AUTOMATION IN MICRO-IRRIGATION

Today in India inclination towards automization of drip / micro irrigation is gaining momentum due to :

- Automation eliminates manual operation to open or close valves, especially in intensive irrigation process.

- Possibility to change frequency of irrigation and fertigation process and also to optimize these processes.

- Adoption of advanced crop systems and new technologies, especially new crops system that are complex and difficult to operate manually.

- Use of water from different sources and increased water and fertilizer use efficiency.

- System can be operated at night, thus the day time can be utilized for other agricultural activities.

- Pump starts and stops exactly when required, thus optimizing energy requirements.

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What is Automation?

Automation of drip/micro irrigation system refers to operation of the system with no or minimum manual interventions.

Irrigation automation is well justified where a large area to be irrigated is divided into small segments called irrigation blocks and segments are irrigated in sequence to match the flow or water available from the water source.

SYSTEMS OF AUTOMATION

1.   Time based system

In time based system, time is the basis of irrigation. Time of operation is calculated according to volume of water required and the average flow rate of water. The duration of individual valves has to be fed in the controller along with system start time, also the controller clock is to be set with the current day and time. As the clock of the controller knocks the start time of programme, it starts sending signals to the first automatic valve in the programme sequence, the pump also starts up at the same time. As soon as duration of first valve is over the controller either stops or switches on to next valve. When the operation of last valve is over, controller stops sending signals to valves and pump. The same process is repeated at next run time.

2.   Volume based system

In volume based system, the preset amount of water can be applied in the field segments by using automatic volume controlled metering valves. Automation using volume based systems are of 2 types. In first type of system, automatic metering valve with pulse output provides one pulse after completing one dial of the automatic metering valve. Thus, by counting the number of pulses received by the controller, it can count the volume of water passed through. After providing required volume of water through first valve, it closes down and controller switches on the next valve in the sequence.

In second type of system, no controller is required. Automatic metering valves are positioned near each field segment. All automatic metering valves are interconnected in series with the help of control tube. For automatic closing and opening of the metering valves with the help of water pressure signal, components like t-connector, shuttle valve and a 3 way relay (called Shastomit) are also installed along the circuit. During sequential operation only one automatic metering valve remains open. The next valve in the series opens after the first

valve closes. Shut down of the irrigation pump can be made automatic after closure of the last valve in series by connecting the spare end of the last valve T-connector to a micro-switch with the help of control tube. Micro-switch is connected to the pump motor starter's magnetic coil. After the last automatic metering valve closes, it transmits pressure signal to the micro-switch with the help of pressure which in turn activates a pressure switch and terminates the motor starter circuit resulting in automatic shutdown of irrigation pump.

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3.   Open Loop Systems

In an open loop system, the operator makes the decision on the amount of water that will be applied and when the irrigation event will occur. This information is programmed into the controller and the water is applied according to the desired schedule. Open loop control systems use either the irrigation duration or a specified applied volume for control purposes.

Open loop control systems are typically low in cost and readily available from a variety of vendors. The drawback of open loop systems is their inability to respond automatically to changing conditions in the environment. In addition, they may require frequent resetting to achieve high levels of irrigation efficiency.

4.   Closed Loop Systems

This type of system requires feedback from one or more sensors. The operator develops a general control strategy. Once the general strategy is defined, the control system takes over and makes detailed decisions of when to apply water and how much water to apply. Irrigation decisions are made and actions are carried out based on data from sensors. In this type of system, the feedback and control of the system are done continuously.

Closed loop controllers require data acquisition of environmental parameters (such as soil moisture, temperature, radiation, wind-speed, etc) as well as system parameters (pressure, flow, etc.).

5.   Real Time Feedback System

Real time feedback is the application if irrigation based on actual dynamic demand of the plant itself, plant root zone effectively reflecting all environmental factors acting upon the plant. Operating within controlled parameters, the plant itself determines the degree of irrigation required. Various sensors viz., tensiometers, relative humidity sensors, rain sensors, temperature sensors etc control the irrigation scheduling. These sensors provide feedback to the controller to control its operation.

A computer-based control system consists of a combination of hardware and software that acts as a supervisor with the purpose of managing irrigation and other related practices such as fertigation and maintenance. Generally, the computer-based control systems used to manage micro irrigation systems can be divided into two categories:

- Interactive systems that collect and process information from various points in the system, and allow manual control of the system from a central point by remote operation of valves or other control devices.

- Fully automatic systems that control the performance of the system by automatically actuating pumps, valves, etc. in response to feedback received from the monitoring system. These systems use closed control loops which include:

- Monitoring the state variables (pressure, flow, etc.) within the system.

- Comparing the state variables with their desired or target state.

- Deciding what actions are necessary to change the state of the system.

- Carrying out the necessary actions.

    Performing these functions requires a combination of hardware and software that must be implemented for each specific application.

Interactive Systems

Interactive systems are usually built around a microcomputer, either a standard personal computer (PC) or a specially designed unit. The information is transferred into a central unit either directly from sensors in the pipeline or from intermediate units which collect the data from a number of sensors and then process and store them temporarily for further transfer to the central computer. These systems have features that enable the operator to transmit commands back to the various control units of the irrigation system. The field devices such as valves, regulators, pumps, etc. are fitted with electrically operated servo-devices which enable actuation of the pumps, closing and opening of valves, and adjusting pilot valves of flow regulators. This type of system permits the operator to govern the flow from the central computer by controlling flow parameters such as pressure and flow rate, according to specific needs at the given time, and to receive immediate feedback on the response of the system.

