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Study the engineering aspect of an advance siphon pump (Pha Ya Rangh Hai Nam) for a small farm irrigation

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Abstract. This study aims to investigate the performance of the advance siphon pump, which is an indigenous knowledge of free energy pump. It was introduced to investigate the potential of conveying water by using the energy equation of fluid mechanics to explain the mechanism of the prototype. The prototype design followed the information by interviewing the expert of Nernporkin learning center in Kanchanaburi province. The study was divided into 3 procedures; 1) investigating the possibility of prototype for pulling water from reservoir to supply the difference levels area, 2) investigating the effect of the difference of the elevation (ΔH) to the discharge rate from outlet, and 3) investigating the effect of outlet pipe length to the discharge rate. The results conclude that the advance siphon can deliver water only when the higher level of reservoir supplies the lower area ($\Delta H > 0$), while the minimum of ΔH for water transportation is 0.05 meter. The experimental results confirm that the important parameters affect directly the discharge rates, which are the outlet pipe diameter, the length of the outlet pipe and ΔH . The discharge rate will increase when increasing the ΔH , the outlet pipe diameter and shorten the length of the outlet pipe.

1. Introduction

Irrigation is a system that transports water from a storage reservoir to the field or farm. The irrigation system would be either an open channel or the pipelines [1]. The widespread irrigation system of farming in Thailand is the pipelines since the water loss is not very much. However, the pipeline's system needs to install the energy source for increasing the head of water to be conveyed to the field. The general pumps for farming are the engine driven water pump and the electric water pump [1, 2]. However, they consume the price for the energy source such as fuel or electricity. This cost would increase the farm production expenses, reduce farm profit, and decrease the ability of farmers to compete in the market [1].

A free energy water pump would be a solution for irrigation in the farm. At present, many researchers and inventors interest the technology about how to develop the irrigation system that operates with free energy [1]. The concept of gravitational power is one of the well-known methods of irrigation. The siphon irrigation is a favorite method for field intake water from the farm channel into the field. It is a series of small diameter pipes used to convey water over the channel embankment [1]. The study on how to automate the siphon in the Australian cotton farm and summarize that it's difficult to complete automation of water delivery using overbank siphons [3].

The observations of the free energy water pump in Thailand find that there are many local philosophers proclaim a prototype name Pha Ya Rangh Hai Nam could convey the water with free



energy [4]. In the early state, our research team surveys many rural areas such as Kanchanaburi and Songkla provinces for interviewing the experts. At the sufficiency economy learning center Nernporkin Kanchanaburi and Ban Khokpayom Songkla, the Pha Ya Rangh Hai Nam is the free energy water pumps that were used in the demonstrated farms. Today, the pump is still used for irrigation in the demonstrated farm at Songkla only.

The Pha Ya Rangh Hai Nam is an attractive free energy pump for many inventors and farmers in Thailand [4]. Some experts argued that it can deliver water from the lower area to supply the higher area. However, there is not any scientific evidence to support this statement. This research aims to investigate the discharge rate when utilizing the Pha Ya Rangh Hai Nam prototype for delivering water from the different elevations between the storage reservoir and the outlet pipe. The study also investigates the effect of implementing the different diameters and lengths of the outlet pipe, to the discharge rate. Finally, the prototype equips with the air chamber [5] to study the discharge rate when lengthening the length of the outlet pipe.

2. Materials and Methods

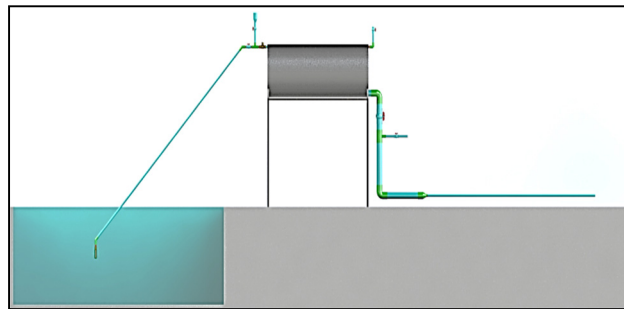


Figure 1. The Pha Ya Rangh Hai Nam siphon pump.

