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Automation Of Water Distribution Plant

Ramleela Khare[1], Dr Filipe Rodrigues E Melo[2]

[1]Director Research, The MRPC Company, Hyderabad, India

[2]Assoc. Professor Commerce, St. Xavier's College Of Arts, Science & Commerce, Goa.

Abstract

Water management is a matter of high priority in India and those responsible for major operations of water distribution need to be educated in this endeavor. Automation provides optimized solution to all problems of distribution of water and maintenance of the related equipment. The paper highlights all aspects of this subject and suggests low cost new equipment and system of operation and new techniques for reliable and efficient management of this technology in totality. The entire network including a standby generator has features of SCADA (Supervisory Control and Data Acquisition) automation to control and monitor water supply and in case of power failures to maintain continuity of power supply. The scheme of automation is such that the Manager of water distribution can implement it with full understanding of the project without being dependent on contractors and suppliers.

Keywords: *Water Management, Water Network Automation, SCADA*

1. Introduction

Apart from suitable water distribution there are other problems which can be also squashed through automation. To mention a few: public is using suction pumps to suck the water directly from the home street pipelining which results in decrease in water pressure. This almost amounts to the water theft and this can be monitored through the variations in the flow given by the Sensors mounted on the channels. The system includes RTU, water flow Sensors and actuators for monitoring the entire project, control and power panels for the pump stations by industrial PLC and PC system, with network components: flow sensors, GSM modules, and pH sensors.

The PLC and RTU monitor main parameters of water distribution networks. The data of SCADA system (Supervisory Control and Data Acquisition) leads to optimization of the process of Decision Support System (DSS). Other problems are that of filtration, pumping of water, distribution of water and testing of water. Water supply comprises three different sections for distribution. First is the pumping station, which does the sucking of water from water source. The second is a filtration process which measures pH and chlorine. The third is the distribution system through which water is sent to all the municipal wards. Currently these three sections are working independently. Apart from theft, another challenge is leakage of water. To overcome the said problems an automated system has been proposed which optimizes the water distribution by reducing wastage of water as well as eliminates the theft of water. The water supply system is a part of the urban need which must assure the *continuity* of the water distribution, water quality *control* by *monitoring*.

2. Water Monitoring System

[1] The system includes pumping stations, filtering treatment, storage tanks, distribution network and central dispatch unit. The complete SCADA system structure includes central dispatch station (head quarters) with Master Computer that communicates with other PLC's or RTU's located in control panels throughout the network. The PLC(s) handle the direct control of the technical process whereas the central dispatching unit interfaces with SCADA. The data analysis and treatment is implemented by the central station.

The reduction of the operating cost as well as reduction in the water losses is achieved by the implementation of an intelligent control system. The online supervision of the water network is realized by the central dispatch operators who can remote control the actuators according to the requirements of the water flow, the pressure and flow transducers installed in booster stations throughout the network. These devices are connected to the RTU's which transmit the data to the central dispatch station to offer dynamic behavior. The RTU's provide the data acquisition facility for sensors using digital and analog modules; ensure the preliminary signal treatment and transfer wireless data communication to the dispatch unit.

3. The SCADA System

The SCADA system of the central dispatch unit manages the data communication [2] with all the RTU's and PLC's, which store the received data from measuring points and the pumping stations. It offers advanced analysis functions as well as the remote control operations of the important technical parameters. The proposed SCADA automation in water supply system consists of PLC, pH sensors, chlorine measurement system, and sensors for water theft detection, GSM module, SCADA system and motor driver.

3.1. PLC

Programmable Logic Controller is the heart of automated water supply system. PLC helps in controlling pump station motor contactors, stirrer motors, and distributed valves as well as to measure pH of the water. PLC programming is done using Ladder Diagram Language. Ladder diagram is specialized schematic language commonly used to document industrial control logic systems. It is called "ladder" diagram because it resembles a ladder with two vertical rails (supply power) and as many "rungs" (horizontal lines) as there are control circuits to represent. Stirrer motor is used for oxidation purpose at the filtration tank. These motors are turned on and off using PLC according to the requirement for purification of water. The PLC takes output from pH and chlorine sensors and values are displayed in the control room of SCADA.

