

## Application of Autocontrol Technology in Water-saving Garden Irrigation

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**Abstract**—Along with the shortage of water resources and green water cost increase, City Garden general construction of the water saving irrigation system, water-saving irrigation automatic control device of water-saving potential has been green maintenance unit recognition, therefore, landscape water-saving irrigation automatic control technology popularization and promotion. This paper mainly introduces the city landscape water-saving irrigation automatic control system of the type and composition, analysis of water saving irrigation monitor and controller structure and function, developed the city landscape water-saving irrigation control system, and the effect is better.

**Keywords**—automatic control; landscape; water saving irrigation

### I. INTRODUCTION

Water-saving irrigation can be defined as the way to save or reduce the amount of water for irrigation diverted from streams, reservoirs, underwater or other water sources by using different technical water-saving measures as well as garden water-saving measures and administrative water-saving measures. This is a traditional way for saving water and is popular now. Based on this, a nationwide water-saving irrigation campaign is under way. Urban green space is a multi-layered community formed by trees, shrubs and grass in a certain way and proportion; this multi-layered community which is composed of different plants has different requirements about water, so in order to meet the growth needs of different plants, different irrigation methods and different irrigation amounts shall be employed. People can hardly control the different irrigation methods and different irrigation amounts in the same irrigation system by themselves, while autocontrol can help to realize irrigation in appropriate time with the right amount. This paper mainly describes the types and work principles of automatic turf irrigation system.

### II. SIGNIFICANCE OF AUTOMATED IRRIGATION

#### A. Automated irrigation can help to reduce management cost and improve efficiency

Turf relies on conservation much more than planting, and the key for conservation is how to realize scientific irrigation. Irrigation, as an important measure to make up for the shortage of rainfall in quantity and its non-uniformity in

space and time and ensure the water essential for turf's growth in appropriate time and amount, has been an important and costly part in modern turf management. Having experienced flood irrigation, tube irrigation and spray irrigation, there are new turf irrigation methods now as trickle irrigation and subsurface irrigation. Traditional irrigation management basically depends on persons. It's extremely urgent to realize irrigation automation for the sake of reducing the manpower and cost for irrigation management. In addition, spray irrigation of turf is mostly conducted at night; one of the reasons is that spray irrigation in the daytime may have more evaporation loss. [1] Generally, over 10% water can be saved during the spray irrigation at night compared with that in the daytime. The next reason for spray irrigation of turf at night is that spraying in the daytime is not suitable for some turfs, such as golf courses which may have matches and recreational areas of parks which may have social activities. Autocontrol spray irrigation of these turfs which need spray irrigation at night can greatly save people's efforts of management.

#### B. Automated irrigation system can help to improve the level of control and the comprehensive dispatching capacity of the irrigation system

Currently, people have been well acquainted that management is an important link restricting the development of water-saving irrigation technology. For the lack of favorable technical management measures in practical use, the water-saving effects of many new irrigation techniques (such as spray irrigation, trickle irrigation, micro-sprayer irrigation, and subsurface irrigation) can't be well displayed and they can't be popularized in large areas. At present, except golf courses which adopt autocontrol, most garden irrigation systems are operated by management staffs according to their experience [2]. Actually, the area of turf only expands greatly in the recent 10 years, and the scientific law of turf watering can't be well combined with management staffs' practical experience. The combination of computer technology, autocontrol technology and water-saving irrigation technology is of important meaning to improve the automation level of water-saving irrigation, grasp the growth conditions, environment, growth rhythm and watering law of turfs faster and more precisely, control irrigation more precisely and timely, save labor and improve economic performance. Ecological effect is proportional to the leaf area of unit green space. In pursuit of greater

ecological effect of green space, it's a must to form the multi-layered community composed of trees, shrubs and grass, because for the urban green spaces of the same area, ecological effect of multi-layered community can be several times and even tens of times of that of one layered community. This is well recognized by the vast landscaping workers and it has been the future development trend of urban green spaces; green spaces composed of only a large area of turfs are fewer and fewer gradually. Multi-layered community is certainly composed of different plants, and accordingly, it may have different requirements about water.

