



AN INTEGRATED SYSTEM BASED ON WEB FOR REMOTE SAFETY AND CONTROL OF INDUSTRIAL PROCESSES

V.K. VASANTH¹, S.K. SANJAY KUMAR²

ASSISTANT PROFESSOR¹, PG STUDENT²

DEPARTMENT OF MECHANICAL ENGINEERING, M.E/INDUSTRIAL SAFETY ENGINEERING
K.S.R. COLLEGE OF ENGINEERING(AUTONOMOUS), TIRUCHENGODE, TAMIL NADU, INDIA.

ABSTRACT

The contributions of control systems and information technology are important in the functioning of today's world. Further, these systems have brought changes in communication modalities that have been no less profound. Combining industrial safety concepts with the powerful communication features of Internet, feasible network solutions can be designed using either wired or wireless networks. In these networks, Web based remote Safety is classified into different categories based on the research directions such as major research, Safety the process/ operations with the web enabled platform, process Safety with control features over the web platform and Safety, control as well as reporting and fault diagnosis features. The web enabled Safety and control platform have many advantages for the engineering community as well for the business community such as Safety the process and operational performance of the entire system from a remote location, providing expert support for performance optimization and minimizing the downtime between failures on the system control level or plant level. Recent research attempts that have been made in the web-based platforms for applications at different levels are in the areas of educational laboratory experimental studies, industrial applications etc., where the operations are required to be continuously monitored, controlled and fault diagnosis to be done away from plant locations. However, detailed analysis of various web-based remote Safety and control systems shows that most of the difficulties exist in architecture, data transfer, web-based graphical user interface, multiple user access, security and safety.

Keywords: Safety, World Wide Web, Supervisory Control and Data Acquisition.

1. INTRODUCTION

Today's watch word industrial safety is a combination of control systems and information technology. This is an era of information technology and it has influenced every realm of society and dramatically impacted on the traditional industry. The present industrial safety systems are categorized into three different levels I) Safety, ii) Safety and control, and iii) added features to web-based Safety and fault diagnosis both for the management level as well as the controller level. Internet has played a vital role over the past decade interfacing people and systems. The existing industrial safety field combines the features of Internet and gives feasible network solutions in terms of wired or wireless network. The Internet and the World Wide Web (WWW) have created a revolution in the way information is archived, accessed and processed. Furthermore, these systems have brought changes in communication modalities that have been no less profound. Business, commercial and societal interactions have all changed irrevocably as stated by Yang (2011). The web enabled Safety and control platform has many advantages for the engineering community as well for the business community. Safety of the process and the operational performance of the entire system away from plant is possible. Expert support for performance optimization is also quite possible and the most important issue of downtime between failures on the system controller

level or process level failure can be minimized between the plant engineers and service providing vendors over web-enabled platform. The web-based remote Safety, control and fault diagnosis is a multi-domain feature where the plant engineers and service providers are bridged together to perform better plant operation, maintenance and safety from time to time. The recent research attempts made in web-based platforms for the different levels of applications were demonstrated in the areas of educational laboratory studies of experiments, chemical – refinery and steel plant etc., where the operations are required to be continuously monitored, controlled and fault diagnosed away from plant locations.

In the past years, before the Personal Computer (PC) was widely incorporated into industrial safety systems, all the faults that occurred in industrial process were checked and dealt with by trained and experienced engineers. In order to deal with abnormal conditions and handle it in real time it is necessary to automate the measurement operations as well as to improve the operating efficiency.

In recent decades, this scenario has been dramatically changed due to the wide adaptation of industrial safety applications. A typical industrial safety system as illustrated usually made up of a physical system, transducer, device drivers and data I/O, host computer, network server and remote computer. Information technologies have rapidly developed in recent years, and they have provided sufficient technical support for building modern industrial safety system with more open architecture with respect to the previous ones. It turns out that the computerized real-time Safety analysis and automated technologies can realize the full safety of an industrial measurement system. The combination of emerging information technologies with traditional condition Safety systems allow for the continuous running status Safety for essential equipment as well as comprehensive data processing and centralized resource management. Web-based remote Safety is classified into different categories based on the research directions. Major research, Safety the process / operations with the web-enabled platform, process Safety with control features over the web platform and the next level Safety, control as well as fault diagnosis features are the present focus on the recent research issues in industrial safety.

2. OBJECTIVE

The focus of this research work is to develop a remote Safety, controlling and fault diagnosis system which is based on Supervisory Control and Data Acquisition (WEB) and Virtual Private Network (VPN). The following objectives have been adopted:

Studying the various Web-based remote Safety and control systems and different web related features such as network communication architecture, web-based user interface, communication latency and security aspects.

