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An Improved Automated Herbicides Machine for Farmers at Oil Palm Plantation

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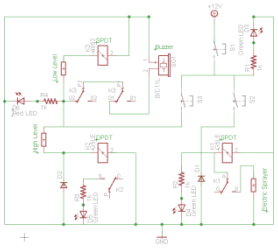
Graphical abstract



Abstract

This project improves on the existing manual herbicides tanks used by farmers at oil palm plantations. The main objective is to design and construct an automated machine that can facilitate the farmer's work of clearing grass at small scale oil palm plantations. In this project, a portable machine trolley which can be handled with ease was contructed. This machine allows the farmers to freely control the flow of herbicide directly towards the grass using one hand. The system will automatically pump the fluid inside the tank and, indicate the signal for high and low water level. The herbicides tank can accommodate 30 L at one time and regulate the pressure manually. This system is controlled by a relay circuit. As a result, the output of the pump can produce a pressure of 0.7 MPa or 7 Bar and the distance of the water from static machine can spray out up to 15 m. The maximum flow of water measured is 5.0 L per minute maximum. As a result, it gives farmers more options for clearing grass at oil palm plantations.

Keywords: Automated herbicides machine; oil palm plantation; electric sprayer; pressure; distance

1.0 INTRODUCTION

Nowadays, the agriculture sector is growing rapidly. In line with the government's motto "Agriculture is Business", this sector provides a bright future and many opportunities. The oil palm sector is one of the important contributors to Malaysia's economic growth. Malaysia as the largest producer and exporter of palm oil in the world contributes 11% of the world's oil and fats production as well as 27% of export trade of oils and fats. To ensure the quality of oil palm production as well as for easy harvesting and collecting, it is important to keep the plantations and the roads in the plantations free of wild grass, weeds and shrubbery. See Figure 1.

Figure 1 Road at oil palm plantation

There are a variety of machines or manual tank for herbicides in the market but they do not meet the needs of small scale farmers. In order to facilitate the work of farmers work at oil palm plantations, an Automated Herbicides Machine (AHM) is one of the easiest ways for farmers to prevent weed from growing densely on their small scale plantations. This method will help farmers reduce cost of man power and may increase work efficiency in terms of time and labour.

Furthermore, this machine comprises iron steel that acts as a "trolley" or carrier for DC motor water pump, pressure regulator, herbicides tank, rubber hose and also water level sensor. If set with the right parameters, depending on the volume of herbicides in the tank, the machine will function as expected. In addition, the distance between a DC electric sprayer water pump and the desired location might influence the speed of the motor resulting in a change of water pump pressure.

2.0 LITERATURE REVIEW

This section discusses the literature review which covers, the hardware material for trolley, wheels and herbicide tank. followed by the DC motor use to supply power, suitable sensors to measure output pressure and the current level in the tank and lastly, the microcontroller to control the sensors in the machine.

The hardware material for trolley, wheels and herbicide tank involves the installation of four wheels in which two castor wheels are driven by a DC motors while the other two function as supporter. This arrangement enables the trolley to move freely in reverse and forward directions in clockwise or anticlockwise directions with the same number of rotations for both motors [1]. The manual sprayer that requires workers to carry a herbicides tank on their back is not only inefficient but also poses environmental threat to the worker [2].

The spray nozzle is a simple device, but it works very precisely and accurately in the work instruments. A spray system that does not function at a high level may increase operational cost every year. Moreover, spraying efficiency will be reduced and the process can be undermined if the nozzles become half blocked [8]. Dynamic pressure is created when the water jet effects land on a firm surface and only needs just a second to reach a high value MPa up to GPa range. The typical instruments do not possibly measure this kind of pressure [3].

Flowmeters that act as a differential pressure in the flow is related to the flow rate, is one of the first types of flow meters. To save energy when pumping the fluids, the latest flowmeters do not normally use differential pressure for measurement of flow. Instead, they use a control valve to regulate the fluid flow inside the pipe. The control valve acts as variable restriction in the flow. Differential pressure is generated in the fluid flow caused by control valve [5].

