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Research Article

Automation of Dripper Discharge Testing Machine

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Abstract

Drip Irrigation is one of the best solution in today's water crisis situation. Amount of water required for different crops is different, so requirement of water varies from crop to crop. Therefore, discharge measurement of drippers plays an important role in dripper manufacturing companies. Automation of the discharge testing machine will help in saving valuable time to test, saving manpower, energy and optimizing profits. This project essentially considers all the factors that affect testing discharge of drippers and aims to devise a system that accurately measures the discharge with minimal human efforts.

Keywords: *Discharge measurement, sensors, automation*

1. Introduction

Drip Irrigation is one of the best solution in today's water crisis situation. Drip irrigation is a form of irrigation that saves water and fertilizer by allowing water to drip slowly to the roots of many different plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. It is chosen instead of surface irrigation for various reasons, often including concern about minimizing evaporation. Amount of water required for different crops is different, so requirement of water varies from crop to crop. Therefore Discharge measurement is carried out in Dripper manufacturing companies. Automation of the discharge testing machine will help in saving valuable time to test, saving manpower, energy and optimizing profits.

2. Problem Statement

To Automate and recreate a manual Dripper Testing Machine using PLC (Programmable Logic Controller) to reduce batch testing time and save valuable time to increase productivity and profits. The Machine should be economical than existing Machine available for the same task of testing. Machine should be compact in arrangement and confirm to the space available in the company floor.

3. Objectives

1) The main objective of project is to construct such a Machine in which we can test discharge of 25 drippers simultaneously and automatically which is manually done at present.
2) It should be economical than the traditional machine available in market.
3) It should save time. The automated machine will approx require approx 10 minutes against the earlier manual machine which tests 25 drippers in approx 25 minutes, hence saving valuable man hours as well as improve productivity.
4) It should be compact. Floor space available in the Factory requires the machine to be longer rather than broad.

4. Methodology

1) First step was to decide the right mechanism for measuring the water discharge from the drippers based on the availability and selection of appropriate sensor. Then the drainage mechanism will be designed and appropriate components such as drainage valves will be selected. Other components such as clamps etc. will be selected.
2) Second step was designing the electronic and system around the sensor, actuators and PLC. Based on the designed electrical system, number of Digital and Analog inputs and outputs for the PLC will be determined. Accordingly appropriate PLC will be selected.
3) Third step was selecting appropriate material for the frame and designing the physical setup by doing the stress analysis for the frame. Next step will be physically installing various components on the panel and panel wiring. Next step will be the development of PLC program according to the requirement

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4) Last step would be installing the sensor and actuators and integrating them with the panel and installing all the components together.

5. Theory and Analysis

A] Sensor Selection

Sensor is selected based on properties mentioned as follows: Greater accuracy, Less resolution, Optimum range, Requiring less space, Compatible to the purpose, No or least sloshing effect, Cost, Life. Following types of sensors were considered for selection: Capacitance level measuring sensor, Pressure level transmitter, Magnetostrictive resistance level measuring sensor, Optical level measuring sensor, Electromagnetic level measuring sensor(microwave), Ultrasonic level measuring sensor, Load cells. Out of the above Load cell was finalized (of accuracy 1%Full scale and range 0-1 kg) due to excellent compatibility and compactness in the system.

B] Frame Analysis

Frame was modeled in Pro E Wildfire 4.0 and was analyzed in Ansys 15. Loads of the conical parts and load of motor and pump was taken into consideration for the analysis. The meshing element shape was selected as tetragonal for lower meshing time. Meshing size was reduced in critical load taking plate for detailed results. Maximum Von Mises stress was found out to be 2.06e7 dyne/cm^2 . Maximum deflection was found out to be 0.006mm which was well within limits.

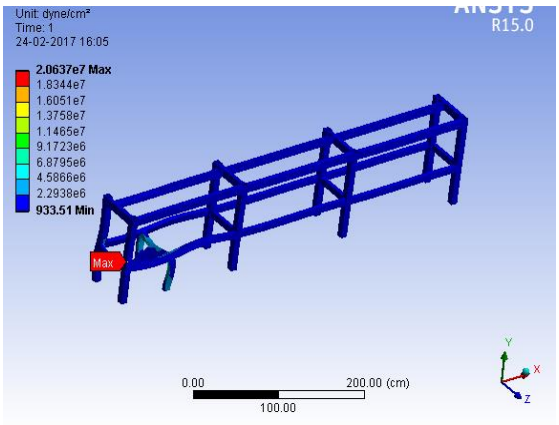


Figure 1 Stress analysis of main frame

C] PLC Program

Considering the system requirements the pump had to first pressurize water for circulation to respective drippers, the program had to be developed taking this into consideration. Therefore a timer was included in the circuitry. When the solenoid valve closes, the load cells must start reading data and feed to the PLC. A Trial program considering following requirements was made.

D] Solenoid Valve Selection

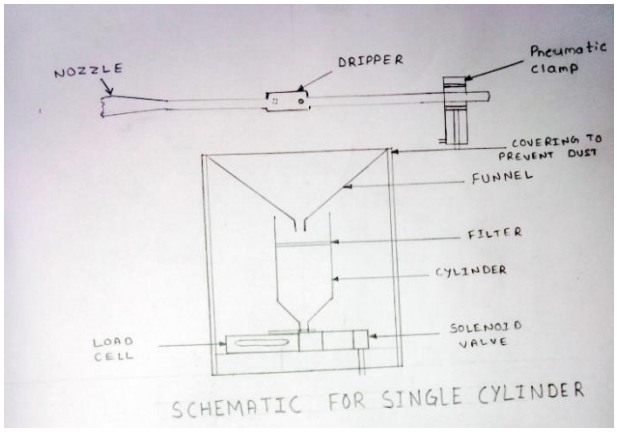
Solenoid valve is required for positive drainage of water as required for the application, Accordingly the draining time for 50ml of water was calculated by the formula:

$$t = \sqrt{(H/g)} * 2\,a/A \quad (1)$$

where,
t= time to drain 50ml water
H= height of water column
g= gravitational acceleration (9.81 m/s^2)
a= Area of water column cross section
A= Area of orifice
Accordingly solenoid valve with ¼" diameter was selected which gave time as 6.38 seconds which was appropriate. The size of this valve is also suitable for assemblage with load cells.

E] Setup arrangement

Following diagram shows the arrangement that was finalized for the process of testing.



Water is passed through the dripper from the nozzle, which comes out of dripper holes. Then this water discharge through dripper is measured in the cylinder with the help of load cell that measures the weight and then converts this weight into level or discharge received and displays it on the computer or other display.

Conclusions

1) After analysis of different sensors, load cells were found to be appropriate for this particular application for water weight measurement.
2) Frame was found to sustain loads with minimum deflection as analyzed in Ansys 15 which is in accordance with required conditions for load cells. Maximum deflection was well within limits.
3) Stress induced in frame was found to be safe.
4) Solenoid valve of orifice diameter 1/4" was found suitable.

5) Arrangement of 25 in line was selected considering space constraint and ease of accessibility.

Future Scope

1) Ultrasonic sensor which is cheap as compared to load cell can be used as a sensor. The challenge remains to stabilize water levels and also the complexity of the system with ultrasonic sensor.
2) Using a conveyor belt with a single ultrasonic sensor can be used to save sensor costs.

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