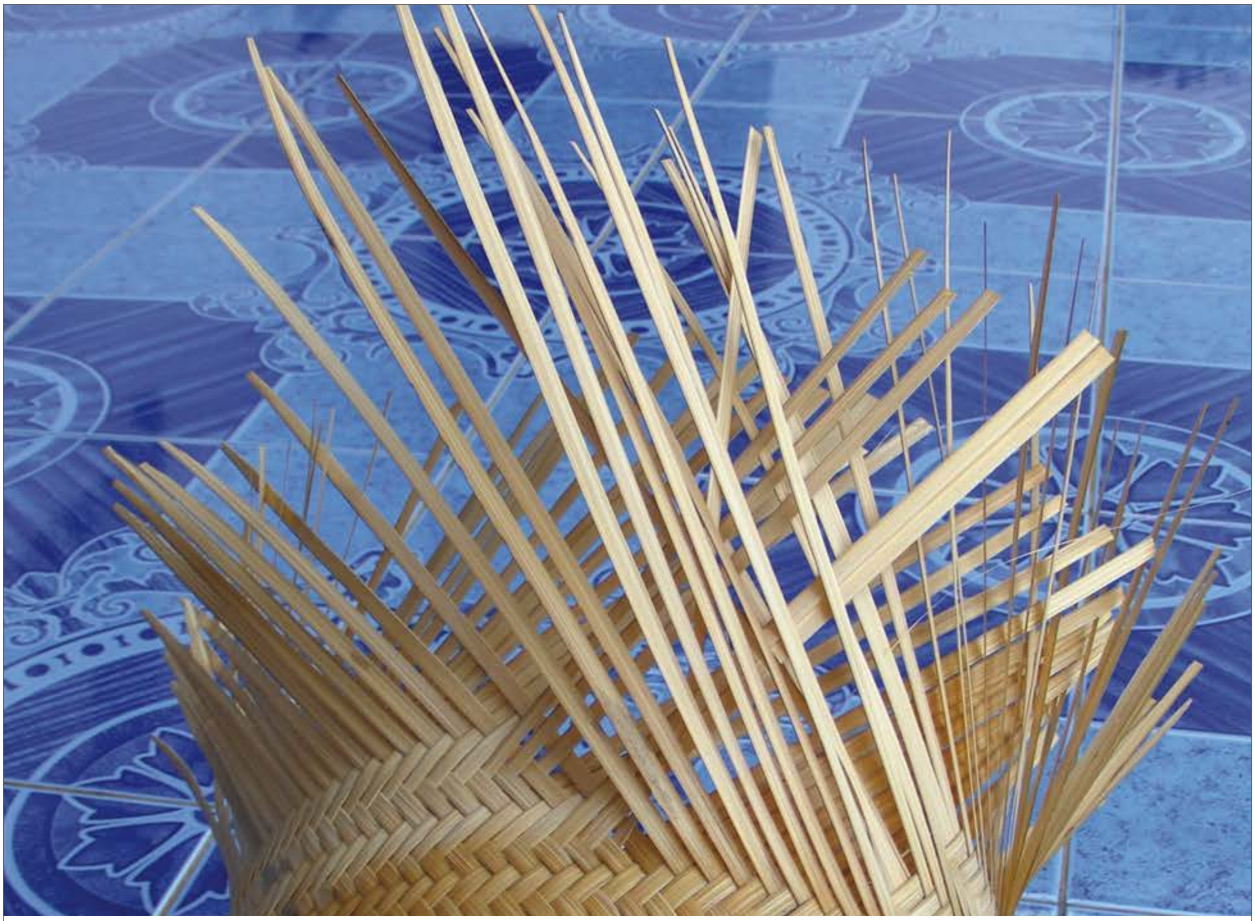

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Development of Automatic Stopper Device for Commonly used Centrifugal Pumps in Egypt

R.A. Hegazy and A.M. Elsheikha
Department of Agricultural Engineering, College of Agriculture, Kafrelsheikh University, 33516, Kafrelsheikh, Egypt

Corresponding Author: Rashad Aziz Hegazy, Department of Agricultural Engineering, Faculty of Agriculture Kafrelsheikh University, Kafrelsheikh Governorate, P.O. Box 33516, Egypt

ABSTRACT

Centrifugal instruments are prevailing used for irrigating fields in Egypt as the most common surface irrigation method. The major problem which confronts the farmers at operating these instruments is stopping it at the time of water shortage. Two main reasons can lead to operate these machines in absence of water, first one related suction tube which it is not completely covered by water in sometimes; second one is existence of accumulated mud and other materials around suction tube filter. So, the main object was to develop an automatic stopper device to turn off the machine at its time of running out of water. The device consisted of three main parts, metal base, water tank and disconnecting arm. The theory depended at using part of discharged water which comes to small tube for cooling engine and to keep this amount of water fixed all the time in specific tank. This amount of water working as equilibrium force and any change in its amount will reflect to movement in the manufactured device components. The device showed good performance in turning of machine at the moment that 35% of filter face height became without water coverage. It also can stop the engine if the water residues and mud cover 50% or more of suction tube area which is so important for farmer to keep the machine running without problems.

