Optimization of Water Distribution System for Improving Water Quality Standards

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***Abstract*—This paper concentrates on overcoming the drawbacks of the current water distribution system implemented by the Municipal Corporation of Greater Mumbai (MCGM). The whole network is currently under manual operation and also there is no provision for determining contamination and leakages. As a reason, of the trial and error methods used for determining contamination and leakages there is a huge loss of the available resources also leading to major inconvenience to the traffic and civilians. The MCGM is also not able to detect partial flow in pipes at high altitude areas leading to water shortages. The proposed system ensures equitable distribution of water, maintains the quality, quantity, flow and pressure of water. This also reduces traffic snarls and reduces labor dependency The main result obtained would be that, Water would be valued. The continuity of water supply can be maintained. The quality of the water supply would be maintained and contamination would be quickly detected. The grievances of the public would be quickly solved.**

Keywords—Automation in Water Distribution System; automatic valve operation; flow meter using Flex Sensor

I. INTRODUCTION

The implementation of modern solutions in an efficient functioning of the public water supply services implies the existence of proper systems based on computer technology. In this way, to obtain this information based on analysis of the technological process, there is proposed an analytical informatics system which allows an optimum drive of this process. This also ensures greater safety regarding the drinkable water distribution with the sole purpose of continuously improving the quality of the services offered to people. [1], [2]

In the making of the architectural model for the proposed system, the following principles have been considered:

- Distributed processing systems;
- Principle of autonomous and integrated working on equipment;
- Principle of mutual installation of the equipments to provide the essential working of the system;
- Principle of transparency in using and working;
- Principle of best cost/performance ratio;
- Principles destined to provide effective monitoring, control and management of real-time and extended time installations are based on the data acquisition from installations.
- Principle destined to provide the required information for analyzing the behavior in operation and working out the statistics related to the working of the existing networks, installations and equipments, for establishing the technical and economic solutions for improving the technical conditions of various installations, equipments and development strategies.

The proposed system uses a distributed architecture, in which there are two distinguished levels:

- A local area level corresponding to the water distribution stations;
- A central level corresponding to the main monitoring station

The local area level system is based on the usage of microcontroller subsystems, and the central level contains high speed computers for the supervision or operative drive of remote processes. The communication between the main monitoring, the local monitoring and control systems is done by the help of some data sending techniques, depending upon the type of the communication environment between these points (cable, optical fiber, telephone line, radio channel/wireless, GSM). The basic characteristics of this system are long time analysis and continuous analysis of the supply network, interoperability and flexibility of the system. [3], [4], [5]

II. ARCHITECTURE OF THE SYSTEM

The information tracking in real time and the range enlargement of this information, the tracking of the working parameters comparatively with the accepted limits, storing the data from the process and its continuous processing and automatic providing of the parameters settings and last but not least, providing the linking the central level system for possibilities of two-sided data and controls transmission making it necessary for large-scale introducing and distribution of the digital technologies. [6], [7].From an architectural point of view, the system is developed on distributed, network model based on the present standard level of computational technique, in order to fulfill the requests for fast processing of an important quantity of information, the requests for high viability and the necessity of open access to the informatics system.