Developing experimental setup for remote Safety and control which mainly focuses on reliable security, multiple user accessibility and easy data transfer so as to make effective and efficient Safety.

Developing a framework and fault diagnosis system for DCS for better plant operation.

Implementing and testing the above framework in DCS and validation of the effectiveness of the system.

However, scope of the experimental work is limited to remote Safety, control and fault diagnosis using the experimental setup developed for this purpose.

3. LITERATURE SURVEY

TOMMILA ET AL (2011) discussed new ways of implementing existing functions and defined that new functionality, e.g. management of hierarchical structures and exception handling should be included in the basic control platform and engineering tools. The current 'flat' collection of application modules like loops and sequences had to be organized in a more hierarchical fashion based on process structure. Each process system is seen as an intelligent resource capable of performing different processing tasks. The interaction mechanisms between different safety activities are defined on the basis of object-oriented analysis and design and emerging international standards. A standardized distribution middleware takes care of the needs specific to the control domain. Above that, a higher-level working environment for the other system components of the control platform is needed.

Kazantzakis et al (2013) developed a Supervisory Control Data Acquisition (WEB) based remote Safety system for renewable energy systems. It is based on client / server architecture and it does not require a physical connection, e.g. through network, serial communication port or standard interface such as the IEEE-488 of the monitored system with data collection server.

YANG (2014) ET al formulated the design phase requirements of Internet-based control systems which include requirement specification, architecture design, control algorithm design, interface design, and security and safety analysis. These links result in a range of response time, resolution, reliability, and reparability depending upon the level at which the connection is made. For example, if a fast response time is required a link to the control loop level should be made. If only management information is needed, the Internet should be linked with a higher level in the information architecture such as the management level or the optimization level.

CROWLEY ET AL (2015) experimentally explored the implementation of wireless sensor network with Global system for Mobile (GSM) based communication for real-time temperature logging of seafood produce. Subsequently the network developed and applied to the Safety of whelk catches from harvest to delivery at the processing plant. The GSM communication has performed very well, especially in circumstances where problems with poor network coverage were expected to be encountered.

KIMURA AND KANDA (2015) reported remote Safety system as one component of manufacturing support system. The proposed remote Safety system can support single-night unmanned night time operations for diversified manufacturing from the operator's home as the remote site. According to the results, the remote Safety system performed quite well for providing backup of manufacturing systems during unmanned nighttime operation.

4. SYSTEM ANALYSIS

4.1 EXISTING SYSTEM

The existing system makes use of people, things, technology and security systems which turn up unreliable and cannot be trusted upon. There are certain CCTV cameras which are placed at certain locations in order to monitor flow of events at that place. The visuals from each of these CCTV cameras is projected onto a main system which requires to be monitored upon continuously hence increasing human interference. The current system also does not be trusted in places without proper lighting and places where severe power shortage occurs. In places without power backup during power cuts the entire system gets disconnected and needs to be restarted when the power supply resumes. This can be dangerous and requires continuous human intervention. Moreover, the cost maintenance of this system is high and hence this system cannot be accessible to the middle class and lower middle-class people.

4.2 PROPOSED SYSTEM

A novel real-time web-enabled platform for information Safety and fault diagnosis in a Distributed Control System with expert decision support is proposed. The on-line Safety and maintenance system is a vital tool for the operator and for the plant engineer to know the status of the distributed control system. This novel web-based expert service support maintenance has the system of integrating hardware and software which reduces the distributed control system's service maintenance. Real-time on-line diagnosis helps plant engineer to maximize the plant operation. In order to show the applicability and effectiveness of the design and implementation of web-based remote supervisory control, the information system is tested with a typical industrial process temperature control experiment setup. The implementation of industrial process control is made possible by the use of Internet, PLC controlled by PC and WEB.