2.1 Energy equation of water flow in Pha Ya Rangh Hai Nam siphon pump

The advance siphon pump or Pha Ya Rangh Hai Nam is the Thai siphon pump (figure1) that favorable in many farmlands for a decade [3]. To understand the engineering aspect of the prototype, the energy equation of fluid mechanics was employed for this study [6]. The conservation of energy for fluid flow in a pipe is introduced into this research as follow.

The Bernoulli's equation calculates the energy under actual flow in pipe (flow with loss) as the equation below [6].

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L \quad (1)$$

From the equation (1) the velocity of water from the outlet can describe as the following equation.

$$V_2 = \left(\frac{2g\Delta Z}{\left[1 + k + f \left(\frac{L}{D} + \frac{L_e}{D} \right) \right]} \right)^{\frac{1}{2}} \quad (2)$$

$$L_{total} = \frac{L}{D} + \frac{L_e}{D} \quad (3)$$

In this study, the calculation of L_{total} can estimate as equation (4), and the coefficient of loss in the pipe (k_{total}) can estimate as equation (5).

$$L_{total} = (L_{inlet} + L_{tank} + L_{pipeline} + L_{outlet}) \quad (4)$$

$$k_{total} = (k_{inlet} + k_{tank} + k_{outlet} + k_{pipeline}) \quad (5)$$

The factor friction (f) can estimate by the iteration calculate with Moody diagrams [7, 8], then the final value of f equal 0.4. The amount of water flow rate from the outlet pipeline describe as the follow equation.

$$Q = AV_2 \quad (6)$$

2.2 The experiments setup to investigate the engineering aspect of Pha Ya Rangh Hai Nam siphon pump

To investigate the siphon pump prototype, the water level needs to keep constant by using the electrical pump and floating valve as show in the figure 2 [4]. The prototype starts to operate by filling the water into the tank until it full and none of air inside. After opening the ball valve at the outlet pipe, the water discharge will run out from the outlet and the vacuum will occur inside the tank then the water is pulled from the reservoir. This is an ideal water circulation of the Pha Ya Rangh Hai Nam siphon pump.

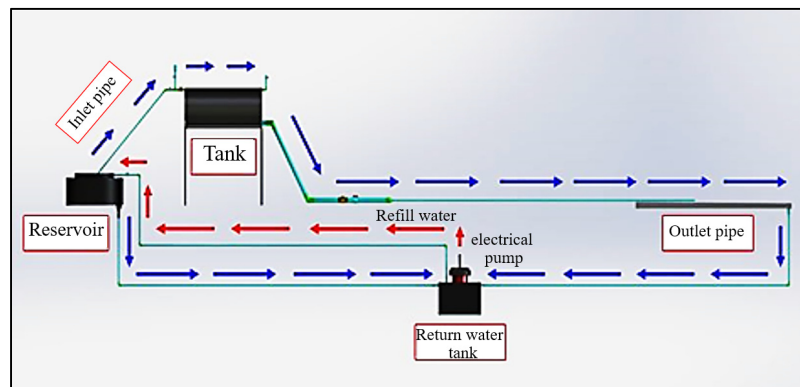


Figure 2. The experiment setup of siphon pump prototype.

2.2.1. Study the effect of level difference between reservoir and irrigated to the discharge rate

The first experiment setup the different elevation between the inlet and the outlet pipe (ΔH) as the figure 3. The early test setup to confirm the possibility of pulling water from the different values of the ΔH such as 1) $\Delta H = -5$ cm, 2) $\Delta H = 0$ cm, and 3) $\Delta H = 5$ cm. Then test to measure the discharge rate when setup ΔH at three levels such as 5, 10 and 15 cm each treatment test for 5 replications.

2.2.2. Study the effect of pipelines length and diameter to the discharge rate

The experiment compares the discharge rate when installing the outlet pipe with different conditions. Each condition composes of 1) the two outlet pipe diameters such as 0.5 and 1 inch 2) the three different levels of ΔH such as 5, 10 and 15 cm. 3) the three lengths of the outlet pipeline include 12, 16 and 20 m. Each condition tests to measure the discharge rate for five replications. The outlet pipe length of 12, 16 and 20m are equal to 3, 4 and 5 pieces of PVC pipe (polyvinyl chloride pipe) in the market.