Automatic Systems

In fully automated systems the human factor is eliminated and replaced by a computer specifically programmed to react appropriately to any changes in the parameters monitored by sensors. The automatic functions are activated by feedback from field units and corrections in the flow parameters by control of devices in the irrigation system until the desired performance level is attained. Automatic systems can also perform auxiliary functions such as stopping irrigation in case of rain, injecting acid to control pH, sounding alarms, etc. Most control systems include protection in emergencies such as loss of the handled liquid due to pipe burst. They close the main valve of the whole system or of a branching, when an unusually high flow rate or an unusual pressure drop is reported by the sensors.

7.   Sensor Controlled Micro Irrigation

Control by twin sensors

One sensor is placed in the root zone and actuates the opening of water flow. The second sensor, located on the limit of the wetted zone, triggers the closing of water flow.

Control by single sensor

One sensor open and closes the water supply.

System Component Of An Automatic Irrigation System

Controllers

This device is the heart of the automation, which coordinates operations of the entire system. The controller is programmed to run various zones of an area for their required duration or volume. In some cases sensors are used to provide feedback to the controller. In the simplest form, irrigation controllers are devices which combine an electronic calendar and clock and are housed in suitable enclosure for protection from the elements.

The PLC's, microprocessors and computers are now available and being used extensively. (PLC-Programmable Logic Controllers).

Electromechanical Controllers

These types of controllers are generally very reliable and **not** very sensitive to the quality of the power available. However, because of the mechanically-based components, they are limited in the features they provide.

Electronic Controllers

These types of systems are more sensitive to power-line quality than electromechanical controllers, and may be affected by spikes, surges and brownouts. These type of systems may require electrical suppression devices in order to operate reliably. Since electronic based these provide a large number of features at a relatively low cost.

Sensors

A sensor is a device placed in the system that produces an electrical signal directly related to the parameter that is to be measured. Sensors are an extremely important component of the control loop because they provide the basic data that drive an automatic control system.

In general, there are two types of sensors: continuous and discrete.

Continuous sensors produce a continuous electrical signal, such as a voltage, current, conductivity, capacitance, or any other measurable electrical property. Continuous sensors are used when just knowing the on/off state of a sensor is not sufficient. For example, to measure pressure drop across a filter or determine tension in the soil with a tensiometer fitted with a pressure transducer requires continuous-type sensors.

Discrete sensors are basically switches (mechanical or electronic) that indicate whether an on or off condition exists. Discrete sensors are useful for indicating thresholds, such as the opening and closure of devices such as valves, alarms, etc.

Various types of soil moisture sensors, weather instrumentation, plant-water stress or crop-canopy temperature are available and can be used in feedback mode for irrigation management.

The available sensors,

1. The analog tensiometer
2. The contact tensiometer
3. Electrical resistance sensors (most widely used)
4. Dielectric sensors
5. Thermal soil matric potential sensor
6. Gypsum block soil moisture sensors
7. Tdr-based soil moisture sensors (Time Domain Reflectometry)

Control Valves

Replacement of conventional manual valve by either solenoid valve or hydraulic valve is necessary for automation. These valves operate on hydraulic pressure. The operation of hydraulic valve depends on the type of valve and whether it is NC (normally closed) or NO (normally open) in principle. A command can be transmitted to these hydraulic valves by means of control tubes and solenoid coils. Most remote control valves are "normally closed" meaning that the valve is closed until the solenoid is actuated by the controller. A "normally open" control valve remains open until such time as the solenoid is actuated.

Solenoid Coil

Solenoid coil is used to convert electrical pulses into hydraulic pulses, which enables opening and closing of specific hydraulic valve. The solenoid coil has a metal plunger inside the electromagnetic coil. The coil gets actuated after receiving required voltage. It pulls up the plunger and water passes from the lower orifice port to control tubing towards the hydraulic valve. When operation time is over, the controller stops sending signals to the solenoid coil to deactivate. Thus the plunger again seals the orifice port to close.

Automatic Metering Valve

These valves are required only in volume based irrigation system. The volume of water required for the irrigation can be adjusted in these automatic metering valves. These valves can be simple metering valve which shuts off after delivering preset quantity of water or automatic metering valve with pulse output which provides pulses to the controller to count the volume of water.

Valves

Automated valves are activated either electrically, hydraulically or pneumatically and used to switch water on or off, flush filters, mains and laterals, sequence water from one field or segment to other.

Metering pumps

These pumps are suitable for feeding of known quantity of fertilizers/chemicals. The capacity of pumps varies from 1.5 to 3.5 litres / hour.

Peristaltic Pumps

These are ideal systems for accurate pumping of fluids at low flow rates. These can be used for accurate dosing of chemicals, when desired.

Flow Transducers

These can be used for measuring flow and totalizing the flow. These have rotor blade and each rotor blade has a stainless steel tip which is detected by a sensor mounted externally the glass tube. The pulse output, proportional to flow rate is measured by the counter.

Sequencer systems

Electromechanical and electronic time driven sequencer systems are available. In electromechanical system the gears can be used to provide a variety of time periods for a single revolution of the camshaft. In the electronic sequencer controllers have programmable steps which may be executed one or automatically repeated.

Irrigation has developed mostly in response to the crop production needs of developed countries. The automatic micro irrigation system for one crop may not suit the other crop. The design of automatic micro irrigation system needs knowledge of the irrigation requirements and the hardware elements, so that maximum benefit may be derived with minimum investment. The investment potential and skill level of the users also influence the design of system. Under Indian conditions, a simple, low-cost, easy to operate and easy to maintain system is desirable. It will help in popularizing micro irrigation systems and reap its benefits.

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