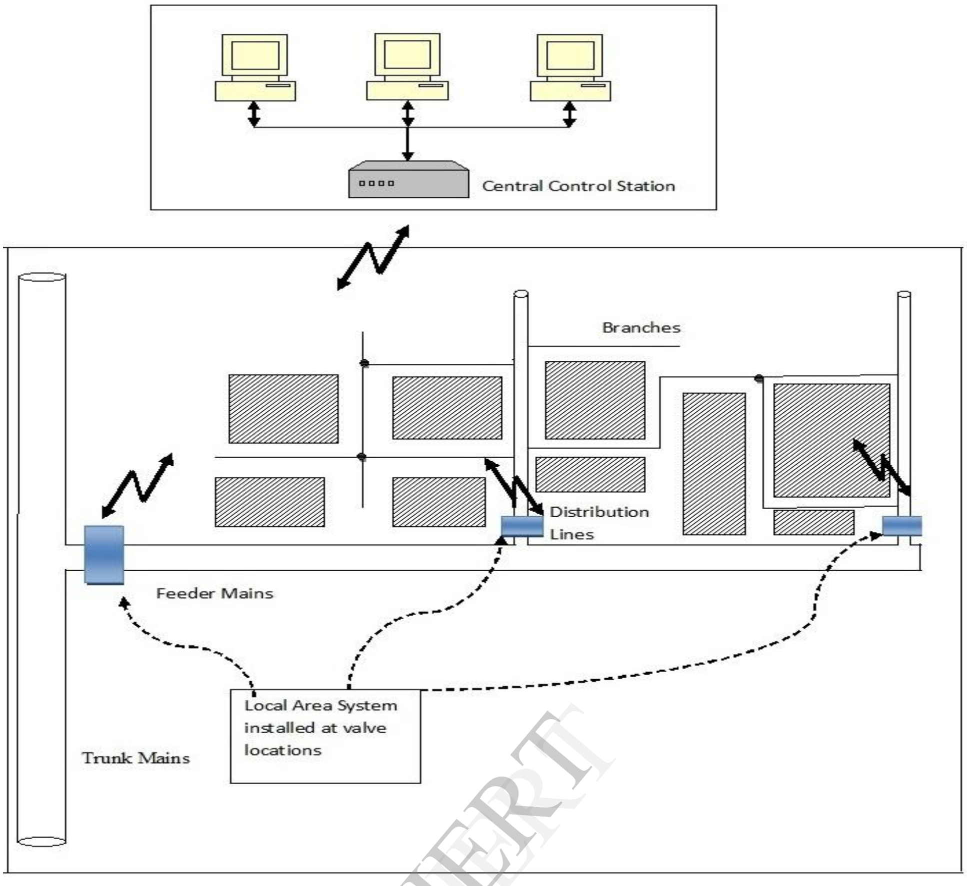

Fig. 1. Architecture of the proposed system

The proposed system uses a distributed architecture hierarchical which contains the following blocks:

A. *Local Area System*

The local area system is located at feeder and distribution level.This system comprises of the following components:

1) Transducers signals adapting block: This block realizes the bringing of the signals taken from the process through the transducers in the unified signals range compatible with the inputs of the computing system interfaces. The parameters measured are:

- pH
- Turbidity
- Flow
- Pressure.
- Dissolved Oxygen
- Salinity
- Oxidation Reduction Potential (ORP)

2) Motor Operated Valves: The Motor Operated Valves (MOV) serve to be important ingredients of the piping system.They are often referred to as on-off valves, as the motors serve the purpose of opening/closing of valves either fully or partially.An electric motor is mounted on the valve and geared to the valve stem so that when the motor operates the valve will open or close.

Fig. 2. Motor Operated Valve

Applications of Motor Operated Valves:

- Whenever a frequent operation is required.
- Valves located in remote, inaccessible or hazardous areas.

3) Local data acquisition and command equipment-Programmable Logic Controller (PLC): Each local water distribution system is provided with a data acquisition and command equipment (PLC) associated with a PC which does:

- Automation, acquisition of the specific parameters;
- Primary processes (filtering, validation of the values from the transducers, framing between limits);
- Warning in case of crossing the limits;
- Communication with the superior hierarchical level.

B. Central System

At the Water Staging level, there is the Central System which does:

- Supervising the entire system;
- Displaying the system's scheme;
- Displaying the synoptic schemes with real time supervision for each local equipment;
- Elaborating the general monitoring bulletin.

The communication between the central and the local systems is done through telephone modems or radio.

Fig. 3. Central Control Room

III. FUNCTIONING OF THE SYSTEM

The proposed system assures the acquisition from the transducers of the characteristic parameters of the functioning of the installations within the water distribution networks, the monitoring and command of the valves at the local area level, the recording of acquired data, sending the data to the central system, elaborating the stations balance sheets, sending the results to the decision factors. In this way, each local area has its own data acquisition and command local equipment which communicates with the Central System.

The local data acquisition and command equipment realizes the following functions:

- Data register in the local database;
- Generating states of warning/pre-warning;
- Communication with the superior hierarchical;
- Access to the general database within the central system for obtaining reports and statistic information on request.

In case the data acquisition unit detects the warning/pre-warning state. It generates a special message which is sent to the Central System in order to inform about the special state. The warning/pre-warning state refers to the crossing of some limits. The general and special data (warning/pre-warning) are used by the central system to generate different functioning reports or for generating of evolutions in time of some parameters requested by the user. Water quality measures, flow, level and pressure are packed in the local station at a fixed period of time. The goal of the central system is to assure the management of a station network composed of local area system and industrial programmable logic controllers. Various information collected by the local area systems are sent to the supervision centers installed in the water treatment station and to the central water management area, the place where there is supervised the entire network of the city. The information is packed in a database, making it possible to generate reports. [8],[9],[10],[11]

