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Design an Irrigation System for Vegetable Farming Suitable for Malaysia Environment

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Abstract: The objectives of this project is to design an irrigation system for chili farming suitable for Malaysia environment. This system used only one pump where it only pumps the water from the river to the tank, and potential energy is used to irrigate the plant. Standard design process by G. E Dieter was used as the methodology of this project. As a result, the drip irrigation system has been successfully designed. The system consists of the centrifugal pump, water tank and structural support, piping system, and support system. The pump produces flow rate of 500 l/min and max head of 22 m, the tank size is 4000 liters, the number of chili plant is 3700, and the structure height for tank is 5 meter. The pump is operating for 10 minutes per day. The total cost estimation for this project is RM 7691.90 and the Return of Investment (ROI) for this system is 6 months' period during first harvesting seasons.

Keywords: Irrigation system, Chilli plant, Design, Specification, Pump, Return of Investment, Cost

1. Introduction

Current drip irrigation system is a little expansive and uses too many components thus not suitable for large scales farming. The current drip irrigation system needs more cost to maintain the system in term of the electricity bills, water bills, and other maintenance. The objectives of this project is to design a drip irrigation system for chili farming which is cost-effective, suitable for the Malaysian environment, and adaptable to small and large-scale farming. The system involves basic component where it includes tank, pump, piping system, and support system. This project main water supply is based on water from pond, river or well. This design of this project uses one pump only where the pump is used to pump the water from water source to the tank. The tank is placed on a certain amount of height in order for it to have enough potential energy to irrigate the water from the tank to the plant.

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2. Literature Review

2.1 Component of System

Basic component to design a drip irrigation system [1] includes pump, water tank, tank support, irrigation timer and control valve, complete piping system, pipe connector and emitters.

2.2 List of formula

2.2.1 Energy Equations

In this equation, the relationship between pressure head and velocity head is inverse, meaning that as water velocity rises, pressure head decreases. In addition, the friction between the water and the pipe rises, resulting in a direct relationship between water velocity and head loss. This equation is used to calculate the pump head.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_L \quad \textit{Eq. 1}$$

2.2.2 Head Loss

Head loss is potential energy that is converted to kinetic energy. Head losses are due to the frictional resistance and change in pipe geometry of the piping system (valves, fittings, entrance, and etc.). This equation is used to calculate the Head Loss in the piping system.

$$h_L = f\,\frac{LV^2}{D2g} + \frac{k_L V^2}{2g} \quad \textit{Eq. 2}$$

2.2.3 Major Loss

The major losses, also known as the friction losses, occur due to the resistance exerted by the boundary layer formed on the pipeline walls and the flowing water [2]. The Darcy-Weisbach is used to calculate the major losses [3].

$$h_{L\,major} = f\,\frac{LV^2}{D2g} \quad \textit{Eq. 3}$$

2.2.4 Minor Loss

Minor losses are local energy losses caused by the disruption of the flow due to the installation of appurtenances, such as valves, bends, and other fittings [4]. There are two methods used to calculate the minor losses, the equivalent length method and the resistance coefficient “K” method

$$h_{L\,major} = \frac{k_L V^2}{2g} \quad \textit{Eq. 4}$$

2.2.5 Pump Power

The power delivered to the pump can also be determined by taking the product of the motor output current and voltage.

$$P_h = \rho g Q h_p \quad \textit{Eq. 5}$$

3. Methodology

This project used the basic design process proposed by G. E Dieter. Figure 1 shows the flow chart of design process proposed by G. E Dieter.