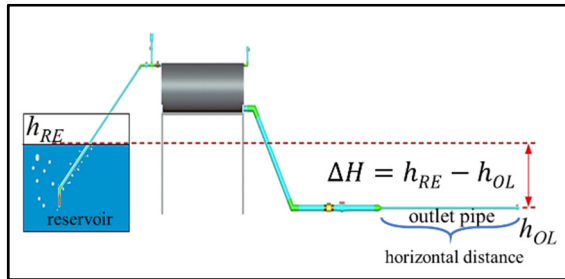


Figure 3. The study of the level different effect on the discharge

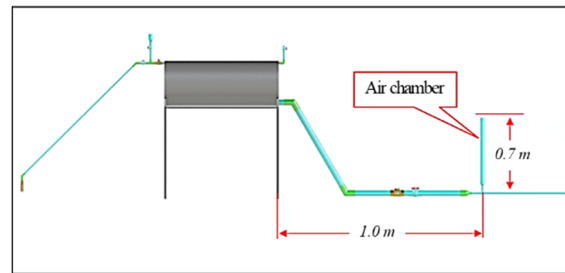


Figure 4. The installation of an air chamber to the pipeline

2.2.3. Study the effect of installing air chamber to the pipelines

The air chamber is a standing pipe that equips with the outlet pipeline for increasing the pressure of the discharge [5]. In this study, the air chamber installs into the prototype as figure 4. This test is to verify the most extended length of the outlet pipe by measuring the discharge rate while lengthening the outlet pipe from 12, 16, 20, 50 and 100 m. The test utilized the outlet pipe diameter of 1.0 inch and fixed the ΔH of 5 cm, which is the smallest ΔH that provide the continuous flow in this study.

3. Results and Discussions

3.1 The effect of the level difference between reservoir and irrigated to the discharge rate

Table 1. The possibility of pulling water by setting ΔH such as 1) $\Delta H = -5$ cm, 2) $\Delta H = 0$ cm and 3) $\Delta H = 5$ cm.

ΔH (m)	Testing period (hour: minute: second)	Possibility of irrigation
-0.05	00: 15: 22	impossible
0.00	00: 18: 38	impossible
+0.05	24: 00 :00	possible

The experiment showed that the siphon pump prototype could operate continuously in the condition of the $\Delta H > 0$. While the condition of $\Delta H \leq 0$ was not possible to irrigate continuously, the discharge will stop after the water ran out of the tank until empty.

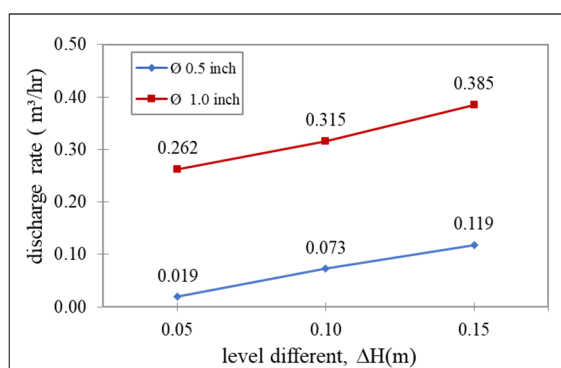


Figure 5. The discharge rate when equipped the 0.5 and 1 inch pipe and setup ΔH of 5-15 cm (as state in 2.2.1)

Figure 5 shows that the tendency of the discharge rate increase when raising the ΔH . The discharge rate of the different diameter of an outlet pipeline shows that the bigger diameter pipe presents the higher discharge rate. This matter show that the siphon pump prototype works very well when implement the large diameter of outlet pipe and the higher value of ΔH provides the larger discharge rate.

