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Automation of pesticide mixing and spray control technique for agriculture

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Abstract:

Automation plays a major role in the field of engineering. It helps in increasing the accuracy of work that is being carried out. The safety measure that has to be taken care in any application is ensured by employing proper automation technique. Pesticide control is a major issue in the field of agriculture. The mixing of pesticide and the spray process has to be handled with utmost care for the benefit of the farmers. The mixing of pesticide should be proper in order to maintain the crops till the cultivation. Hence we have proposed an automation technique for the proper mixing of the pesticide. At the same time, mixing process is done by using a stirrer since hand mixing results in improper output as well as it causes harm to the farmers.

Keywords: Ratio controller, Microcontroller, sprayer with nozzle.

I. INTRODUCTION

The requirement of coverage and spray droplet size depends upon the mobility and size of the pest. The mode of action of pesticide, its relative toxicity and other physicochemical properties, help to decide the handling precautions, agitation requirement etc. Further the complete knowledge of the equipment is necessary to develop desired skill of operation, to select and to estimate the number and type of equipments needed to treat the crop in minimum time and to optimize use of the equipment. Our design objective is to mixture and control the pesticide in appropriate ratio. The controller has access to the reference commands to mixture and control the pesticide.

The success of pest control operations by pesticide application greatly depends on the following factors:-

i. Quality of pesticide

ii. Timing of application

iii. Quality of application and coverage

Different types of pesticides are used for controlling various pests. For example Insecticides are applied against insect pests, Fungicides against crop diseases, Herbicides against weeds etc. in order to protect the crop losses. But it is essential that besides choosing an appropriate pesticide for application it has to be a quality product i.e., proper quantity of pesticide active ingredient must be ensure that the quantity is maintained in production and marketing of pesticide formulations. The application of pesticide is very successful when applied at the most susceptible stage of the pest. If the timing of pesticide application is carefully considered and followed, the results will be good pest control and economy. Therefore for large area treatment careful selection of equipment becomes necessary so that within the available 'Time' the area could be treated.

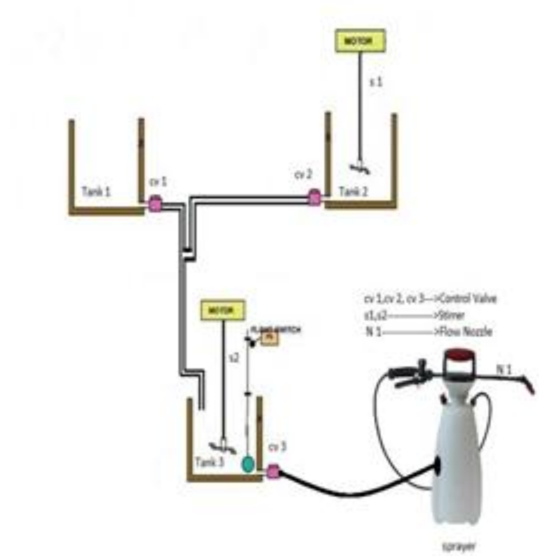


Fig: 1 Pesticide Mixer Hardware Setup

The plant consists of three tanks in cascaded arrangement. The upper tank (tank 1) is fed by pesticides (liquid state) and upper tank (Tank 2) is fed by pesticides (powder pesticides) via controlled valves. Elsewhere both the pesticides from tank 1 and 2 are in liquid state. We can stop the stirrer and continue the process. The lower tank (tank 3) is fed by Pesticide from an exit at the bottom of Tank 1, 2tank. It is arranged in interacting process arrangement.

Example 1

To destroy Barmuda grass and Korai grass

a. Round up (pesticide name) at Tank 1
b. Ammonium sulphate (salt) at tank 2

Appropriate mixture is collected from Tank 1 and 2 collected to tank 3 by Ratio controller because pesticide with salt can improve better efficiency to destroy grass.