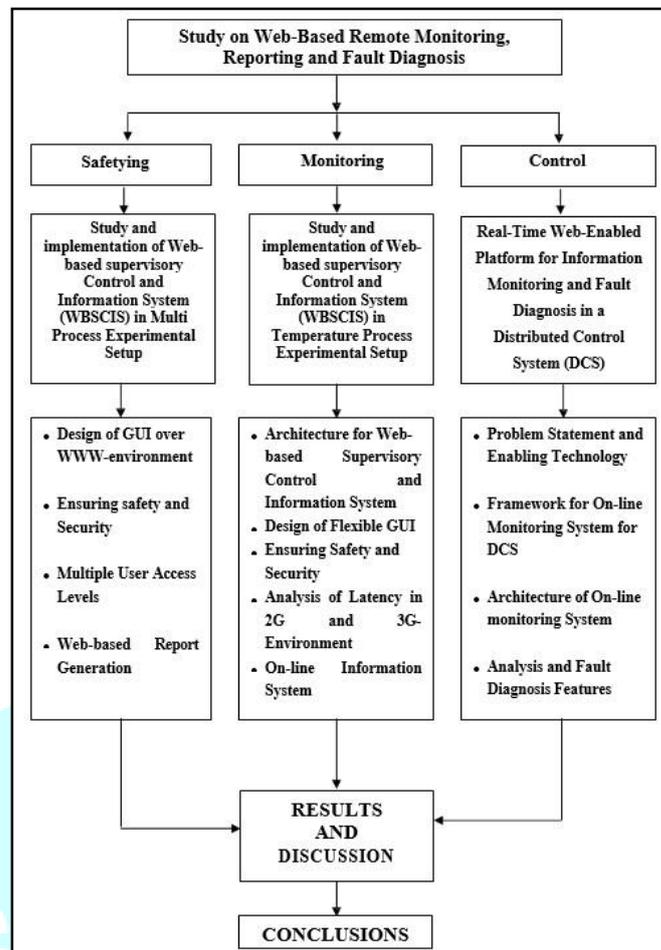


FIG :1 PROPOSED BLOCK DIAGRAM

There is an abundant use of computer technologies in almost all the fields now-a-days particularly in industrial process Safety. The on-line Safety and control of the equipment and devices is made possible by WEB and other technologies. The objective of this experimental study is to develop a multi-process experimental setup which is monitored and control from the remote client side. In this case study, two real-time process experimental setup are considered: first is a level control experimental setup and the second one is a pressure and flow control experimental setup. Here, remote Safety of the experimental setup is undertaken in two different aspects to deal with the problem of web-based GUI and network security aspect. At the first stage a web-based GUI is developed and second stage GSM-2G - mobile network via the gateway device through specified access points is configured for security reasons. In this system, the focus is on developing a system which monitors the process through different sessions, in which failure, if any, in a particular device of a particular session is recorded and an online report that is generated would be more efficient for industrial management which provides management level information. The XML report thus generated has to be automatically forwarded to the intended e-mail recipients pertaining to the engineering operator level as well management level.

5. METHODOLOGY

In this system in order to implement a remote Safety system, a real-time process experimental setup is considered. In order to achieve remote Safety, first a process experimental setup is developed and interfaced with Allen Bradley PLC -1400 series PLC.

