

Final Report of Sub-Project

Improved Design to Reduce Drudgery in Operation of the Human-operated Treadle Pump for Irrigation

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By

Prof. S.K. Saha

IIT Delhi

Department of Mechanical Engineering

IIT Delhi, HauzKhas

New Delhi 110 016

Tel: (011)2659 1135; Fax: (011)2658 2053

Email: saha@mech.iitd.ac.in

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1. Background and Need

An internal meeting with the participants of the Management Development Programme for Rural Enterprises was conducted on 18th November, 2011 at IIT Delhi. In this meeting, Shri C. P. Kushwaha of Gramodaya Rachnatmak Vikash Sansthan, Chariawaha Khas, Deoria, U.P. stated that Treadle pumps are being used by the farmers for lifting water for irrigation in the smaller fields. This involved drudgery. He requested RuTAG-IIT Delhi to address the issue of reducing drudgery. The problem was shortlisted by RuTAG-IIT Delhi to address.

2. Preliminary Investigations and Problem Formulation

Treadle pump is a foot operated device which uses the human power to generate the reciprocating motion of the piston by the use of slider crank mechanism to suck water out of the ground. It is a twin-cylinder reciprocating water pump presently being used by thousands of small/marginal farmers in various places of eastern U.P, Bihar, Orissa and other places. These are particularly popular in areas where water level is not too low (around 10m or less). However, they expressed the need for improving the ergonomic design to make the operation less cumbersome. Further the problem of rapid wearing out of the piston washers was also experienced. The present project is targeted towards developing suitable modification in the pump to make it more efficient and user friendly.

A RuTAG- IIT Delhi team comprised of Dr. Jagpal Singh and Shri Raj Kumar Gupta visited Gramodaya Rachnatmak Vikash Sansthan, Chariawaha Khas, Deoria, U.P. during December 15–16, 2011. After interaction with the users in Dhanauti, Lakhanchand and Chariawaha Khas villages and the staff of the NGO the following problems have been identified:

1. Lot of stress on the knees and lower and upper side muscles of the feet.
2. The rubber washer is replaced after an interval of 15-20 days and thus proving costly.
3. The cost of washers is about Rs.60 per pair.
4. One experienced person can operate the treadle pump for about an hour. While new person can work for about 20-25 minutes.
5. Approximately 20 kg. load is put on each pedal.
6. The stroke (cylinder head) length is short due to which operator has to put more effort.

It was also observed that

1. The device was not scientifically tested and analyzed keeping the engineering aspects in view.
2. The design used was not standardized.
3. There was no upper flange to guide the movement of the piston rod due to which rubber washer did not move in straight direction which caused inordinate rubbing to the washers.
4. The inner surface of the cylinder was not smooth due to which the rubbing of washer was more which resulted in applying more effort by the operator.
5. The lever length of the pedal was less due to which operator had to put more effort in operation.
6. The suction valve was placed on the side of the cylinder, not in the centre of the cylinder, due to which the stroke load increased which caused more effort in operation.
7. There was no proper support (handle) to maintain the position of the operator which caused uncomfortable posture of the operator due to which the operator got tired soon.

Our field visits to study the performance and the prevailing designs of the treadle pumps revealed that there was ample scope for improving the mechanical as well as the ergonomic design of the pumps and also the piston material.

3. Action Plan and Deliverables

- I. Detailed study of the existing design (Fig. 1) of the treadle pump, its basic mechanism, design parameters, performance characteristics.
- II. Analysis of the design and detailed study of the problems.
- III. Propose an improved design, which overcomes the problems and is more efficient, ergonomically comfortable to use and also cost effective.
- IV. Field testing of the improved design.
- V. The project was intended to evolve an improved user-friendly design.

4. Duration: Nine Months

5. Action Taken

A Treadle Pump was purchased through the NGO (Gramodaya Rachnatmak Vikash Sansthan, Chariawaha Khas, Deoria) for studying the problem more closely and the potential design changes. The treadle pump was installed at Micro Model of IIT Delhi for problem identification and testing (Fig. 4). After conducting the detailed study of the problems, analysis and CAD model (Fig. 3) of the existing design, following improvements were carried out:



Fig. 1 Existing Treadle Pump

- 1) A handle made up of MS Pipe has been fixed with the base of the Treadle Pump to support the operator during operation. See Fig. 2.
- 2) After proper testing the appropriate lever length was decided. For easy operation three options for changing the pedal of lever length have been provided. Three holes have been made in the lever length at the distance of three inches to make it adjustable.
- 3) Moveable wooden pedal were fixed in the middle holes of the lever for smooth running of the Treadle Pump by the operator of the normal weight. If the weight of operator is less, the paddle may be placed in rear hole of the lever while it may be placed in front hole if the operator is heavy.
- 4) The earlier cylinder was made up of MS sheet which was not uniformly round. It was replaced by a new cylinder made up of seamless pipe. The inner side of the cylinder was made smooth by machining. The suction valve was earlier placed on the side of the cylinder which was one of the reasons of rubbing of the washer from one side. The suction valve has now been fixed in the centre of the cylinder for smooth operation.