Example 2:

To destroy unwanted grass inside the onion farm

a. Oxy Gold (Pesticide name) at Tank 1
b. Targa Super (Pesticide name) at tank 2 (Can stop the stirrer at Tank 2 when pesticides both are liquid)

II. CONTROL TECHNIQUE

Ratio Control setup:

The ratio control is used to maintain the flow rate of one stream in a process at a defined or specified proportion relative to that of another. A common application for ratio control is to combine or blend two feed streams to produce a mixed flow with a desired composition or physical property.

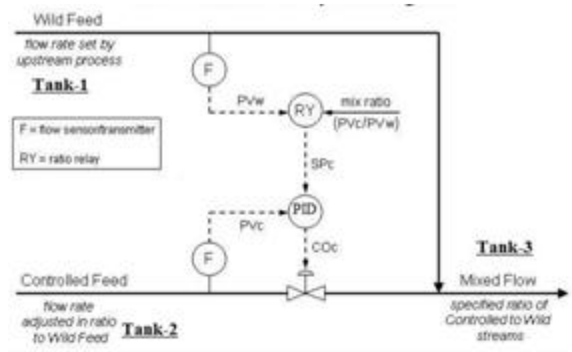
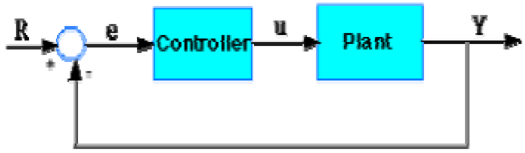


Fig: 2 Ratio Control Conceptual Diagram

The conceptual diagram above shows that the flow rate of one of the streams feeding the mixed flow, designated as the *wild feed*, can change freely. Its flow rate might change based on product demand, maintenance limitations, feedstock variations, energy availability, the actions of another controller in the plant, or it may simply be that this is the stream we are least willing to manipulate during normal operation. The other stream shown feeding the mixed flow is designated as the *controlled feed*. A final control element (FCE) in the controlled feed stream receives and reacts to the controller output signal, COc, from the ratio control architecture. While the conceptual diagrams in this article show a valve as the FCE, we note that other flow manipulation devices such as variable speed pumps or compressors may also be used in ratio control implementations.

Proportional-Integral-Derivative Actions (PID):

PID controller works in a closed-loop system. The variable (e) represents the tracking error, the difference between the desired input value (R) and the actual output (Y). This error signal (e) will be sent to the PID controller, and the controller computes both the derivative and the integral of this error signal. The signal (u) just past the controller is now equal to the proportional gain (Kp) times the magnitude of the error plus the integral gain (Ki) times the integral of the error plus the derivative gain (Kd) times the derivative of the error.



This signal (u) will be sent to the plant in **(milliliter),** and the new output (Y) will be obtained to **Tank 3.** This new output (Y) (**Flow)** from will be sent back to the sensor again to find the new error signal (e). The controller takes this new error signal and computes derivative and integral again. This process **goes open and closes the valve.**

$$C(s) = Kp(1 + \frac{1}{TIs} + TD * s)$$

Where,

K_P: Proportional Gain constant
T_I: Integral reset time
T_D: Derivative time or rate time

The proportional control (Kp) is used so that the control signal responds to the error immediately. But the error is never reduced to zero and an offset error is inherently present. To remove the offset error the Integral control action (T_I) is used. Derivative control (T_D) is used to remove the oscillations in the response. Also, the presence of derivative control reduces the need of selecting large Kp value to achieve stability.

III. PERFORMANCE EVALUATION CRITERIA

Quantification of system performance is achieved through a performance index. The performance selected depends on the process under consideration and is chosen such that emphasis is placed on specific aspects of system performance. Furthermore, performance index is defined as a quantitative measure to depict the system performance of the designed PID controller. Using this technique an 'optimum system' can often be designed and a set of PID parameters in the system can be adjusted to meet the required specification. The integral error is a good measure for evaluating the set point and disturbance response. The followings are some commonly used criteria based on the integral error for a step set point or disturbance response.

$$IAE: \int_{\infty}^{0} [e(t)]dt$$

$$ISE: \int_{0}^{\infty} [e(t)]^2 dt$$

$$ITAE: \int_{0}^{\infty} t[e(t)]dt$$

The above performance indexes are used to minimize the overshoot, settling time, steady state error and reference tracking error for PID controller system.