The PLC receives information from (1) Water level Sensors, (2) PH Sensors, (3) GSM Receiver connected to Flow Sensors, (4) Distribution Valve

The PLC sends the signal to

(1) Pumping station Motor Relay, (2) Stirrer Motor Relay, (3) Distribution Valve, (4) Computer for SCADA.

The technical equipment installed in the pumping stations are controlled by a PLC which acquires all the hydraulic parameters (pressure, flow, reservoirs water level, free and residual chlorine, pH) and the electrical parameters for all the electric drives [1]. The pumping module implemented in the PLC includes a schedule optimization tool based on the following criteria: (i) hourly electrical energy tariffs (ii) water level detector to detect levels whenever low

or mid level PLC will turn on pump station motor. Current status of the entire sensor will be displayed on Computer. SCADA software used can display graphical and numerical user interface.

The water level in the tank is monitored through Sensors which are positioned at three locations in the tank that is near bottom, middle and the top. If the water level drops in the tank then the pumps that are programmed through SCADA will turn on. It is preferable to have one or more standby motor controlled by PLC in case of power failures in the pump station.

3.2. The Data Acquired from Remote Sites

The sensors and devices at the pumping stations near the water reservoirs transmit data to the computer installed in the water distribution control room. The computer software has a SCADA application program developed for water distribution management. The dispatch SCADA system provides daily, monthly, yearly diagrams, tables and reports related to the operator requested parameters. The system stores the acquired data in a database for later analysis [2].

3.3 Remote Water SCADA System and Features

Avoids unnecessary pumping; prevents overflow or empty running condition; improves equipment life; facilitates reduction in wear and tear by offering equal runtime of equipment; central control; data logging and analysis; single point monitoring of diversely located water schemes; reduces manpower overheads & dependency; prevents damages; offers protection against overload, SPP etc.; centralized information of water generated, facilitating accurate distribution accounting.

Tube-wells are monitored for overload conditions of equipment and subsequent temperature rise. Under an overload situation arising due to over-current, over-voltage or phase-reversal, a cut-off signal trips the power to tube-well and avoid costly damages. For more than one pump / tube-well system, where one or more are stand-by motor units, these are operated under equal run time concept meaning that the mechanical wear and tear is uniform for all driven equipments. Automatic maintenance schedules will ensure that the user is reminded of shutdown schedules for individual driven equipment under a pro-active approach to maintain these machines and prevent break down maintenance as far as possible. Most pumping stations have powerful power generators to provide back-up in case of electricity failure. Through SCADA system a continuous check can be maintained on consumption of diesel and any pilferages relating to this. The water-table recorder measures the water level and helps management to keep track of the health of the tube-well and also enables decision-making in construction of new tube-wells.

4. SCADA automation for a Water distribution plant

A Schematic Diagram (Figure 1) shows water distribution plant comprising; Reservoirs: 4nos,
Tube wells: 5nos, Sumps: 4nos, Pump houses: 5nos
Filtration: 1no, Total motors: 25nos.

SCADA Architecture Components;

Master unit (Data base server, computer): 1no
RTU -Remote Terminal Unit (Wireless): 10nos
PLC -Programmable Logistic Controller: 5nos
SCADA Software: 1no

Electronic Measuring Instruments;