3.2 The effect of pipelines length and diameter to the discharge rate

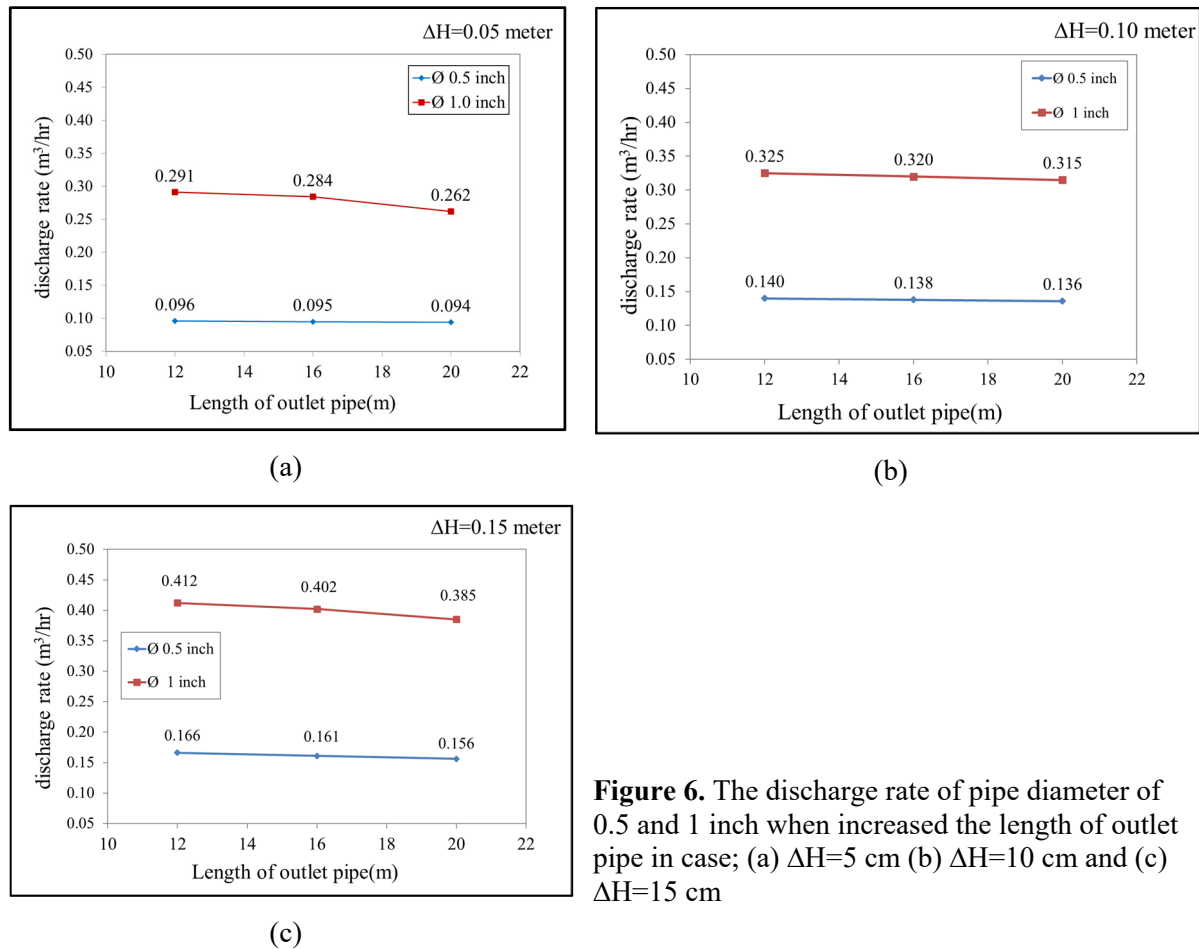


Figure 6. The discharge rate of pipe diameter of 0.5 and 1 inch when increased the length of outlet pipe in case; (a) $\Delta H=5$ cm (b) $\Delta H=10$ cm and (c) $\Delta H=15$ cm

Figure 6 shows the effect of extending the length of the outlet pipe from 12 to 20 m. The discharge rate slightly decreased when lengthening the length of the outlet pipe. While the bigger diameter of the outlet pipe providing a higher discharge rate and the higher value of ΔH provides the larger discharge rate too. The tendency of the discharge rates when varying the three levels of ΔH depicted in figure 6 (a), (b) and (c). The discharge rates vary when the parameters such as ΔH , length of the outlet pipe and diameter of the pipe. These phenomena could explain by Bernoulli's equation (equation (1)). The ΔH , which is the different value of Z_1 and Z_2 , increases will affect the higher velocity of water in the pipe (as mention in equation (2)) then the discharge rate will gain as described in the equation (6). The discharge rate will increase when applying the bigger diameter of the pipe; it can explain by equation (6). Since the bigger outlet pipe has a more significant cross-sectional area; A so that it can provide the larger discharge rate. While lengthening the length of the outlet pipe will increase the L_{total} in equation (3) and equation (4), then the velocity of the water will decrease (as mention in equation (2)). Therefore, the discharge rate will decrease when increasing the length of the outlet pipe. This matter shows that when employs the siphon pump to irrigate afar plantation, the discharge rate willing decrease and the irrigated distant would be limited.