During garden irrigation, in most traditional methods, people control the amount and time of water flowing to the garden, that's spray irrigation or trickle irrigation system, and the discharge time is also controlled by people. As a result, the amount of water flowing to the garden is either more than the planned irrigation amount or less than the planned irrigation amount. If autocontrol irrigation is adopted, the irrigation flow and time can be reasonably calculated and precisely controlled according to plants needs, soil conditions, plant growing stages and so on, which can reduce the waste of water caused by the ineffective implementation of controlling methods and planning results.

### C. *Water saving can stimulate the development of national economy*

It's an undoubted fact that our country is lack of water resources. Along with the development of national economy, the contradiction between industrial water and agricultural water as well as domestic water and agricultural water is increasingly aggravated; the development trend requires a reduction of agricultural water so as to increase the water used for industry, people's life and construction of ecological environment.[2] Besides, the water use efficiency in garden irrigation is very low. Comprehensive irrigation water use coefficient in our country is less than 0.5; compared with developed countries, we have great potentials in water saving. Besides the technical measures which can improve the water use efficiency, advanced irrigation technologies and management techniques are also very important in saving garden irrigation water.

## III. OPERATING PRINCIPLES OF AUTOMATIC CONTROL SYSTEM OF WATER- SAVING GARDEN IRRIGATION

### A. *Basic concept of automation and autocontrol*

Automation is defined as the process in which machines or devices operate or control themselves according to the specified programs or instructions automatically without the intervention of persons; autocontrol means that the production process can move on automatically according to the scheduled rules with the help of a controller without the direct intervention of persons. The equipment giving such control is called a controller, and the controlled machines or devices are called controlled object; they two together form an automatic control system. Although different automatic control devices have different tasks, in fact, they do nothing but to control the certain physical parameters of the controlled objects to keep their due rules automatically. In

order to replace manual control with auto-control, there shall be 3 kinds of mechanisms which can replace the operators of manual control in the automatic control system. They are:

- Measuring mechanism, used to measure the controlled amount;
- Comparison mechanism, used to make a comparison between the controlled amount and the given value to work out the error, and finish control according to the nature of the error. Besides, as to the given value, in manual control, as long as the operator knows it, everything is ok, but in the autocontrol system, there shall be another mechanism called instructing mechanism to give the given value.[3]

### B. *Work principles of autocontrol irrigation system*

#### 1) *Common types of autocontrol irrigation system*

Autocontrol is designed to enable the production process or other processes to move forward automatically according to the working procedure made by people, and when the controlled object works, it needs no direct intervention of people. According to the degree of system automation, autocontrol irrigation system can be divided into full autocontrol irrigation system and semi autocontrol irrigation system. The full autocontrol irrigation system needs no direct intervention of people; it can start and stop the water pump automatically for a very long time according to the pre-composed control program and some parameters reflecting the water requirements of plants and irrigate the plants in certain sequences of rotation irrigation automatically. What people shall do is only to adjust the control programs and check and repair the control equipment. In such a system, besides the douche (sprayer, dripper and so on), conduit, pipe fittings and water pump, and motor, there shall also be central control unit, electromagnetic valve, and sensors (soil moisture sensor, temperature sensor, pressure sensor, level sensor, rain sensor and so on) and wire. In semiautomatic irrigation system, there is no sensor mounted in the field. The irrigation time, irrigation amount and irrigation cycle are all decided by the pre-composed programs instead of the feedback information of plants, soil moisture and meteorologic conditions. Such systems have different levels of automation. [3]For example, some pumping stations are automatically controlled, others are manually controlled; some have no central control unit and only have some sequence conversion valves or volume valves fixed on the branch pipes. According to the different structures, automatic control system can be divided into open loop system and closed loop system. If the automatic control system has feedback signals, it's then called a closed loop system; otherwise, it's known as an open loop system. Similarly, automated irrigation system can also be divided into closed-loop control irrigation system and open-loop control irrigation system. One thing needs to be pointed out is that both closed-loop control irrigation system and open-loop control irrigation system are fully automatic irrigation system, which can realize self washing of machine set (or head valve) and filter as well as autocontrol of the overall process of water flow distribution in the pipe network. The central computer control system used widely in garden and

