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Study of different automatic irrigation systems

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■ **ABSTRACT :** At the present era, the farmers have been using irrigation techniques in India through manual control, in which farmers irrigate the land at the regular intervals. The farmer has to keep watch on irrigation timetable, which varies according to crop, soil and season. Common methods of water distribution can be enhanced or replaced by using recent technological advances. The Government has invested good amount of money to develop the technology in order to increase the productivity of agriculture. Automatic irrigation system is one of the prudent technologies for more efficient utilization of water resources and applies irrigation water as and when required by the crop. This paper presents the available automatic irrigation system controllers in India, which covers them from different firms manufacturing and selling them to the farmers. All the features of these products are explained shortly.

■ **KEY WORDS :** Automatic, Controller, Irrigation, Sensor

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The major components of the irrigation system such as control valves, flow transducers and fertilizer pumps can be easily automated. The conventional manual valve is to be replaced by either solenoid valve or hydraulic valve (Abdurrahman *et al*., 2015). 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 (Rane *et al*., 2015). Solenoid coil is used to convert electrical pulses into hydraulic pulses, which enables opening and closing of specific hydraulic valve (Prathyusha and Suman, 2012). Flow transducers can be used for measuring flow and totalizing the flow. The pulse output, proportional to flow rate is measured by the counter. Automated fertilizer injectors with EC/pH level detector can be used for fertilizer and acid injection in irrigation system (Nallani and Hency, 2015).

However, the promotion/adoptions of all above systems are very limited on farmer's field. The reasons are: (a) There are constraints into select an appropriate and suitable automatic irrigation system to their fields and crops to be grown, (b) The data availability, (c) Dependability on technical personnel, (d) Self adjustiveness with power failure and accidental storms and finally, (e) Very high initial investment and maintenance (Reddy and Rao, 2016).

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.

Advantages of irrigation automation systems:

– 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.

Systems of automation:

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.

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.

The major advantage of volume based irrigation system over time-based system is that is assures to deliver the preset amount of water irrespective of continuous availability of electricity, but time based system is comparatively cheaper and hence gaining more popularity than the volume based system.

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.

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.).

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.

System component of an automatic irrigation system:

Irrigation 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.

Fig. 1 : MiniAg controller

Fig. 2 : Single net

Fig. 3 : NMC Pro

Fig. 4 : Irri care

Fig. 5 : Gavish

Fig. 6 : NMC Junior

Wireless irrigation:

Designed for medium to very large farm lands where wiring to the control valve is not possible or if possible then could be very costly affair.

These devices has two major components

RF Gateway:

– These units are fitted in the irrigation controllers and acts as mediator between irrigation controllers and field RTUs (Remote Terminal Units).

– Works on license free frequency band of 865 MHz

Fig. 7 : RF Gateway

RTU (Remote Terminal Units):

– These units are the field units located far away from the irrigation controller where wiring is not possible or feasible to the control valves.

– These units have built in solar panel and rechargeable internal batteries.

– This unit too works on license free frequency band of 865 MHz.

– These also have input to get sensor data on remote locations like pressure, flow or soil moisture.

Works in mesh technology so to cover large areas. One unit acts as repeater to the nearby RTUs approximately 1.5 kms in radius.

Fig. 8 : Remote terminal units

Radionet:

Optimized seamless network enables exceptional system architecture with enhanced through put in virtually any environment. With four expansion slots, Radionet provides almost unlimited control and monitoring configurations to simply expand modules and strengthen performance. It ensures optimal long term operation with instant recording and charting of frequency interruptions across the entire network from the initial unit installation.

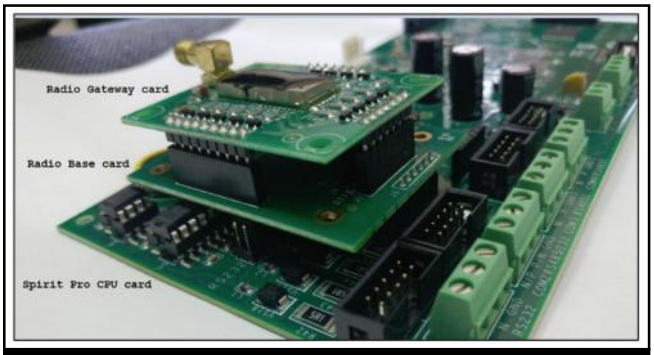

Fig. 9 : Radionet

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 sensors:

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:

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.

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.

Fig. 10 : Control valves

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.

Fig. 11 : Solenoid coil

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.