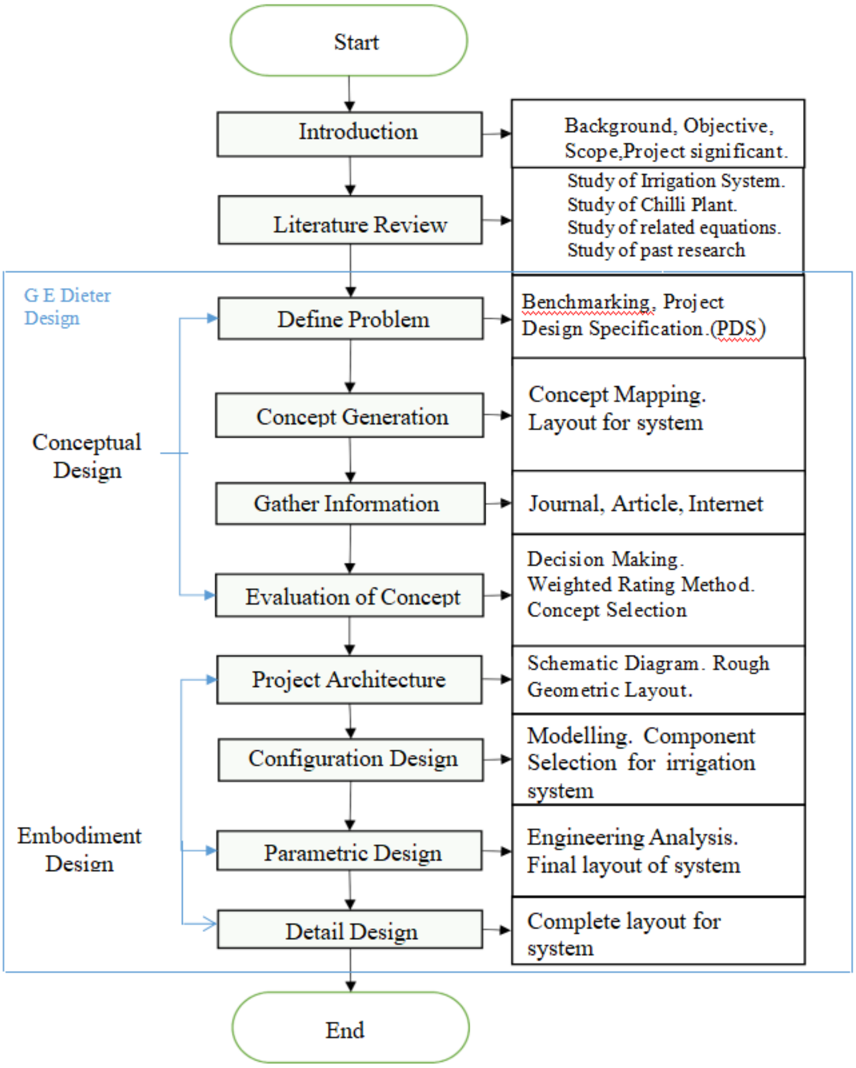

Figure 1: George E. Dieter flow chart

In the first phase of this project, an overview on the current irrigation system was done in order to review the problem and investigate the current irrigation system. Then the process is continued with component selection for the drip irrigation system. After the components of the system are determined, the project continues with determining the specification of components. Next, the calculation related to determining the pump size, the land size, the plant amount, the tank size, and the tank structural minimum height was done to determine the specification of the system. Lastly, the calculation related to total cost and cost savings was done to determine when the ROI is achieved.

4. Results and Discussion

As a result, the drip irrigation system has been successfully designed. The basic design includes the main component of the systems that involves the pumping system, the water tank and structural support, piping system, and support system. Figure 2 shows the basic layout of the drip irrigation system.

