pipe was very heavy. The only way to solve this problem is by man power.
- Heavy weight of the PVC; as thick-walled PVC is used for the pump, the weight of a total of 18m of pipe is considerable. It takes 5 persons to remove the pipes from the well;
- Importance of inner chamfer of pipes; as the piston is inserted through the pipes, an inner chamfer is very important. During installation the piston got stuck on an insufficient chamfer of one of the pipes.

Installation on site in Butajira took one day. After installation, problems were found with a leaking foot valve. This was due to a cracked foot valve seating caused by impact of the falling foot valve and the shallow water level in the well. The problem was solved by removing the pipes from the well, repairing the foot valve seating and re-installation of the pipes. This took one day.
A 500 litre storage tank was installed at the site to store water for drinking and to have a constant flow of water and pressure for irrigation.

Field testing

During the testing of the pump in the field, the focus during the first two days was on functioning of the driving structure and pulley structure as well as the pump part. To test this under controlled conditions, the pump was operated manually. The first testing with animals took place on Monday 12 March. The first attempt to use a horse did not succeed, as the horse did not cooperate. The second attempt was done by using a bullock (ox). Although the bullock is supposed to produce less power than a horse, the attempt was successful. With the bullock, a rotation speed was measured of 18 seconds per rotation at normal conditions to 14 seconds per rotation when bustled. For normal rotation speed following and beating the bullock was also necessary. The pump stroke was set at 1m, whit a theoretical yield of 7,7litres per stroke. The actual yield has not been measured but is estimated at 7 litres per stroke (which is 0,4 to 0,5 litre per second)
The second test with an animal on Tuesday 13 March. Using the bullock was not successful as the animal was weakened by a morning ploughing. Mr. Mohammed (the owner) suggested using a donkey. Although the donkey was able to turn the pump (stroke set at 1m), it appeared to be too heavy. The pumping lasted for 15 minutes before the donkey gave up. During the pumping, the donkey had to be beaten and the pole had to be pulled by human force to support the donkey. Discussions showed that Mr. Mohammed does not have his own horse and although better for the job, he is reluctant to use his bullock. As a bullock is more valuable than a donkey and of great importance for the work on the land, he preferred to use his donkey.

During testing, no serious problems where found. The only problem was with the connection of the cable to the rods, where a weld broke and the piston dropped. Fishing the piston and repairing the connection took 4 hours.

The overall impression of the testing is that the owners as well as the animals have to get used to the pump. After the training, it is important that the pump will be used for a couple of weeks to practice. It is expected that after a couple of weeks of use most of the problems related to the use of animals will be solved. This has to be evaluated during the first monitoring visits.

Cost issues

The animal driven deepwell pump as built and installed has been designed from a 'minimum cost' perspective, using materials that are easily available on the market in Addis Ababa. However, during the production, installation and testing of the pump the costs have not been minimized due to time constraints. The total costs of the pump as installed in the vicinity of Butajira is estimated at 14.000 Birr (€1.200), including all materials, concrete work on site and a steel storage tank of 500 litres. In this estimate, also the materials that were obtained from the EWTEC workshop are included. Labour for production and installation as well as transport are not included. Based on the prices of the different materials, it is estimated that the production of a second pump will cost around 9.000 Birr (€775) excluding transport and labour and profit. PVC pipes accounts for about 25% of this amount.
For a second pump, focus should be on further reducing the costs. Based on experiences during use (which animals are being used; what are the actual forces on the pump, etc), the construction can be further simplified to reduce the costs.

Recommendations for monitoring and evaluation

Due to the experimental nature of the project, proper monitoring is essential. The monitoring visits should be used to:

- Check on the technical state and performance of the pump (including preventive maintenance and problem shooting and solving);
- Support the users in the operation of the pump and train the users when needed;
- Improve the performance of the pump by making adjustments based on the experiences of the users;
- Gather information about the technical performance of the pump;
- Gather information about the user acceptance of the pump by interviewing the users;
- Gather information about the economical impact by interviewing the users and by observation of improved farming systems (as irrigation);

In the first phase after installation, monitoring should focus on technical performance and training of users. This to prevent an early failure of the pump with the risk that the experiment will not yield any data about user acceptance and economical impact. This first phase will take about 6 months. Technical follow-up should be done by the two trained mechanics Mr. Getachew and Mr. Zerihun. It is recommended that Mr. Getachew will be in charge of this and will get the means to carry out the following schedule of monitoring visits:
1st visit 1 week after installation;

2nd visit 2 weeks after 1st visit;
After the second visit one visit every month or more frequently if needed.

An extensive evaluation of the project to gather information about user acceptance and (socio) economic impact should take place 6 - 12 moths after installation.

Recommendations for continuation with animal powered pumping

When continuing with animal powered pumping in Ethiopia, the following issues should be considered:

Costs / affordability

The prototype of the animal driven pump is still rather expensive. By optimizing the design, the cost should go down further as to compete with other deep well pump options as the motor rope pump.

Technical performance

The technical performance of the pump should be evaluated further to see how it performs in actual use; the low frequency pump together with the asymmetric and heavy load requires a strong construction. Besides, when distributing the load more equally, the animal should be able to deliver more power. These ideas have to be tested during actual use to see if and how the technical performance can be improved.
New design should focus on lighter (cheaper) materials (for example wood) and higher pump frequency. Using a driving structure directly around the well to can be one option to reduce complexity.

Social acceptance

For large scale introduction of animal powered pumping, serious attention should be paid to the social acceptance: using animal traction is often not associated with progress and modernity. This might seriously hamper the acceptance of the. A user acceptance study should be part of monitoring of the project. In case of any indications of problems with user acceptance, a separate evaluation should be done by a social scientist to find out if and how these issues can be overcome.