Fig. 12 : Flow transducers

Automated fertilizer injectors:

These automated or electrically driven fertilizer injectors are used to inject fertilizers and acid with irrigation either with EC/pH level control method, proportional with respect to main line flow or continuous.

These are categorized in following types:

Fertilizer dosing pumps:

These pumps are available in 100LPH/200LPH/300LPH and 500LPH capacities. These pumps are injects subject to inject without EC/pH correction. Injection rate can be adjusted with the knob on the pump as per user requirements

Fig. 13 : Fertilizer dosing pumps

Advanced fertilizer injectors (EC/pH correction/ maintain facility):

These are very advanced fertilizer injector machines connected in by-pass to the main line. They are specifically designed for small to medium scale open field farms. These have electrically operated fertilizer injectors for proportional or level control method injections as per command received from the irrigation controllers.

Fig. 14 : Advanced fertilizer injectors

The machine has multiple fertilizer channels and one acid channel. To get the real time data of EC/pH machines has industrial EC/pH transmitter which sends signals to the irrigation controller and thus controller manages or open/close the electrically operated direct acting solenoid valves on the injectors. Built with stainless steel vacuum or booster pump to manage the proper injection rate and back pressure prevention.

Mixer Machines (Exact correction of EC/pH):

These are very sophisticated fertilizer/acid injection machines installed inline on the system. They are specifically designed for soilless culture where irrigation and fertilizer requirements are of very short cycles. The machines have PE tanks of 100 ltr/200ltr/300ltr and 500ltrs designed or built with flow requirements of particular field. The raw water is filled in the tank for a particular level; after particular level reaches the mixer/ delivery pump on the machine take charge of fertilizer and acid injection in the tank as per preset values of EC/ pH defined the irrigation controller and thus mixes solution in the tank. As the required level of EC/pH achieves the same pump on the machines opens its delivery valves and irrigates to the particular section or control valve defined in the irrigation controller

Fig. 15 : Mixer machines

Netajet inline:

It provides fast and accurate fertilizer and acid control. Also, converts precise pulse fertigation into a uniform solution

Fig. 16 : Netajet inline

NetaJet – Bypass:

It offers EC and pH measurement and control. It provides accurate fertilizer and acid control with minimum expenses and intervention. It also delivers high precision solution for midrange to large applications.

Fig. 17 : NetaJet – bypass

NetaJet high flow:

It delivers accurate control of fertilizers and acid in extreme flow rate of over 100m^3/hr (440 Gallon/min). It has pre-regulated compensation channel based on unique Venturi injectors. It offers EC & pH measurement and control.

Fig. 18 : NetaJet High Flow

Fertikit 3G:

Fertikit 3G is based on a standard platform operating in various modes, while accommodating diverse dosing channels, dosing boosters, controllers, peripherals and accessories. It has modular design with four operating modes. It has upto 8 highly-accurate fertilizer/acid 50-1,000 l/hr (13-265 gal/hr) dosing channels. It is field-proven in all environmental conditions. It can be cost-efûcient solution for soil and substrate applications with minimal investment.

Fig. 19 : Fertikit 3G

NetaFlex™ 3G:

It has wide range of soil/substrate applications. Minimal investment is required. It has efficient water, fertilizer and energy consumption. It is having very large range of irrigation water capacities. It can offer guaranteed EC and pH control. It is almost completely maintenance-free Venturi operations with no moving parts. It is easy to install and maintain system. Also, covers all applications ranging from greenhouse in soil, to very intensive soilless media. It requires minimal investment with rapid ROI. It has versatile flow capacity: from 0.1Ha to 10Ha. It can operate upto 6* highly accurate 50-600 l/hr (13-156 gal/hr) fertilizer/acid dosing channels. Similar work related to the present investigation was also carried out byKansara *et al.* (2015) and Mane *et al.* (2014).

Fig. 20 : NetaFlex™ 3G

Conclusion:

Automatic irrigation system refers to operation of the system with no or minimum manual interventions. The automatic irrigation systems are time based, volume based, open loop, closed loop and real time feedback system. The automatic irrigation system includes the controllers, sensors, control valves, solenoid coils and flow transducers. The various available controllers are MiniAg Controller, Single Net, NMC Pro, Irri Care, Gavish, NMC - Junior Pro, etc. The wireless controllers are RF Gateway, RTU (Remote Terminal Units) and

Radionet. The sensors may be continuous and discrete type. The available automated fertilizer injectors are Fertilizer dosing pumps, Advanced fertilizer injectors, Mixer Machines, Netajet Inline, NetaJet – Bypass, NetaJet High Flow, Fertikit 3G, NetaFlex™ 3G, etc.

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