Besides that, the difference in ratio between water and air will lead to the changes in resistance value and thus measure the water level sensor. When the water level is higher than air, the current value becomes high. In contrast, the current value will be low if the level of air is higher than the volume of water. As a result, the volume of water inside a tank or vessel can indicate between water and non-contact by measuring the water level [6]. Pipe pressure rating is based on pipe working pressure [7]. Pressure rates of each pipeline are sorted out based on the working pressure due to the savings on pipeline cost. The linear programming method that can be used to stabilize the best design model of water carrying pipeline with the longitudinal section of the pipeline, pipe material and pressure rates are decided [7].

Next, a farm chemical sprayer injection pump and controller was developed for a wide range of flow conditions. The pump accurately allocates chemicals to be mixed with a measured water flow. The operation of pistons at low velocity will be controlled by stepper motors, which means it will control the solenoid valve at the inlets and outlets. Besides that, one of the pistons discharges, while the other continuously fill chemical to ensure a continuous flow of chemical in the pump. In order to keep the actual volume flow rate independent of the properties of the chemical, the pistons will move slowly. It is essential for the pump to be in this condition because it will also be used for other chemical mixtures. [4]. This provides an accurate and endless flow of chemical that will not be affected by varying fluid properties and flow conditions. The design is absolute for chemical injection sprayer application [4]. Pressure regulator is one method that can be used to minimize pressure from the supply of natural gas to user's appliances. This regulator was designed to control and reduce the pressure, indicate the gas volume based on meter. Thus, it is reliable enough to ensure a stable pressure level [8].

A regulator, comprising of a control valve and a movable plug, is located in the flow path and narrow the flow. The control valve is driven by an actuator while the diaphragm divides a casing into two chambers and provides the thrust to move the control valve. One chamber is connected to the downstream volume through a sensing line and the pressure-induced force exerted on the diaphragm is balanced by the set value of the downstream pressure. Pilot-controlled regulators work pneumatically with power autonomy and there are type of regulators in which the clean force is required to move the actuator supplied by the pilot. Figure 2 shows the schematic of a pressure regulating station [8].

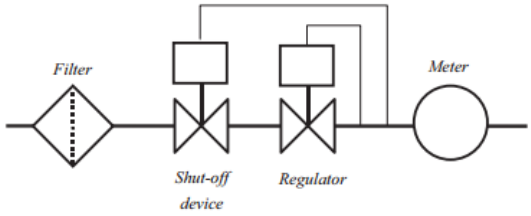


Figure 2 Schematic of a pressure regulating station

3.0 METHODOLOGY

The research methodology describes and explains the methods or steps taken to build an AHM as well as other aspects related to the project. The project is sequenced according to input, process, output and feedback. The steps to develop and construct the project is shown in Figure 3.

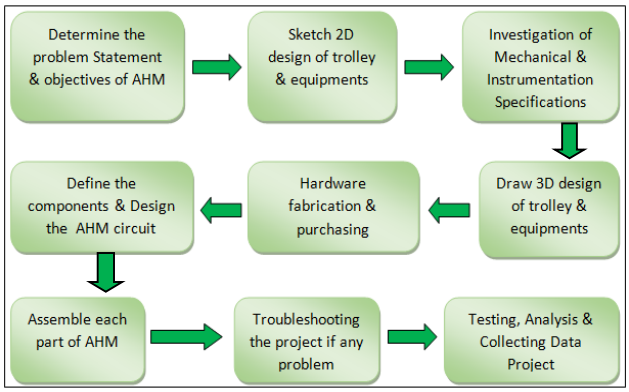


Figure 3 Flow of AHM construction

The trolley is designed and customized using Solidworks software. The materials used for the trolley fabrication mechanism, are mild steel for holder and other structures, and stainless steel for the base material. This ensures that the base can be easily removed for the purpose of cleaning.

The mild steel material used in the trolley structure is to accommodate a load up to 50 kg. Four wheels are assembled to the trolley for smooth movement on rough surfaces at oil palm plantations. In addition, this trolley has some special features such as portable tyres, holder height setting, foldable holder; and its compact size allows it to be put in the car boot.

The main equipment in this project is the electric sprayer water pump. It uses a 12V DC car battery as power source to pump the fluid inside the herbicides tank automatically once the button is switched on. Thus, farmers do not need to produce pressure manually as the water pump can spray out as far as 15 metres at a maximum pressure of 7.0 Bar or 0.7 MPa and 5.0 L per minute for fluid flow.