IV. CONTROLLER TUNING

The tuning rules work well only on processes with very long time constants relative to their dead times, and on level and flow control loops by Ziegler-Nichols method. However, its performance is not good on flow, liquid pressure at the tank 1 and 2of the project, and many other loops that require fast adjustment to minimize the error with the help of below procedure.

The tuning procedure is as follows:

1. Bring the process to (or as close to as possible) the specified operating point of the control system to ensure that the controller during the tuning is "feeling" representative process dynamic and to
Minimize the chance that variables during the tuning reach limits. Bring the process to the operating point by manually adjusting the control variable, with the controller in manual mode, until the process variable is approximately equal to the set point.
2. Turn the PID controller into a P controller by setting set Ti = ∞7 and Td = 0. Initially set gain
Kp = 0. Close the control loop by setting the controller in automatic mode.
3. Increase Kp until there are sustained oscillations in the signals in the control system, e.g. in the process measurement, after an excitation of the system. (The sustained oscillations corresponds to the system).

V. STIRRER SETUP

DC motor rotates in forward and reverse directions alternatively for desired time in Tank 2. First motor rotates forward (clockwise) for some time (say few minutes or even seconds). Then it stops for a particular time specified during the mixing operation. Again it rotates reverse (anticlockwise) for specified time and then stops. This process continues till proper mixing is achieved.

Sequential timer circuit operates for different processes one after another which means one process ends and it triggers next (Sequential in nature). The last process triggers the first process when it ends, and thus the cycle continues. These sequence timers are micro controller based multi-functional and programmable. So operation time of each process can be controlled by programming.

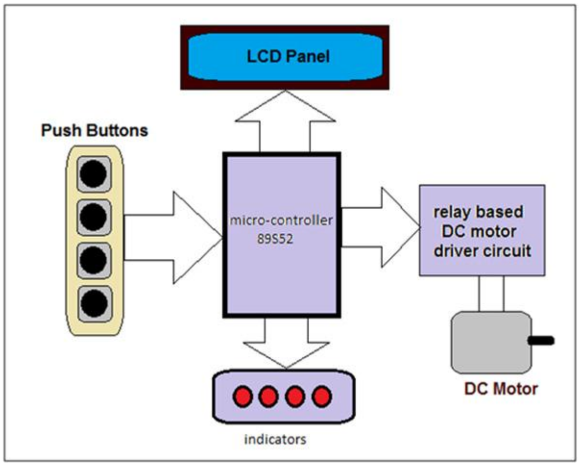


Fig: 3 Stirrer setup

Here the given Setup demonstrates one such sequential timer controlled DC motor in which the forward rotation time, reverse rotation time and stop time for motor can be programmed. And then when process starts the motor starts rotating forward and reverse as per programmed time intervals.

Push buttons: - the circuit requires only 4 push buttons for different settings and user inputs

Sl. no	Switch	Function
1	Start	To start rotating motor
2	Increase time	Increase time set by 1 sec – up to 60 sec (ON)
3	Decrease time	Decrease time set by 1 sec – up to 1 sec (OFF)
4	Stop	Enter set time

VI. FLOW NOZZLE

A spray nozzle is a device which makes use of the pressure energy of the liquid to increase its speed through an orifice and break it into drops. Its performance can be identified and described precisely, so that the design engineer can specify exactly the spray nozzle required for a given process.

Fig: 4 Spray Nozzles

The above nozzle consists of pressure arrangement. We can increase or decrease the pressure of the flow by this arrangement. The above mentioned nozzles can be used for spray control in tall trees with more efficiency and low wastage.

VII. Conclusion

In this spray control method, ratio controller based setup is more efficient and helps in optimizing the control process. The error in this method is very less compared to other tuning methods. This method also helps in the control of pressure drop and flow of the pesticide mixture. The cost of the entire setup is considerably low and it is more easy to control the setup by farmers due to simplicity and can help in better results.

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