Key words: Stopper device, automatic control, centrifugal pumps, lifting water, water shortage

INTRODUCTION

Egypt is mainly an agricultural country in which agricultural and irrigation technologies play an important role in supporting national economy. About 2.3 million hectare is old land irrigated by surface irrigation methods. Traditional centrifugal pumps are commonly used by farmers to lift water from canals and they are widely distributed in different areas due to their simplicity and reparability. International Resources Group (IRG, 2006) cleared that these water pump sets are used widely to lift water from deep well, lake, ponds, river etc., for irrigation, in addition, pumps are the suitable tools for lifting water from surface and the ground basins, they cited that centrifugal pumps are the proper types for doing this job, because of their high pressures and velocities. Most commonly centrifugal instruments used in Egypt are axial-flow, radial-flow and mixed-flow instruments (Fuad and Abd-Ellatef, 1991). The number of diesel operated instruments in Egypt was about 33000 according to 1995 enumeration; most of them are imported (El-Awady, 1998). Therefore, it is necessary to study and modify its characteristics, specially design, speed, discharge and efficiency as recommended by Dhaimat and Al-Helou (2004). However, many efforts done to improve water supply systems but still using such machines is vital for farmers in many large areas, so, there are increasing requirements to improve operations whiles improving the environment and more modification with performance analysis required for these machines to see if such resources employed in the production process were efficiently utilized (Eker *et al.*, 2002; Emokaro and Ekunwe, 2007). Not only, adjusting such machines to work effectively can help farmers but also we can modify working principle of an environment friendly of these water pumping system as recommended by Wahed and Bilal (1999).

Fuel and labors are the most economical variables in running these types of machines, around 53.24% of total annual costs of the movable irrigation instruments (Mashhour and Hassan, 1997). Lifting water by centrifugal pumps not always running smooth, where, the water coming from canal subjects to variation during the year and most of water irrigation canals not clear enough and contain materials such as mud and other residues. Singandhupe *et al.* (2006) mentioned some related issues beside the impact of canal irrigation water on ground water regimes, water quality of return flow and bore well/piezometers wells and assessment of crop water demand and supply during crop season, all of this can led to water shortage during irrigation process which creates problems during usage of water lifting pumps. So, taking above mentioned problems in mind, we need to go for a suitable, economical and practical device which can provide us with a suitable way to shut down centrifugal pumps at the time of water shortage.

MATERIALS AND METHODS

To fulfill the objectives of this study, design and modification of an automatic stopper device were built. Experiments were conducted in Delta region at Kafrelsheikh Governorate, Egypt. The experimental site was located in 31°6'12"N 30°56'40"E zone with 3 m above mean sea level, the developed stopper device was attached to irrigation machine and tested from August to October, 2011. The testing phase was done by using the most common water lifting machine in this area, the specification of the tested machine in Table 1. While the manufacturing phase and adjusting the designed device was conducted in private workshop with local available material. Figure 1 shows the attached device with water lifting machine used in the experiments.

Device component and description: The device consists of three main parts, metal base, water tank and disconnecting arm (Fig. 2). The metal base is carrying compression spring and two vertical bars, one is main bar which connects with the horizontal bar and the other one is supporting bar and connect with metal disconnecting wire. The spring is fixed in one end of the metal base and the other end connects with the end of horizontal bar. The other end of the horizontal bar connects with the carrying arms of water tank. The movement of horizontal bar is in vertical level around

Table 1: Main specification of water lifting machine used in the study

Model	Kirloskar (kJ^{-1})
Description	Vertical, fully enclosed, compression, ignition, single cylinder, 4 stroke, water cooled diesel engine
BORE (inside diameter of the cylinder) (mm)	80
Stroke (piston movement distance) (mm)	110
Power (kW)	3.7
Output (bhp)	5
Speed (rpm)	1500
Specific fuel consumption (SFC) (g kW^{-1} h^{-1})	240
Specific fuel consumption (SFC) (g bhp^{-1} hr^{-1})	185