The tank used in this project can accommodate fluid about 30 L at one time which exceeds the volume capacity of a backpack tank in the market. The low level and high level sensors can activate at 8.3 cm and 44.9 cm respectively from the bottom of the tank and will send a signal to the panel box once triggered.

In this project, it is essential to regulate the pressure based on the distance of the nozzle exit and the desired location. This is to ensure that the applied pressure towards the surface of the soil will not affect the root or growth of the oil palm trees. Farmers will regulate the pressure manually by tuning the head of the

regulator and the reading of the current pressure will be displayed on the pressure regulator meter. The pressure range for this model is from 0 until 1 MPa or 10 Bar.

Generally, the level sensor indicates the current level of water or fluid in the tank. The type of level sensor used in AHM is stainless steel float switch that is triggered once the float switch moves upwards. The float switch used in this project is in NC which means that the ball float rests at a low point.

This float switch uses a magnetic reed switch which contains a set of contacts sealed in a glass tube. A set of contacts will attract and join to each other when a magnet is applied near the contacts. It allows current to pass through the contacts. Then, the contacts will demagnetize and open when the magnet is far away from the contacts, which means there is no connection in the circuit. In this project, the magnetic reed switch is arranged close to each other in a stainless steel rod bar.

The ball float will then enclose the sealed magnet in which the ball will move vertically as the fluid level changes. As shown in Figure 4, the two lead wires will touch and connect the circuit when the magnet comes close to the contacts which will cause the ball switch to move from NC state to NO.

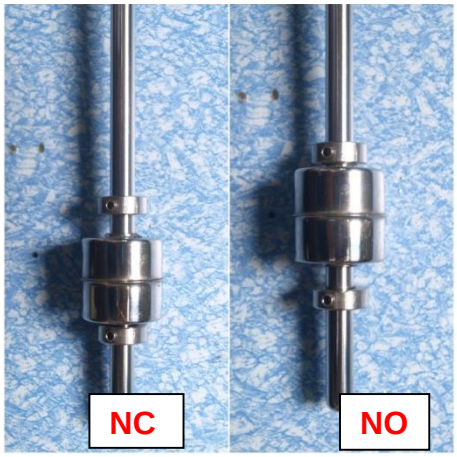


Figure 4 Float switch condition

The schematic components connection diagram of AHM drawn using Eagle 6.5.0 software is shown in Figure 5**.**

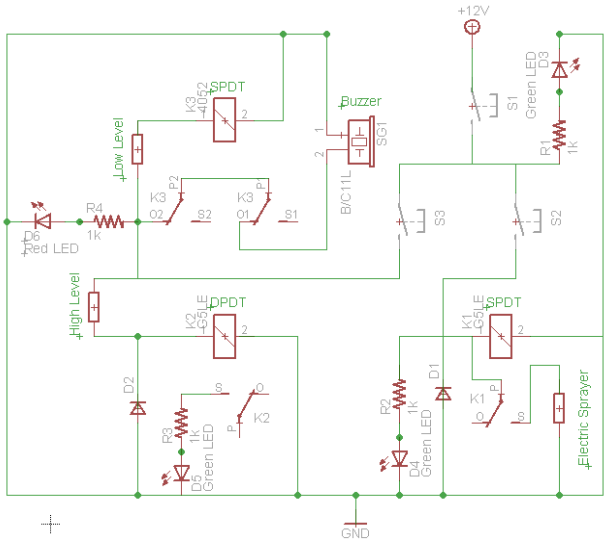


Figure 5 Schematic diagram of AHM

A relay is an electrically operated switch for open and close circuit. It will generate a magnetic field when an electric current passes through the coil. In this project, two SPDT relays and one DPDT relay were used to control the electric sprayer water pump and level sensor condition. There are two types of contacts in the relay, the first is NO in which the contact is open when the relay is not energized while the other contact is NC in which the contact will close when the relay is not energized.

The diodes that are placed across the coil, function as a protection to the switch or relay and other circuits. In addition, the diodes also deliver a path for current. When the current path to the relay is deactivated, it will generate a voltage spike that is sensitive to the semiconductor circuit components. Besides that, a resistor will always be placed in series with the LEDs in the circuit. The purpose of the resistor is to allow the current to pass through the LED within the range of LEDs current flow based on data sheet. The behaviour of the resistor is linear according to Ohm's Law while the behaviour of LED is inverse with the resistor.