green space irrigation is a typical closed-loop control irrigation system, while the sequence control system is a typical open-loop control irrigation system. No matter which control system is used, it can at least enable the user to design the working procedure of the system according to his own requirements, thereby to satisfy his particular requirements of the system. The basic working procedure generally contains the following control tasks: when to start which valve; how much time it will run after start-up; on which days it shall work and on which days it shall not work in a week [4]. After the user sets the working procedure, the system can operate and control itself automatically according to the working procedure. When things change and there are new requirements, the user can easily revise the working procedure.

#### 2) Central computer controlled irrigation system based on automatic weather station

The central computer controlled irrigation system can automatically control several independent irrigation subsystems; that's to say, it can operate several controllers, sensors and other irrigation equipment at the same time. Through the real-time monitor of the operation status of the whole system, it can enable all equipment to be in their optimum regime to realize the system operation without the intervention of people. The central control system can automatically determine the irrigation amount according to meteorological data and soil moisture and realize truly fully automatic irrigation control, and economize on manpower, reduce the operation and management cost to the largest extent. The whole system is composed of the central computer, communication equipment, controller and sensor. Communications between the computer and control equipment of each subsystem can be realized through telephone line, wireless, optical fiber and so on. Between the computer and each field controller, there is also intermediate equipment called cluster control unit (CCU), which can receive information from the computer and then monitor and control other equipment. The computer can pick up weather information through the electronic weather station and automatically figure out and adjust the irrigation time of different subsystems.

#### IV. KEY TECHNOLOGY OF AUTOCONTROL IN WATER-SAVING GARDEN IRRIGATION

According to the composition and feedback mechanism of automatic control system, the autocontrol irrigation system can be divided into open automatic control system and closed automatic control system. The open automatic control system can start and close the irrigation system according to the preset time; closed automatic control system determines the start and close time of the irrigation system through software analysis according to the fed back sensor data. The open automatic control system is generally an independent autocontrol irrigation system; the closed automatic control system is generally a central automatic control system.

##### A. Automatic irrigation controller

Automatic irrigation controller is also called independent control unit; each controller can be a 3-station one, 6-station one, 12-station one or 24-station one. The number of control stations shall be determined according to the design requirements of irrigation system. The number of control stations generally depends on water sources and the number of stations of a controller shall be decided according to the number of control stations. At present, controllers of many brands can be expanded and have more control stations as required. Figure 1 shows the network structure of the whole automatic irrigation controller.

