Design of hydraulic ram pumping system for small scale farmers: A case study of West Pokot County, Kenya

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Abstract:

Hydraulic ram pump (hydram) has been in existence for more than two centuries. However, these pumps have been on the verge of extinction since the invention of motorized pumps. Unfortunately, motorized pumps are uneconomical to operate and maintain. Therefore, as the world's technology shifts to green energy, hydram pumps need to be re-invented. In the late twentieth century, studies have been revived to improve hydram pumps' performance to ensure they are economically competitive. Hence, this study investigated the design and performance of existing hydram pumping systems in West Pokot County, Kenya. The study further developed a prototype system using locally available materials to simulate a fully designed system to supply water to a small community of small-scale farmers. The optimum efficiency achieved by the system was 54%, with an optimum delivery flow rate of 12.938 L/min.

Introduction:

Water is a basic commodity essential for human, industrial, and agricultural development[1]. The need for water has been the key motivation that drives humankind to venture ways of ensuring ease access of it through various pumping mechanisms[2]. The first hydram was invented in 1796 by the Montgolfier brothers. These pumps were modified and utilized until the late nineteenth century after the invention of motorized pump. Recently, the need for sustainable technology and renewable energy, especially in developing countries, has revived the interest in hydram technology.

The motorized pumping systems are uneconomical for small-scale farming in Kenya because of their high operational and maintenance costs. Hence, the over-dependancy on rain-fed agricultural systems. Unfortunately, with climatic change coupled with unreliable rainfall patterns, farmers incur huge losses due to low agricultural yields[3]. Therefore, the most appropriate system will be hydram pumps[4].

This study investigated the existing hydram pumping systems in West Pokot County, Kenya, to assess their design and performance. Thereafter, a reliable, low-cost hydram designed and fabricated using locally available materials. The pump was tested by varying the drive and delivery head and its performance was assessed.

Methods:

Study of existing hydraulic ram pumping systems

The investigation study was conducted on eight hydram systems identified in West Pokot County, Kenya. These sites include; Karas, Kaibos, Chepkono, Kabichbich, Imonpoghet 1, Imonpoghet 2, Kamsis, and Kapsait.

The investigative study focused on the design and performance criteria of the eight pump systems. On design criteria, the following components were assessed; materials used for the system, the size of pump and pipe components and the site conditions (stream flow rates, drive and delivery head). While on performance criteria; the efficiency of the system, failures and breakages were considered.

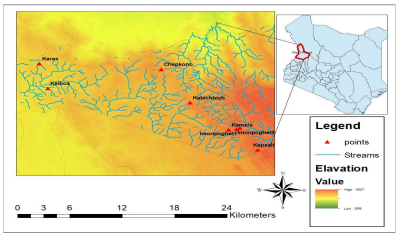


Figure 1. Study area: West Pokot County, Kenya.

Construction and Experimentation of the hydram pump

The hydram pump was designed following Pawlick and Watt guidelines. The designed system was fabricated using PP-R pipes and fittings and GI fittings.

The experiment was conducted on the hydram pump by varying the drive head and delivery head. The data collected were the amount of water at the delivery pipe and impulse valve and pressure in the hydram, using the water meter and the pressure gauge, respectively.

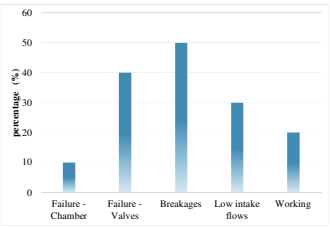
The pump efficiency was calculated using Rankine's equation[5] as shown in Equation 1.

$$E_R = \frac{Q_d h}{H(Q_d+Q_w)} \qquad \text{Equation 1}$$

Results:

The investigation of the existing eight hydram pumping system showed that

- 87.5% of hydram pumps are made up of steel.
- The majority of the pumps were of size 80/40mm and 80/25mm that constitute 50% and 37.5% respectively of the investigated pumps.
- These pumps had lower efficiencies of below 30% due to inadequate design of the system as per site conditions requirements.



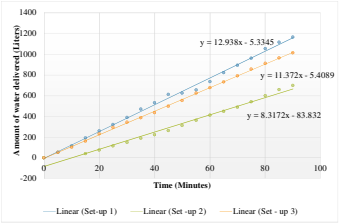


Figure 2: Performance Criteria of the existing system and Figure 3. Experimental results of the prototyped system

The prototype hydram pump was able to obtain higher delivery flow rate. For the three experiments, a higher flow rate of 12.938 L/min was obtained on set-up 1 with a drive head of 2.4 m and a delivery head of 4.2 m. For a higher drive head of 2.8 m and delivery head of 10 m, a flow rate of 11.372 L/min was obtained.

hydram pumping systems.

Optimum efficiency of 54% was obtained in set-up 1 and a minimum of 51.4% in set-up 3. The drop in efficiency results from the increase in delivery/drive head ratio.

Conclusions:

The investigation carried out on the existing system showed that the existing hydraulic ram pumping systems performed with low efficiencies of below 30% due to inadequate design and installation. The designed and constructed prototype pump was able to deliver water with an optimum efficiency of 54% with an optimum delivery flow rate of 12.938 L/min. There is greater potential in hydram pumps, they can be improved further to obtain even higher efficiencies.

The designed prototype provides a simpler and efficient system that can be used in the region for water supply for domestic and agricultural use.

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