TABLE I. MCGM WATER QUALITY STANDARDS

MCGM Water Quality Standards			
Parameter	***Units***	***MCGM Drinking Water Standards***	***MCGM Instream Aquatic Life Standard***
Cadmium	mg/L	0.005	0.00008
Chloride	mg/L	250	230
Chromium, Dissolved Hexavalent	mg/L	-	0.011
Chromium, Dissolved Trivalent	mg/L	-	0.27253
Chromium, Total	mg/L	0.1	-
Copper, Dissolved	mg/L	1.3	0.52955
Cyanide	mg/L	0.2	0.005
Iron	mg/L	0.3	1.5
Lead, Dissolved	mg/L	0.015	2.41176
pH	s.u.	6 -8.5	6.0 - 9.0
Selenium	mg/L	0.05	0.005
Silver Hardness	mg/L	0.1	-
0-50	mg/L		0.001
51-100	mg/L		0.004
101-200	mg/L		0.012
201-400	mg/L		0.024
401-500	mg/L		0.03
501-600	mg/L		0.043
Zinc	mg/L	5	0.59138

IV. TRANSDUCERS USED AT LOCAL LEVEL SYSTEM

A. *Quanta G*

Hydrolab's Quanta G monitors up to eight different water quality parameters simultaneously. The Quanta G is equipped with a heavy duty 1.75" diameter 316 stainless steel housing (or optional PVC)for easy cleaning, minimizing the potential for cross-contamination. SDI-12 output allows the Quanta G to connect directly to third-party data loggers without custom software. Backed with Hydrolab's three-year warranty, the Quanta G is designed for many years of use in the field. It is designed for exceptional reliability and durability in a field environment.

B. *DTS-12 Turbidity Sensor*

The DTS-12 is a turbidity and temperature sensor designed specifically to deliver high accuracy results from a sensor that can be easily field-deployed and requires very little maintenance. The sensor features a 12-month recalibration interval and a built-in silicon wiper blade which helps minimize bio-fouling, helping to ensure accurate sampling from 0 to 1,600 NTU. The DTS-12 meets the quality standards of the USGS and has received their approval for in-situ turbidity monitoring.

- High-accuracy turbidity measurement
- Quick setup and deployment
- Low maintenance requirements
- Accurate even in shallow water
- Quick setup and deployment

C. *Flow and Pressure Measurement using Flex Sensors*

Flex sensors can be employed for the measurement of flow and pressure. Flex Sensor is a single-layer flexible material that changes resistance based on a deflection. As a result, it can accurately measure movement or flow in multiple directions. A layer of the material coated on a substrate produces a sensor, and the material can be applied to uneven, angled or curved surfaces. This flexible sensing technique used in a flow meter provides a direct inferential reading of flow rate without incurring any significant pressure drop. The technique does not use rotating components that could easily fail and is reasonably priced. Depending upon the flow level and the pressure of water inside the pipes, the sensor generates a particular electrical resistance. An algorithm is designed to convert this resistance value into the flow and pressure measurements. Flex sensors are placed in the pipes in vertical position. But in case of large pipes, a problem of fluttering occurs which can be avoided by using the sensor with mechanical structure.

V. RESULTS

The system result is obtained by integrating the data acquired from all transducers at local area level. These results are then compared with the predefined standards to maintain the water quality. In this way the system is designed to meet the following benchmarks with respect to water distribution networks.

TABLE II. INFORMATION OF TARGETS AND SERVICE LEVEL BENCHMARKING TO BE ACHIEVED BY IMPLEMENTATION OF THE SYSTEM

Sr No.	Service Level Benchmarking	Present Status	Expected Efficiency after Implementation of the System
1	Coverage of Water Supply Connections	99 %	100 %
2	Per Capita Supply of Water	135 liters per day per person	150 liters per day per person
3	Continuity of Water Supply	8 – 10 hours	24 x 7
4	Quality of Water Supply	95 %	100 %
5	Efficiency in redresssal of Customer Complaints	2 -3 days	Within 24 hours
6	Time required for detecting and solving problems	2 – 10 days	1 – 2 days
7	Metering of Water utilized	Present only at reservoir level	Can be known at each valve

VI. CONCLUSION

The proposed system presented in the paper is a complex control and monitoring system for the water supply parameters, implemented in urban areas.
The monitoring and command system enforces the beneficiary with a powerful working instrument which allows:

- Growth of productivity in functioning of the local stations;
- Valve command and energy consumption reduction;
- Performance levels and water quality improvements;
- Continuous functioning in supplying water to the population;
- Permanent real-time monitoring the technological parameter's state and the energy consumptions;

- User assistance in elaborating technical analysis and post analysis;
- Offering information to the decision factors for taking optimum decisions;
- Assuring informatics flows needed for management.

Through the features that it offers, the system can work interconnected with other monitoring system and also with computing systems from the network and so allowing access to information, at different divisional levels.

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