4.0 RESULTS AND DISCUSSION

The ideal specification of AHM with portable trolley and foldable holder is created. In addition, the buzzer of low level sensor will ring when the water inside the tank achieves a height of 8.3 cm from the bottom of the tank. Testing of this experiment was conducted in an open area using water as fluid instead of mixture of herbicides.

Initially, the electric sprayer water pump was tested by connecting the electrical wires directly from a power supply without any circuit. As a result, water can be sprayed from the outflow of water pump for as far as15 m at a maximum pressure of 0.7 MPa as claimed by the company. Next, the water pump pressure is adjusted several times within the range to obtain the relationship between pressure and distance.

The exact measurement of the distance data begins from the outflow of the pressure regulator or the length of water tubing and combines with the distance of water sprayed from the nozzle. The final results of this experiment are tabulated in Table 1. It shows the relationship between pressure produced by electric sprayer water pump and the distance of water from the outflow of water pump and nozzle.

Table 1 Data of pressure against distance

Pressure (MPa)	Distance (m)
0	7
0.1	9
0.2	10
0.3	11
0.4	11
0.5	11
0.6	11.5
0.7	12

As shown in Figure 6, when the pressure begins at 0 until 0.3 MPa, the distance increases rapidly. However at certain value of pressure between 0.3 and 0.5 MPa, the distance of water remains constant. Conversely, at values of 0.5 until 0.7 MPa, the distance slightly increases as pressure increases.

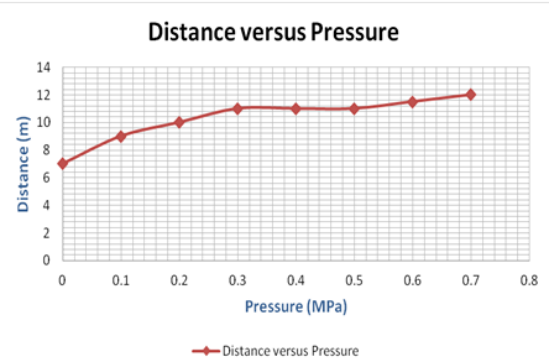


Figure 6 Graph of pressure against distance

Based on the results obtained from the experiment, there is a leakage of water between the tubing and connectors due to human error like inaccurate installation, loose tubing during experiment, rough walls and pressure flaps inside the tubing [10]. As a consequence, there was a slight loss in the pressure which resulted in poor performance.

In addition, the type of pressure regulator used in this project was not suitable for water flow usage. This is because the specific pressure regulator for water flow was too difficult to obtain and the price was too expensive. Based on graphical data, the distance must be 0 m with the pressure of 0 MPa due to the 0 % valve opening. Thus, the relationship of distance and pressure should be directly proportional for an ideal relationship. Besides that, the surrounding where the experiment was conducted also influenced the distance results based on the pressure adjustment due to the open area.

In this project, several issues need to be highlighted. The main problem in this project is the difficulty of finding a suitable electric sprayer water .There is a need to ensure whether the type of water pump used can be operated using a car battery as power supply regardless of the maximum pressure of the water pump and flow rating. Besides, other equipment that needs to be considered is the range of pressure regulator for tuning and whether it is suitable for fluid usage or air to avoid disturbance that will affect the results between distance of water and pressure.

■5.0 CONCLUSION

To conclude, AHM can address the usual problems face by farmers at oil palm plantations. The prototyping AHM trolley facilitates the farmer's work as the hardware design is suitable with the soil surface. It moves smoothly and is easy to handle even at a maximum load and therefore is capable of increasing the farmer's work time efficiency. This however, depends on labour efficiency in terms of energy and the current volume of fluid inside the tank. The pressure of electric sprayer water pump can reach maximum value for about 100 psi or 7.0 Bar to flow out the fluid inside the tank.

This herbicides machine can also help farmers reduce fatigue due to the long working hours when using back pack herbicides tank.. In contrast, AHM, does not require farmers to carry the tank as it is put on the trolley. The farmers only need to use one hand while clearing grass at the oil palm plantations.

In this project a car battery was chosen as the main power source to replace gasoline as it is environmentally friendly. Futhermore, it also cultivates awareness among farmers on the effects of gasoline to the environment in terms of producing greenhouse gases and causing the depletion of ozone layer [9].

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