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Efficient Water Distribution System Using Supervisory Control and Data Acquisition (SCADA): A Case Study of Vijayawada Municipal Corporation, Andhra Pradesh, India

Dr. G.Venkata Ramana

Professor & HOD, Dept. of Civil Engg. GRIET, Hyderabad, India

ramanagedela@gmail.com

Abstract

As on today, the population of India is more than a thousand million. The urban population would be around 40% and rest will be semi urban and rural. This means a very large demand on the civic amenities including water supply for domestic purposes and in addition more water would be needed for purposes such as irrigation, industry, etc., which have to keep pace with the increasing demands of rising population. Therefore, identification of sources of water supply, their conservation and optimal utilization is of utmost importance. Even the present scale of water supply to urban and rural population is grossly inadequate and not all communities are provided with safe water supply, let alone piped water system; hardly any metropolitan city has a continuous water supply; and very few cities could boast of providing adequate water supply to meet their growing demands at adequate pressure.

Many facts are involved in tackling the problem of providing protected water supply to all communities at the minimum cost and in the shortest possible time. Emphasis has to be laid on both the aspects of the system namely planning, management, technical and financial. At present a number of decisions, both at policy and technical levels, are being based on empirical considerations and divergent practices are in vogue in the country in so far as designing system itself is concerned. The planning and design of water supply network requires great attention these days because ineffective water distribution leads to various losses due to which the ultimate goals of water supply such as quality, quantity and timeliness are not being achieved so, the planning and design requires the expertise of city planners and civil engineers.

Hence in the present study it is dealt with effective water distribution system which deals with the study of water supply, occurrence of water losses and its control. One of the methods through which the effective water distribution can be attained is SCADA. I refer to SUPERVISORY CONTROL AND DATA ACQUISITION mainly aims at providing drinking water as per the Indian standards and reducing the water wastage during distribution, and thereby attaining controlled supervision on both quality and quantity of water. In this project we have dealt with the implementation of SCADA, the process involved in it and its achievement.

Keywords: SCADA, Irrigation, Adequate water.

Introduction

On a global scale, total quantity of water available is about 1600 million cubic km. The hydrological cycle moves enormous quantities of water about the globe. However, much of the world's water has little potential for human use. Only 3% of it is freshwater, most of which lies deep and frozen in Antarctic and Greenland, only about 0.26 % flows in rivers, lakes and in the soils and shallow aquifers which can be readily used. The remaining 97% is saline water. Fig. 1.1 shows the distribution of water in nature.

The present available water sources are not sufficient to meet the demand of enormously increasing population which is expected to increase for about 1500 to 1800 million by the year 2050.

Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world and as the world population continues to rise, so too does the water demand. Awareness of the global importance of preserving water for ecosystem services has only recently emerged as, during the 20th century, more than half the world's wetlands have been lost along with their valuable environmental services for water education.

As a global water crisis threatens, modern civilization must know how world water supply effects the food consumption. Regional variations in the rainfall lead to situations when some parts of the country do not have enough water even to raise a single crop, which effects the food production. To meet the requirement of food production, every water source must be utilized in a proper and effective manner without any wastage.

The planning and design of water supply network requires great attention these days because ineffective water distribution leads to various losses due to which the ultimate goals of water supply such as quality, quantity and timeliness are not being achieved. So the planning and design requires the expertise of city planners and civil engineers.

Increase in power requirement is one of the major constraints which affect the water utilization. Due to inadequate availability of water, required power generation is not being achieved.

Due to the increased number of industries which needs very huge amount of water, availability has become a major problem. This, in turn affects the wildlife survival.

Public drinking water works aims to provide safe potable water to every person. To achieve this they pump raw water from various sources like river and bore wells, process the raw water and then distribute to the public through various service reservoirs present across the city. Both quantity and quality of water is very much important for public drinking water works. Powerful software and measuring instruments can help in optimization of the water supply and improving service delivery to the public.

In the present public drinking water systems, most of the data regarding production of water, usage of chemicals, efficiency of filters, yield of water, chlorination level of the supplied water, amount of clear water pumped, amount of water actually distributed to the public are done manually. There exists no communication media through which this site data could be transferred to the central place for on line controlling and decision making. Manually recording of data is prone to errors and accuracy of the data will also be low. The frequency of measuring various parameters is also very limited, as the production and distribution network is very large in size and operation, complete accountability of water cannot be achieved manually.