Fig. 1: Water lifting machine with developed attached stopper device

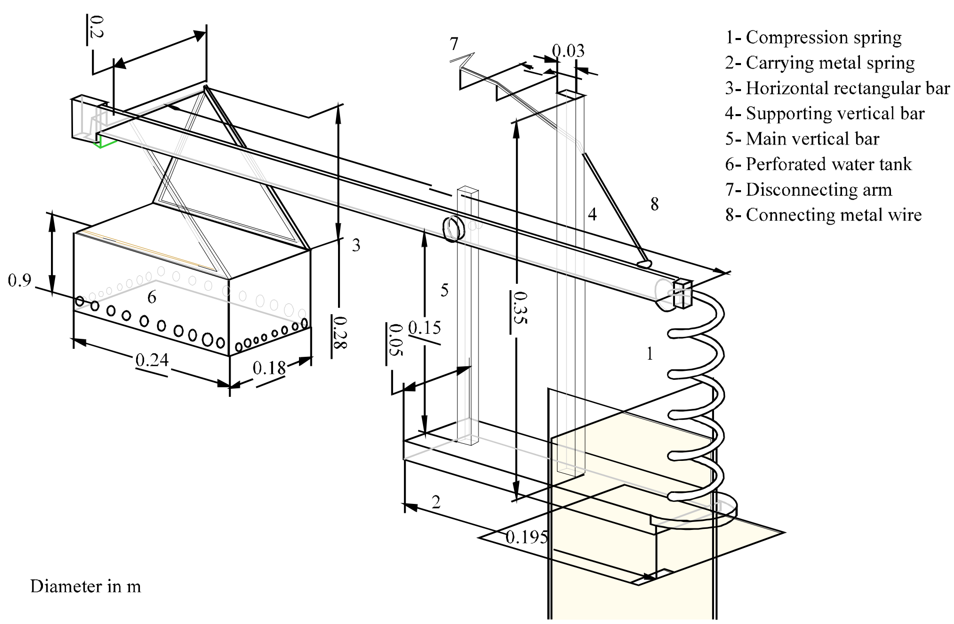

Fig. 2: Trimetric view of manufacturing stopper device

its connecting point with the main vertical bar; the motion of horizontal bar is controlled by the spring as well as the water tank. The connecting wire is acting as a joint between the disconnecting arm and the horizontal bar.

Theory of device operation: When water lifting machine is working, part of discharged water from lifting tube come to small tube which used in cooling engine and other usages. This operation is continues as long as the engine working and water coming from the source. At the time water stop running into main lifting tube, no outgoing water come to small tube. So, the main idea is to keep that outgoing water from that mentioned small tube come to tank, this tank is leaky to keep specific amount of water all the time in it and passes the overloaded water. The horizontal bar is working as balanced connector between the tank and the spring. The energy stored in spring is to be calibrated to remain the horizontal bar in same horizontal level all the time with specific amount of water in tank. When the amount of water decreases or falls out from the tank, the stored energy in spring work to pull the horizontal bar. When the levels of horizontal bar changes, it pulls the connecting wire which leads the disconnecting arm to pull machine spindle to turn off the engine. Attachment of developed device with lifting machine in Fig. 3 done carefully and with all engineering aspects, to overcome any problems or changes to the main machine body.

Study parameters and variables: To study the performance of attached stopper device, the time taken to pull disconnecting arm in the lifting machine was calculated. Decreasing water lifted throw machine suction tube till complete absence of water is the first step of the problem. So, providing different amount of lifted water to the centrifugal pump was the independent variable in this study. Absence of irrigated water can be done either with decreasing water through the canal which makes the lower end of suction tube is not covered completely by water or accumulation of mud and other material around suction tube filter in different amount which decrease also or prevent water discharge to the tube.

To control amount of lifted water through suction tube, two water reducing systems were used, first one was a rotating movable cover attached to the tube to permit a specific amount of water to come through suction tube (Fig. 4).