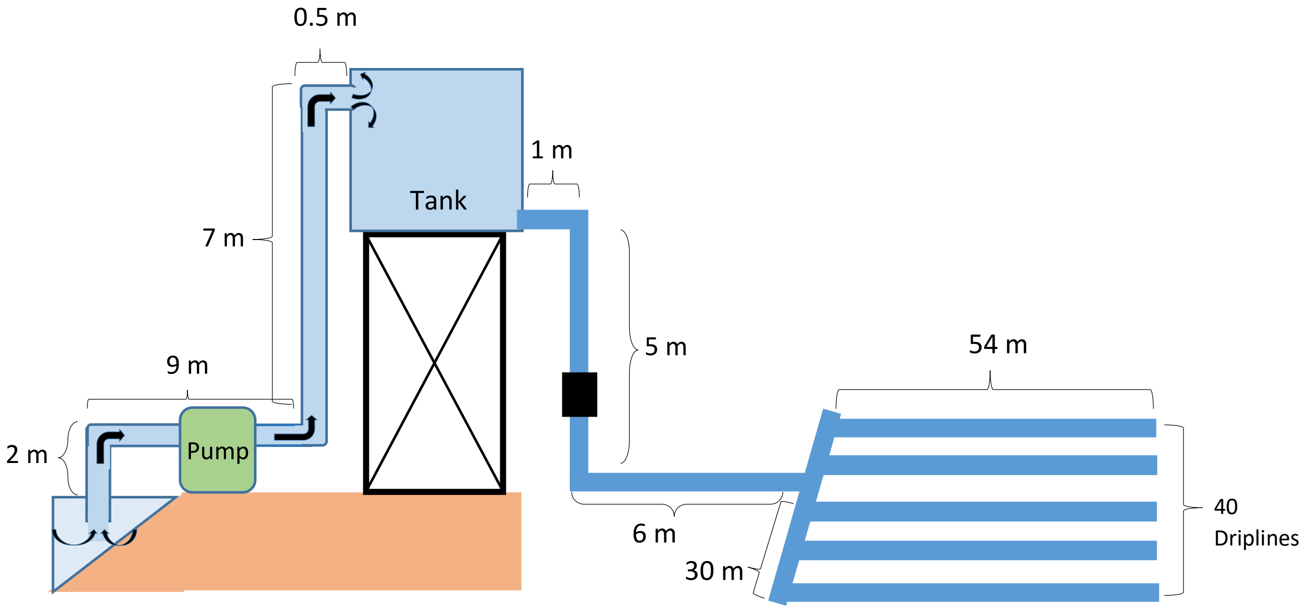

Figure 2 : Basic layout of drip irrigation system with dimensions

The components specification and capability required by the drip irrigation system have been identified. The pump size was calculated using the Energy Equation and tank size is referred to the amount of water needed to irrigate the plant per day which is 3700 liters. List of component used for this project is listed in Table 1.

Table 1 : Component specification of the irrigation system

Centrifugal Pump	Tank	PVC Pipe	Float Switch	Polyethylene pipe	Connector	Timer	Emmiters
Water Pump Power:1.5 Kw/2 Hp, Voltage ; 220 ~ 240 Vac / 50Hz, Inlet / Outlet Port ; 2" x 2" , Max. Flow ; 500 L/Min, Max. Head ; 22, Max. Suct : 8 M	Tomher Water Tanks, 4000L	PVC, Diameter : 0.0762 m Length:16. 5 m	Float Switch, Max height:2 m	Polyethylene, diameter 0.032m, Length:2231m	Elbow, Tee	Irrigation Timer, 5 Timing Sets	200 ml emmiters storage, Amount: 3700 pcs

Since the component specification has been determined, the next thing to do is to estimate the total cost of the project. The cost estimation of this project is referred to the cost of the irrigation system, electricity cost, and cost savings. This drip irrigation system is using only one electrical device that need power supply which is the pump. By using the pump specification that was calculated before, it is possible now to calculate the current usage of centrifugal pump based on the kilowatt per hour calculation. The tariff block for electricity was referred from Tenaga Nasional Berhad [5]. The calculated electric bills for this project per month is only RM 2.00. The irrigation system cost for this project is RM 7691.90 and this cost is referred to 1 acre of land design which offers 3700 plant chili farming. The return of investment of this project can be achieved after the first seasons of harvesting which is 6 months' period. With the lowest fruitage and lowest chili price, it was calculated that for 3700 plant can produced 3145 kg of fruit and sales of RM12,580.00 if the chili price is RM4/kg.

As a discussion, a low cost irrigation system suitable for Malaysia environment has been successfully designed. This system used pump to pump water from river to the tank and the gravity energy is used to irrigate the plant. By using this system, we only need to switch on the pump once a day instead of 4 time a day to irrigate the chili plant. So it can save electricity cost for the system.

Many calculations have been done while completing this project. This calculation is very important to ensure the selected components can help to achieve the main objective of the project. The height of the tank is very important to the project as well. The higher the tank, the greater the flow rate of the water flows to the plant. The height of the tank is set at 5 meter so that it can give extra gravity energy to the fluid. The high position at the tank will affect the cost of the project. The higher the position of the tank, the greater the cost involved as it involves structural building material.

Lastly, the irrigation system cost was calculated and it can be concluded that the system is low cost, since the return of investment can be achieved during the first season of the harvesting. Even when the chili price is on the lowest, the profits of 6-month chili harvesting can fulfill the return of investment of the irrigation system.

5. Conclusion

The project's goals of developing an irrigation system for vegetable growing that is suitable for Malaysia's environment were accomplished as a direct result of its completion. A drip irrigation system that use potential energy to irrigate water has been design. The system that has been designed was proven to be cost savings in term of maintenance and electrical bills where the electrical bill is only RM2.00 per month. The pump maintenance cost will automatically become less since the system will only use one operating pump. As for the return of investment of this project, the profits of 6-month chili harvesting can fulfill the return of investment of the irrigation system.

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