Water management system aims to provide quality and quantity auditing in public drinking water systems. The system logs data related to various parameters like flow rate, volume accumulated, quality assurance by measuring the dosage of chlorine in various parts of the city. The entire data is transferred to the one central place and reports are provided for further analysis and optimization, rationalization of the existing system and improving service delivery to the public.

Study Area

Vijayawada, the third largest city in the state of Andhra Pradesh after Hyderabad and Visakhapatnam, also it is one of the important commercial and transport centers of the state. Over years the city has grown as a major economic, cultural and administrative nerve centre of coastal Andhra due to its nodal location as an important railway junction of and, also because of National Highway-5 and National Highway-9 traversing the city. The city also has a few places of historic importance. The city is situated at the foot of a low range hills on the northern bank of the river Krishna with its cardinal points as 16° 31’ North latitude and 80° 37’ East longitude, around 70 km away from the coast.

Vijayawada and the surrounding areas experience high temperature. The mean daily maximum temperature is 47^0 C, while minimum is 27.7^0 C in this region. The temperature begins to rise in mid February; April and May are the hottest months. December and January are usually the months with the lowest temperatures during the year. During these two months, the mean daily maximum temperature is about 29^0 C while minimum is about 19^0 C. Cold weather period in Vijayawada is normally found in rainy seasons. The city receives an average annual rainfall of 965 mm and the build of the rainfall is received during south-west monsoon period. North-west monsoon breaks the hot spell and makes the weather bearable. South-west monsoon follows thereafter and extends till the end of September. October and November is generally marked by fine weather. The rainfall in the region generally decreased from east to west. This region receives maximum rainfall both by southwest and retreating monsoons. Two thirds of the annual rainfall is recorded during southwest monsoon. During February to June, the relative humidity in the afternoons ranges from 68-80%.

Methodology

Water is pumped from its source through pumping station or booster and then sent to water treatment plants where the treatment is carried out. The treated water is then distributed for its end usage. Present water distribution system implemented in Vijayawada which just gives the information related to the reservoir filling status and it is collected manually without any proofs. It doesn’t provide any kind of information about the flow rate, level and amount of water loss during filling and distribution.

Though the water works is trying its best to meet the drinking water requirement and its even distribution, the gap between the requirement and supply is being reported. There is scarcity of water in some pockets of the city. To understand the reservoir management, a study has been conducted on Uncounted For Water (UFW) at Elevated Service Reservoir (ELSR), Governerpet. There were 24 overflow instances found in September 2010 and 4,700 kilo liters of purified water are lost in these overflows. The total over flow throughout the year will be 56,400 kilo liters. Cost of water loss for 1 year = Rs 1, 42,692/-. Reasons for overflow are no overflow indication or alert mechanism available and valves are not closed timely.

To mitigate the above water losses and to provide truthful information of the field parameters like flow, water level, chlorine level to the authorities for better controlling of the field operations and systematic documentation of maintenance works SCADA a computerized maintenance management system is implemented. The instruments which are used to carry out SCADA process successfully are flow meter, level meter, chlorine analyzer, Intelligent Electronic Device (IED) and Front End Processor (FEP).

Flow meter:

The flow meter is used to measure the velocity of the flowing water and thereby knowing the velocity, flow can be calculated. Flow measurement is basically requires at water production plant, service reservoirs and bulk water supply lines.

The ultrasonic flow meter is designed to measure the fluid velocity of liquid within a closed type. The transducers are non-invasive, clamp-on type, which will provide benefits of non-fouling operation and easy installation. Fig. 1.2 shows ultrasonic flow meter.

The ultrasonic pulses are fired into the fluid. The time taken by the transducers to generate and receive the pulse is measured. Since the distance between the transmitter and receiver is known and time taken is known, the velocity of water can be found out. The area of the pipe is calculated by using the diameter of the pipe. From the known velocity and area, the flow of liquid can be calculated.

Level meter:

Level meter is an ultrasonic device which is used to measure the level of the water in the reservoirs during the time of filling and also distribution. Level measurement of water is required at all service reservoirs and all underground sumps.

The level monitoring system is highly developed ultrasonic level measurement system which provides non contacting level measurement or wide variety of applications in both liquids and solids. Easy calibrations and maintenances free “fit and forget” performance means that you can install the level monitoring system rapidly with confidence.