- 5) There was difficulty in fixing the washer in the piston due to fixing of washer guide ring with piston rod. It has now been changed by making the washer guide ring attachable and detachable with the help of nut and bolt.
- 6) Using the Treadle pump continuously for long period the holes of the levers without Bushes used to become loose due to which the user had to bear drudgery in operation. To bring the Treadle Pump in normal condition the owner had to replace such levers with new levers which was costly. Now, for easy operation the bushes made up of Brass have been fixed at each hole where moveable pins have been fixed. There will be no need to replace the levers after long period. If necessary, the bushes only may be replaced.



Fig. 2 Improved Treadle Pump

- 7) The washer being used in the Treadle Pump was sent to an Ahmedabad (Gujarat) based manufacturing Company - M/s Nitin Rubber Industries, C-5, Anup Estate, Beside Bharat Party plot, Highway, Amaraiwadi, Ahmedabad for testing the material and proper guidance. The company was requested to manufacture new washer of same dimension with better quality material. The company casted the die of the required dimensions, made washers with better quality material, i.e., NBR Rubber

(Nitrile Rubber) and supplied to RuTAG-IIT Delhi for testing. The washer was found in order.

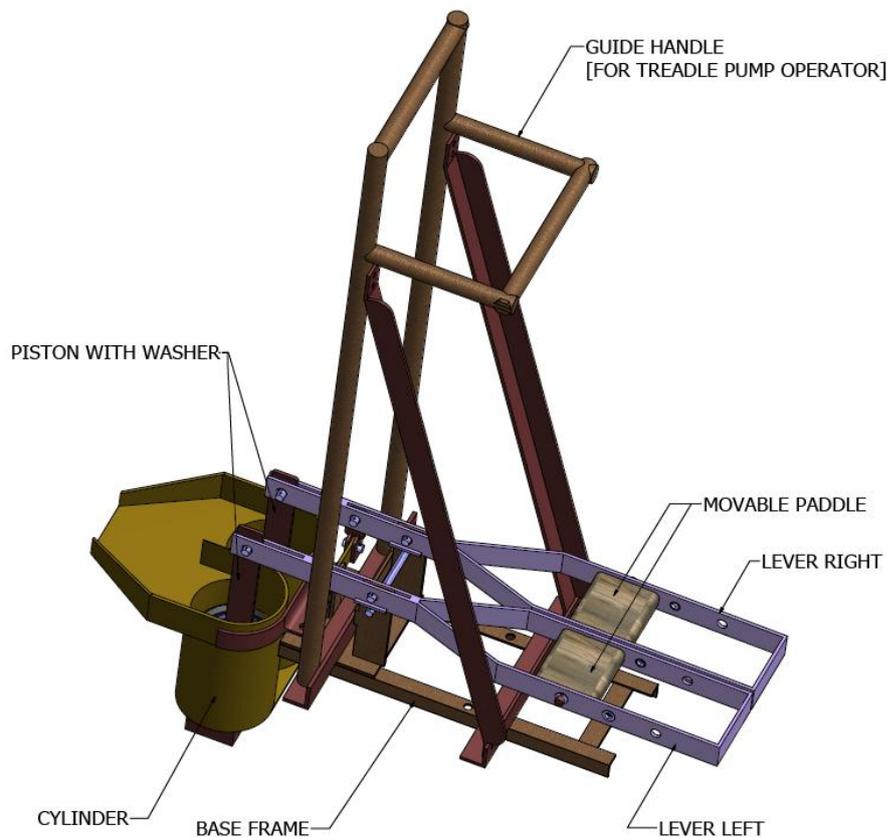


Fig. 3 CAD model of improved Treadle Pump using Autodesk Inventor 2012.

The fabrication of the improved Treadle Pump was done by *Genius Engineers*, Sector-IV, Dwarka, New Delhi. A Demonstration-cum-Testing Programme was organised by RuTAG-IIT Delhi at Micro Model on 17-18 July, 2013 in which users' representatives, manufacturers from Gorakhpur, NGO (Gramodaya Rachnatmak Vikash Sansthan, Chariawaha Khas, Deoria) and the RuTAG-IIT Delhi team participated. The participants saw the demonstration of Treadle Pump and tested one by one and found working smoothly. However, they suggested fixing the bushes in each hole where pins have been provided. This was agreed to and bushes have been fixed in all the holes. The detailed drawings of improved Treadle Pump were shown to the manufacturers. They were agreed to fabricate the improved Treadle pump for commercial production.

The detailed drawings of improved Treadle Pump were sent to the manufacturers- Purvanchal Engineering Complex (Structural Engineers), G-22, Industrial Area, Lachhipur, Gorakhnath, Gorakhpur and M/s Bhagwati Engineers, 92, Rajender Nagar Industrial Area, Mohan Nagar, Ghaziabad for commercial production of improved

Treadle Pump. Gramodaya Rachnatmak Vikash Sansthan, Chariawaha Khas, Deoria and Avadh Bihari Shriram Lok Vikas Sansthan, Mehdawal, Sant Kabir Nagar, U. P. are insisting the manufacturers for commercial production of the Treadle pumps so that the improved Treadle Pumps could be disseminated among the farmers at large scale. The NGOs are also approaching PCRA and NABARD for supporting the NGOs for popularisation of improved Treadle Pumps in all potential areas.



Fig. 4 Visit of RuTAG-IIT Delhi team during testing of Treadle Pump at MICRO- MODEL

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