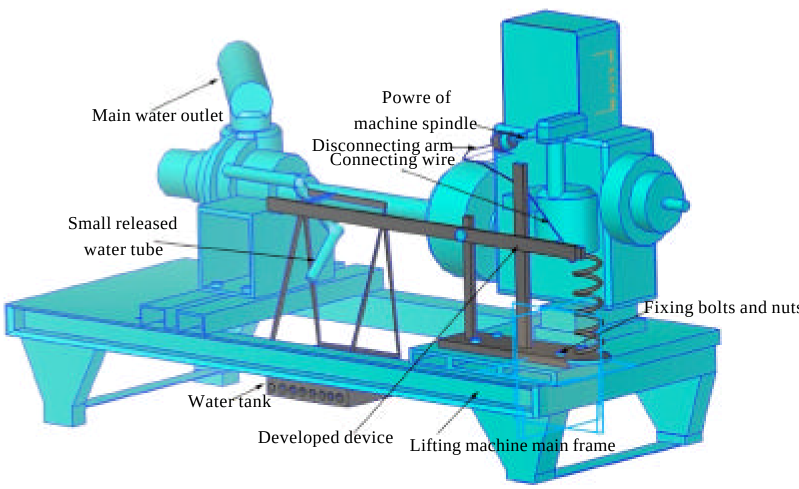

Fig. 3: Arrangement of attached device with used lifting machine

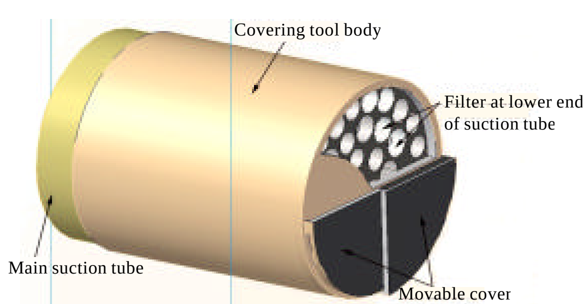

Fig. 4: Rotating movable cover attached to the main suction tube

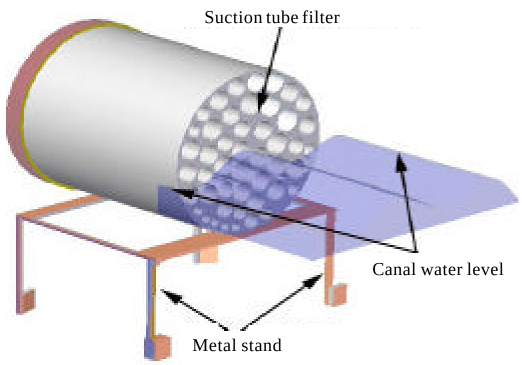

Fig. 5: Metal frame for adjusting water level

This can stand as the mud and different material appears during irrigation process. Second one was used to simulate the shallow water coming in canals, by a metal base to adjust height of the lower end of suction tube to show only a required part of it. Required time to pull machine spindle to turn off the engine was calculated under different coverage surface parts of suction tube (25, 50 and 75% of total surface); also it measured at different coverage parts by water in canal as vertical distance of front filter face which was 380 mm (Fig. 5). The results calculated and analyzed to evaluate the performance of stopper device.

RESULTS AND DISCUSSION

When water height reached end point of the suction tube (0 mm height), the required time to turn off machine engine was about 8.6 sec in average with standard division 0.577 (Table 2). Required time increased to 25.6 sec with standard division 3.511 when water covered veridical distance from front filter face by 100 mm which is equal to 26% of total face height. If the water in canal was sufficient to cover height 250 mm of filter face, the machine continuous to work due to continues water lifting, although that is not target water lifting by machine but it was enough to keep providing water to safe horizontal rod balance, which is connected to the machine spindle. Same machine behave obtained at water height 350 mm with more amount of discharge water.

Table 3 present data collected from using movable cover used to control amount of water accessed to suction tube, when the cover adjusted to let all available water come through the tube (0% converge), there was continues running for lifting water which is consider as normal condition and without existence of any obstacles in water canals. Whoever moving the cover to hide 25% of front area, there was also continues running of lifting water but with less discharge due to decreasing available amount of water.

At the moment we started to cover 50% of filter face area, the lifted water decreased and this variation on water discharge unbalanced the connecting rods which moved to pull the machine spindle to turn off machine, the time estimated was 30 sec in as average with standard division 3 which was higher than estimated time in case of using metal stand. At 75% of coverage the suction tube, the amount of water highly decreased, then the time required to turn off machine was less and ranged from 14 to 17 sec with standard division of 1.527. More than 75% coverage for the tube, some troubles for machine engine appeared maybe due to very less amounts of water provided to suction tube.

Table 2: Effect of using water decreasing metal stand system on time required to turn off machine engine

	Water decreasing system: Time taken (sec)				
	Replications				
Water height (mm)	R1	R2	R3	Average	Standard division
0	9	8	9	8.6	0.577
100	22	26	29	25.6	3.511
250	ND	ND	ND	-	-
350	ND	ND	ND	-	-

ND: No disconnecting, R1, R2 and R3: Replication 1, 2 and 3

Table 3: Effect of using water decreasing movable cover system on time required to turn off machine engine

	Water decreasing system: Time taken (min)				
	Replications				
Coverage percentage (%)	R1	R2	R3	Average	Standard division
0	ND	ND	ND	-	-
25	ND	ND	ND	-	-
50	30	33	27	30	3
75	15	17	14	15.3	1.527

ND: No disconnecting, R1, R2 and R3: Replication 1, 2 and 3

CONCLUSION

Using such developed stopper device can prevent many problems arising due to shortage of water while the farmer operates its centrifugal lifting machine. The machine will turn itself when the amount of water reaches the critical limit which is common in using canal, where water residues and mud normally come to suction tubes. Also, the device can stop the machine if the water decreased till limit which can not cover 65% or more of filter face height. And this is usually occurs at water shortage season where water in canals became shallow.

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