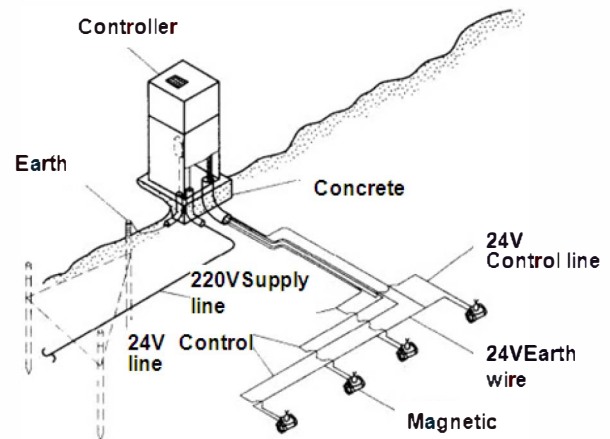


Figure 1. Sketch Map of Automatic Water-saving Irrigation Controller

When the urban green space covers a large area or is relatively disperse, several automatic irrigation controllers may be adopted at the same time, and there is no feedback relationship between each controller; they can operate independently. The automatic irrigation controller is generally composed of the controller, power, magnetic valve and wire; the electric power supply is 220V, working voltage of magnetic valve is 24V; the magnetic valve is generally closed most of the time, and it's only opened when the power supply voltage is 24V. Selection of appropriate automatic irrigation controller shall mainly consider the following several requirements: (1) Cost, quality and the owner's requirements; (2) Functions of control program; (3) Number of control stations; (4) Way of installation; (5) After service. The automatic irrigation controller is convenient to set the irrigation parameters including start time, close time, irrigation cycle and so on for each control station.

##### B. Central automatic irrigation control system

This system is composed of 2 subsystems, namely the evapotranspiration monitor and forecast subsystem and irrigation control subsystem. Evapotranspiration monitor and forecast subsystem is composed of the weather station, data acquisition unit and ET<sub>0</sub> analytical software; it can monitor the air temperature, humidity, wind speed, radiation and other meteorological parameters in real-time, and work out the referential evapotranspiration through ET<sub>0</sub> analytical software; ET<sub>0</sub> value analysis structure can be input to the

control program as the main basis for the controller and irrigation control program to make irrigation decisions.

### C. Functional design of water irrigation monitor and controller

Irrigation monitor and controller mainly includes 20 line sensor input signals; it can connect with several sensors, including flow sensor, pressure sensor, soil moisture sensor, soil temperature sensor, air temperature and humidity sensor, rainfall sensor, wind speed sensor, wind direction sensor and net radiation sensor; signals can be input in analog signal and digital signal and many other sensing signals. The 24 line control signal output can control the start and stop of blower fan, magnetic valve, water pump and motor. The system mainly has the following functional characteristics.

#### 1) Setup of rotation irrigation groups

By default, one control station is taken as one rotation irrigation group. Users can set up the parameters of rotation irrigation group according to the practical situations and revise the parameters of rotation irrigation group at any moment.[5] After the setup of rotation irrigation group, other parameters can be set according to the rotation irrigation group parameters. At present, products from foreign countries adopt no fixed rotation irrigation group and can't be set up, and domestic products basically refer nothing about rotation irrigation group.

#### 2) Setup of irrigation cycle

- Mode of irrigation of the irrigation controller can be set in the following several ways:

- Arbitrary period: Interval between two times of irrigation can be arbitrary, from 0 to 99 days;

- Weekly period: The irrigation frequency is set by week; any day or days in a week can be set for irrigation or no irrigation;

- Monthly period: The irrigation frequency is set by month; any day or days in a month can be set for irrigation or no irrigation;

#### 3) Mode of irrigation

Mode of irrigation of the irrigation controller can be set in the following several ways:

- Continuous irrigation: After the rotation irrigation group starts, the controller can continue with the

irrigation according to the preset irrigation time till the end of irrigation; the irrigation duration is 0 - 240min;

- Rotation subsurface irrigation: In most cases, continuous irrigation can meet the requirements of irrigation, but in some other cases, irrigation in this way may easily cause surface runoff; for purpose of preventing such cases, the irrigation controller can be set to be subsurface irrigation. For the same rotation irrigation group, the controller can be started first for 10min, and then stopped for several minutes; in this way, the rotation irrigation can prevent surface runoff effectively.

- Manual irrigation: The water-saving irrigation controller can also be operated manually in the field.

- Automatic irrigation: The controller can irrigate the plants automatically according to the preset irrigation cycle without the intervention of people.

- Sensor controlled irrigation: It's advisable to choose rain sensor or soil humidity sensor, which can start or stop irrigation automatically according to the preset sensor value. Each rotation irrigation group can set up 10 starting time every day, that is, it can start for 10 times every day.

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