S -Water level Sensors: 26nos
SR -Static Relay: 25nos

OVPR - Over Voltage Protection Relay (Energy meters): 25nos

QPMS - Quality and Pressure Monitoring System: 10nos

SP -Starter Panel: 5nos

EMV -Electronic Motor Valve: Pressure Sensors along with EMV

(sizes = 350mm, 250mm, and 150mm): 15nos

P -Panel: 10nos

IT -Isolation Transformers: 25nos

C -Computer (high configuration): 1nos

4.2. Water Distribution Plant (Figure 1)

In the proposed SCADA implementation on the water plant, the control room will be located at RL30 i.e. first section, which is a sump with capacity of *3 Lakh litres* of water with dimensions 14 x 10 x 2.2. From this *sump* the water is pumped out by 100HP 2nos water motor that runs for 20 Hours a day. This is sent to a distant sump located 500 meters away that is RL92 with capacity of 3lakh litres of water with dimensions 14 x 10 x 2.2 and from this sump the water is pumped out with 100HP, 3Nos motors which also runs for 20 hours (after 2 hours gap) from RL30 pump house. The water from RL92 is channeled to RL127 and RL146 reservoirs. The pipe line running from RL92 pump house to RL146 is approximately 2500meters in length and a diversion pipe line is running to RL 127 reservoir. In this 1st section the pipe line size is 350mm and the capacity of RL127 reservoir is 7.5 Lakh litres of water with dimensions 13 x 10 x 2.5 and RL146 reservoir is of 14 Lakhs liters with dimensions 40 x14 x 3.5.

In second section, there are 5 tube wells which have 15HP, 2Nos water motors in each tube-well. The motors are kept on for 18hrs a day, the water is pumped to filtration plant and from filtration plant it is pumped by 20HP- 2Nos water motors pump to RL80 sump which has capacity of 2lakhs litres with dimensions 14 x 10 x 2.2 and water from this sump is pumped to RL146 reservoir with 30HP, 3Nos water motors. This section has a pipe line size of 150mm and distance between RL80 & RL146 is about 500 meters.

In section three, RL146 reservoir, the water is pumped to RL197 reservoir with 60HP, 2Nos water motors. The RL197 reservoir has capacity of 13 Lakh litres with dimensions 39.7 x 15 x 2.2 and it is located at a distance of 1500 meters from RL146. Pipe size in this section is 250 mm.

In this water distribution plant, we require implementation of supervisory control & data acquisition with all the necessary electronic measuring devices such as water level sensor, pressure meters, energy meters, isolating transformers, motor protective relays, electronic motorized valve controller & wireless method of data transmission which can be operated from control room (RL30). The total distance of all the reservoir, sumps and pump houses is within 6km range from control room.

5. Conclusions

The automation of water distribution network eliminates *water wastage.* SCADA makes it possible to monitor and control the water from the control room. Control room can monitor system all the time without man power. Automation system provides continuous water distribution according to water level. Real time alarms created in SCADA would immediately indicate when any equipment fails in the water Distribution Network.

1. Efficiency: Controlling and monitoring large water network system improves as it is done from control

room where the entire data is acquired on the computer through SCADA. The quantity of water and time scheduling is achieved without interruptions.

2. Economics: Controlling and monitoring of water distribution system of large networks stretched over many kilometers is feasible and economical implementing SCADA automation system. The manual control and monitoring setup involve many personnel, delays and approximations in calculations resulting in losses.

3. Reliability: The automated system is fool-proof system where it would monitor and control all aspects of a water distribution plant and achieve time scheduling and protection from thefts and failures.

4. Decision and Standby: The Automation software is programmed for almost all situations where it would automatically take action against any mishaps. The Standby generators for power supply would also be controlled by this SCADA system when during power failures the generators would switch on and water supply would not be interrupted.

5. Control: When a system of distribution grows larger and sophisticated where distances of reservoir, supply required, machinery and multiple locations are involved, controlling such a system manually is not feasible without losing on time, efficiency, reliability and economics. Manual operations may cause bigger losses in establishments where the supply and quality of water cannot be compromised. Total control through automation overcomes the above conditions.

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GLOSSORY

- PLC monitors Flow and Current.
- Transducer measures current & Voltage.
- Flow meter measures flow.
- Protection of motor against Under Voltage, Over Voltage, Single phasing, phase reversal, short circuit and dry run, etc.
- Automatic switching of pumps as per time schedule
- Integration with valves and auto-chlorination system.
- Detailed 30 minute update at the Headquarter SCADA with daily reports, SMS to the Area supervisor in case of pump tripping.