This works on the principle of timing the echo received from a measured pulse of sound transmitted in an air. Level meter consists of a transducer which acts as both transmitter and receiver. An ultrasonic wave is generated from the transducer in the downward direction and when it touches the water level it gets reflected and received by the receiver. Time delay to travel and reflect from water surface is proportional to the level of water in the reservoir. Hence the level of water in the reservoir can be found out. Fig.1.3 shows the installation of Ultrasonic level meter.

The mounting of level meter involves the selection of a suitable place for mounting as the first step. The selection should be done in such a way that suits the meter to withstand the climate conditions and also the temperature variations. This is usually installed at the top of all the service reservoirs on which the level of water is displayed.

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Also an LCD display screen which show he same numerical level is arranged at the bottom of the reservoir so that to ensure an easy and comfortable way for the operators to check the level of the water.

Chlorine analyzer:

Chlorine analyzer helps us to find the amount of chlorine present in the water. Chlorine measurement is required at water production centre, service reservoirs and areas where chlorine recharge is carried out.

A sample of water is collected and Orthotolidine reagent is added to the sample. Upon the addition the solution turns yellow in colour. The darker it turns, and more chlorine is in the water. If the chlorine level is really high, then the sample will turn brown. Fig. 1.4 illustrates installation of chlorine analyzer.

Intelligent Electronic Device (IED):

Intelligent Electronic Device (IED) provides us the data collected from various equipments and transmits the processed data to the central place. It generates various configurable alarms like, tank overflow, leakages, insufficient flow rate etc. It provides various information locally through Liquid Crystal Display (LCD) like present water level, flow rate, chlorine level and various other statuses for the local operator to optimize the daily operations. Fig.1.5 shows the Intelligent Electronic Device and Fig.1.6 shows its installation.

The data from the flow meter, level meter, chlorine analyzer is collected by transintelligent electronic device which is kept at each reservoir area. The collected data is then transmitted to Front End Processor.

IED transmits the processed data to the central device known as FEP which is front end processor. It provides controlling by means of digital outputs. The data collected by FEP is then transferred to the central monitoring unit to generator output. Fig.1.7 illustrates installation of FEP.

Central Monitoring Unit (CMU):

Central Monitoring Unit validates by sequencing the data received from all the IEDs. It is well equipped to store large amount of data for historical trends. It also updates mimic of all the IEDs with online data and provides control over field operations. It generates various user required reports, graphs,trends etc. and provides centralized monitoring of all IEDs. This helps in providing supervisory control from central place. Fig.1.8 shows Central Monitoring Unit.

The output parameters like water level, flow rate, chlorine level and various other information is displayed through Liquid crystal digital display. Hence we can get overall idea about the information of all the reservoirs at a single glance.

Description of SCADA process

Water input flow and water output flow are measured by using flow meter, water level in the tank is known by using level meter and amount of chlorine present in water can be known from chlorine analyzer. All these three instruments are placed at every reservoir and this data will be collected by the micro-processor based electronic system which is nothing but intelligent electronic device. If any of the lees exceed the maximum limit, an alarm is generated which alerts s to control the process by means of valve controls etc.

Each plant is provided with IED. Each IED is provided with a unique identification number. IED is equipped with a GSM modem. A GSM modem is a special type of modem which accepts a SIM card and operates just like a mobile phone. A GSM modem looks just like a mobile phone. At the FEP, there will be as many modem as there are number of plants. Each modem here is given the same number as given to the mode for the IED of the plant. So, the FEP collects the information from all the plant. And also each reservoir there will be IED's which are equipped with modems. From FEP dial up calls are made to the required modem number by using number key pad provided in order to get the details regarding that particular reservoir or plant. The corresponding information will be displayed on the FEP screen.

Central Monitoring Unit receives the data from FEP and communicates with local units for any missing information. It helps in sequencing the data and provides large amount of data for historical trends. It generates various required reports and graphs and provides centralized monitoring which helps in SUPERVISORY CONTROL from central place. The output may be shown on LCD monitor. The output may be shown on LCD monitor. The data is sent to the associated circle offices so as to make a better control of the water treatment and distribution.

The process involved in SCADA has been shown in the Fig. 1.9 and schematic diagram of SCADA are shown in Fig. 1.10.

Results and Discussions

The following benefits are found after implementation of SCADA.