3.3 The effect of installing air chamber to the pipelines

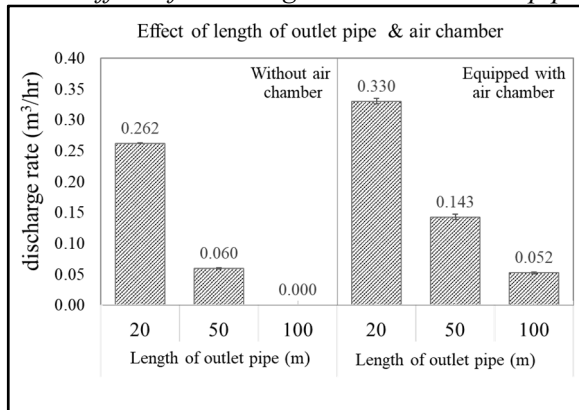


Figure 7. The discharge rate when fixed ΔH of 5 cm, increased the length of the outlet pipe, and install air chamber with the pipe.

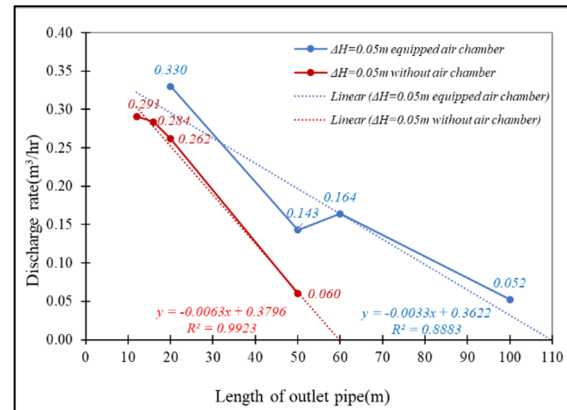


Figure 8. The comparison of the discharge rate when increased the length of the outlet pipe and install an air chamber with the pipe.

Figure 7 shows the effect of installing the air chamber to the outlet pipeline. The figure 7 shows that the tendency of the discharge rate decreases when extending the irrigated distance. The siphon pump that equipped the air chamber to the outlet pipe provides the higher discharge rate and the longer irrigated distance.

Figure 8 presents the variation of discharge rate when ΔH is of 5 cm and varying the irrigated distance from 12 to 100 m. Also, it compares the discharge rate from the siphon pump when equipped and not equipped an air chamber. The graph verifies the limitation of irrigating distance by using the linear regression equations as depicted in figure 8. The siphon pump without air chamber provides the limited irrigation distance of 60 m. While the siphon pump equipped with an air chamber provides the limited irrigation distance of 110 m, this matter presents that the siphon pump could extend the irrigated distance by equipped the air chamber to the outlet pipe.

4. Conclusions

The 'Pha Ya Rangh Hai Nam' siphon pump was designed and constructed by imitating the prototype from the sufficiency economy learning center at Nernporkin, Kanchanaburi province [4]. The study can conclude that the free energy pump cannot deliver water from the lower area to supply the higher area. However, the small difference of the elevation between the water resource and the outlet of 5 cm could operate the pump continuously. This matter shows that the siphon pump provides a considerable advantage for transfer water toward the remote plantation, but the farmers should confirm the elevation between the water resource and the target area.

The siphon pump prototype gains the discharge rate by increasing the ΔH and enlarge the diameter of the outlet pipe. While extending the outlet pipe affects the decline of the discharge rate at the end of the pipeline. The figure 8 shows that the extending of the length of the outlet pipe had a limit length of the outlet pipe since the discharge rate will slightly decrease until the flow stops. Figure 7 shows the outlet pipe with a diameter of 1 inch can extend the irrigated distance of 50 m and the appearance discharge rate about 0.06 m³/hr, while the irrigated distance of 100 m cannot deliver the water.

Finally, the implement of an air chamber to the pipeline could increase the discharge rate and extend the irrigated distance. The experiment when setup the ΔH of 5 cm shows that the longest irrigated distance is about 50 m but after equipped an air chamber the longest irrigated distance is about 100 m. The discharge rate increases for 26–138% after equipped an air chamber with the pipeline.

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