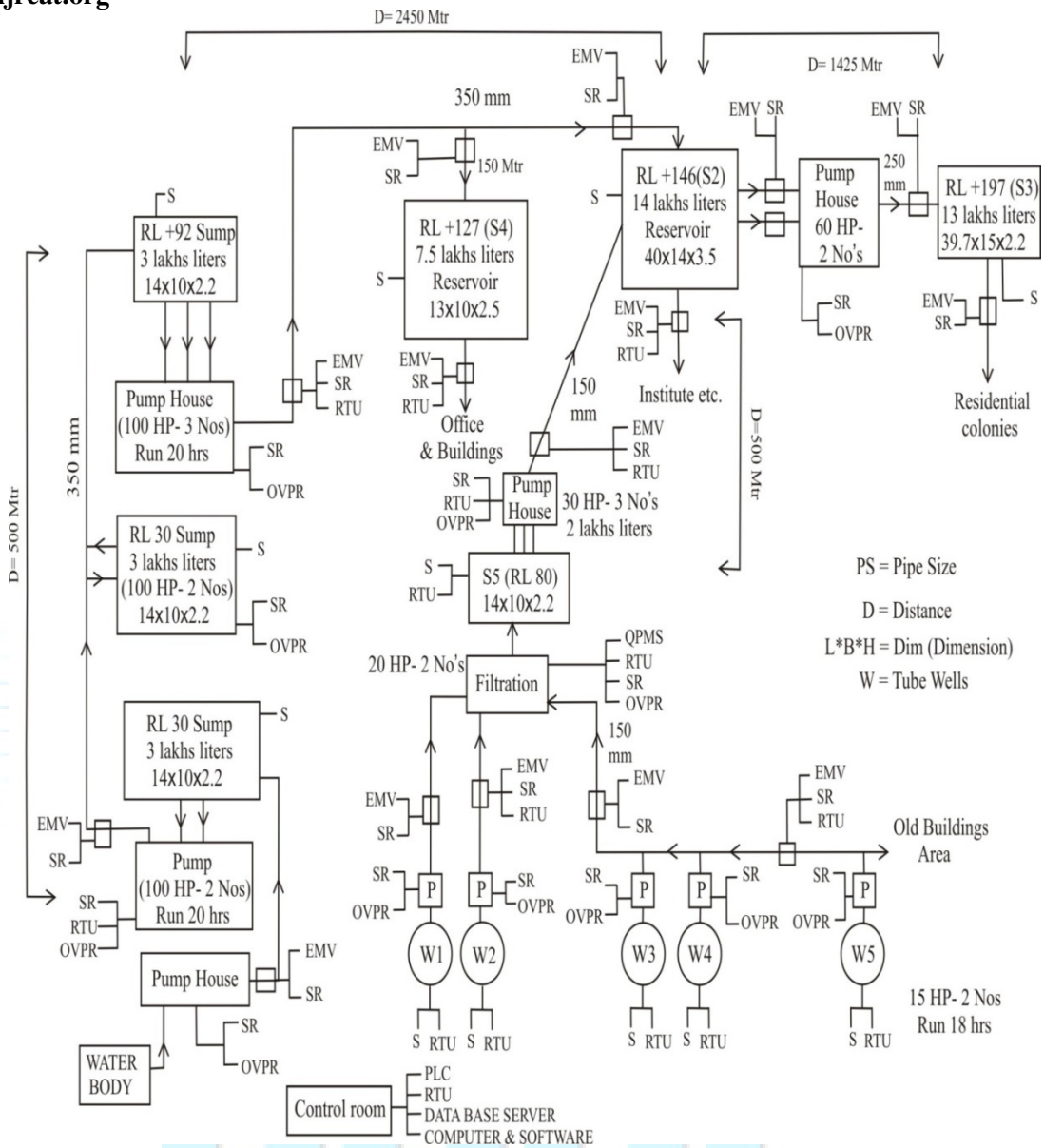

Figure1: Automation being implemented in a Water Distribution plant

SCADA Automation comprises ; Controllers, GSM/GPRS wireless network, Computers (Server), SCADA Software starter panel, Digital energy meters, Electromagnetic flow meters, Auto phase reversal, Pressure transmitters, Isolation transformer Level sensors, Automatic electrical motor relays, Actuators for running a water Pumping Plant, over-head tank, tube-wells, motors by wireless controlling system from control room.