1. Accountability of water is improved.
2. Demand management has been implemented successfully based on online information and historical data availability.
3. In time decision is possible based on automated daily, weekly and monthly reports and trends.
4. Overall plant efficiency is improved.
5. Maintenance of proper chlorine levels is done and optimization of chlorination is improved.
6. Unaccounted For Water (UFW) per each reservoir has been reduced by restricting overflows and leakages at service reservoirs.
7. Even distribution of water throughout the city is improved and met demand management with the help of historical data.
8. Quality of service is improved.
9. Man power usage has been reduced for data collection and accurate data availability for remedial measures.
10. Optimization of plant machinery and chemical usage is improved.
11. Proper maintenance schedule for water production plant has been achieved.

Conclusions

The specific conclusions drawn from the present as follows

1. Equitable distribution of water is possible by using SCADA process where as in the previous system it is not possible.

2. The standards of drinking water are maintained using SCADA process where as in the previous are not maintained as per IS code.
3. SCADA process is able to meet the demand of the population whereas it is not met by the previous system.
4. SCADA ensures the supply of water at the required point of the time whereas in the previous method there may be delays due to uncontrolled monitoring.
5. The amount of unaccounted water is less in SCADA process whereas it is more previous method.
6. By using SCADA we can increase the overall plant efficiency whereas in the previous case it is very difficult.
7. The quality of service is more in SCADA process as compared to that of previous system.
8. By using SCADA process we can generate reports and graphs with all the information such as flow rates, level, UFW whereas in the previous case we cannot know all the details.
9. Manpower required is less in the SCADA process whereas it is more in previous process.
10. The information we obtain from the SCADA process is accurate whereas it is not accurate in the previous system.
11. The duration of supply is maintained properly by using SCADA but it is not maintained in the previous method due to which losses are more.

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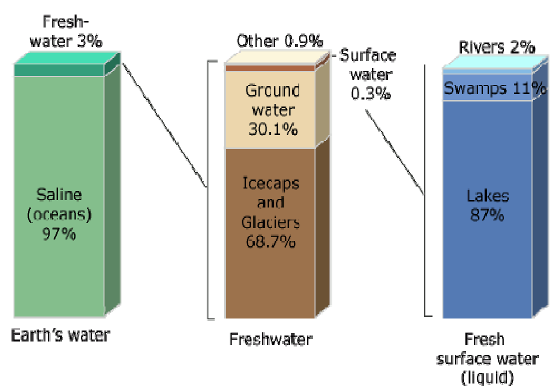

Fig. 1.1 Distribution of water in nature

Fig 1.2 Installation of flow meter

Fig. 1.3 Installation of digital level meter

Fig. 1.4 Chlorine analyzer installation

Fig. 1.5 Intelligent Electronic Device

Fig. 1.6 Intelligent Electronic Device installation

Fig. 1.7 Installation of Front End Processor

Fig. 1.8 Central Monitoring Unit

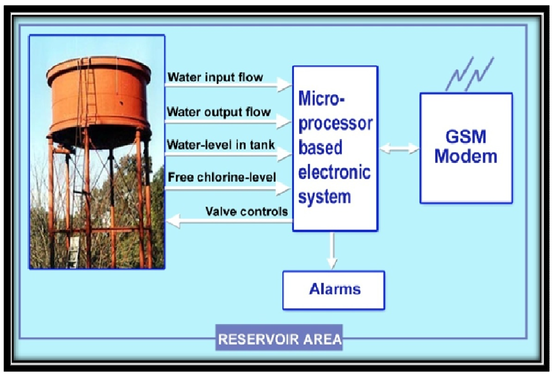

Fig. 1.9 Microprocessor based electronic system

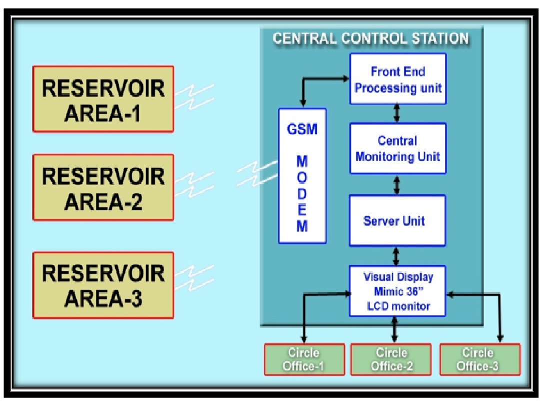

Fig. 1.10 Schematic diagram of SCADA