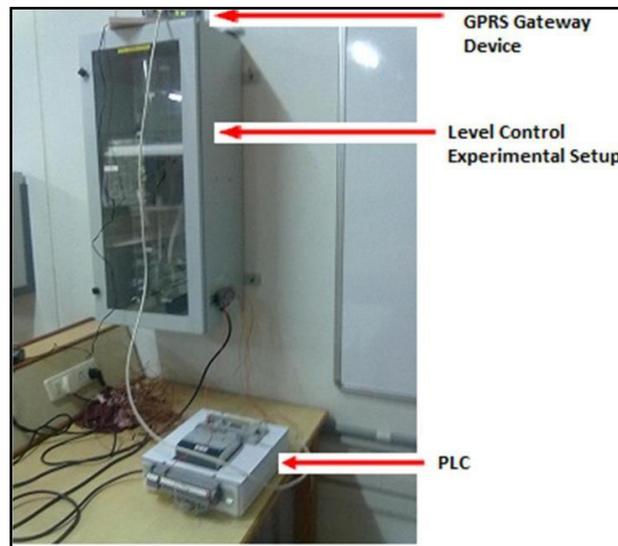


FIG: 2 LEVEL CONTROL EXPERIMENTAL SETUP WITH LCU

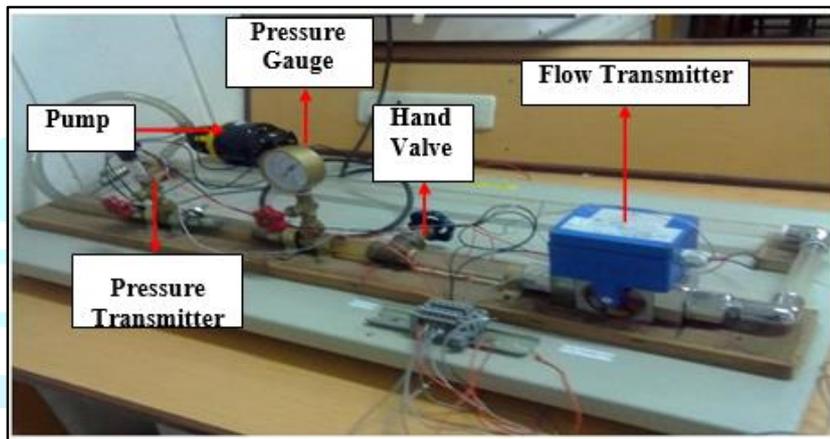


FIG:3 PRESSURE AND FLOW CONTROL EXPERIMENTAL SETUP

PLC Ladder program, which are the control logics are used for the accomplishment of real-time process Safety and control. For the Safety and control of process parameters, a high-level Safety and control system is developed using WEB so as to visualize the experimental setup as well as Safety the process parameters with control actions. A WEB program is developed which includes XML reporting that retrieves the process information and real-time parameters for Management Information System (MIS). Using this report, analysis of the real-time data is made and the diagnosis of process parameters accordingly over the Internet is achieved. The web-based remote Safety and control platform for experimental setup is developed using client/server architecture. The server side is considered to be the remote plant whose process parameters are to be remotely monitored; the process Safety system is connected with 3G gateway device which is actually used to make wireless internet communication via GPRS. In the Client side, in order to connect the remote PLC through Machine to Machine (M2M) device, a WEB program is developed. In the server side there are two nodes. One of the nodes is connected to M2M gateway device through the public IP address and the other node is connected to the LAN through a number of data channels. The M2M and GPRS gateway device are connected via secured VPN. User authentication is provided at different levels through WEB programs in order to restrict unauthorized access and to enable authorized users to access real-time parameters. Whenever a failure occurs, remote diagnosis is done over the Internet to the plant engineers. Moreover, the Management Information System (MIS) pertaining to the real-time process parameters is planned to be developed in the fourth coming stage of the project. Thus, this is a new method of web-based remote Safety industrial safety system.

5.1 SYSTEM ARCHITECTURE FOR EXPERIMENTAL IMPLEMENTATION

In order to implement such a system, it requires hardware support, WEB, mobile network and internet connection. Actually, the main intent here is to develop a system that can sense any failure in real-time process and the failure, if any in the process should be diagnosed by using analogy signal communication using PLC. This signal is sent to the WEB software via the M2M server through gateways. In order to diagnose the failure, an alarm initiation system in the form of SMS is used and that will be sent

to the intended recipient through VPN established by GSM modem. The data acquisition is done by using WEB which gets the input and output data from the PLCs and then stores them in a database. The proposed system architecture for the experimental implementation. The on-line report generation is made possible by using Real-Time Data Base (RTDB) and VBA scripts which can be interfaced to that of the WEB system. Two modes of trend analysis are possible namely on-line and off-line trends. The on-line report can be viewed in web-browser environment. Online report generation refers to experimental process parameters details in structured report format that can be viewed in web-browser environment for hour basis / days / months / years before depending upon the program that has been developed for the same. In this system, in order to implement a remote Safety system, a real-time process station is considered. Here a level Safety system and a pressure and flow Safety system developed for laboratory experiment purpose is considered. So, following are the requisites of the proposed system:

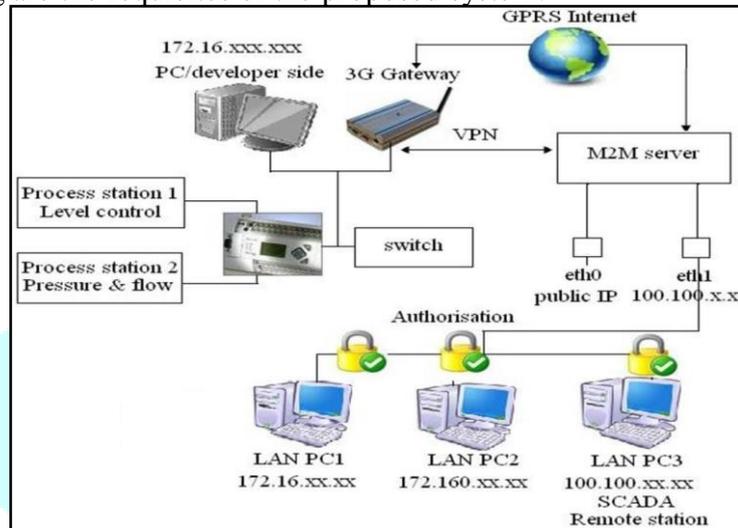


FIG:4 SYSTEM ARCHITECTURE FOR EXPERIMENTAL IMPLEMENTATION

6. IMPLEMENTATION DETAILS

6.1 HARDWARE REQUIREMENTS

- Microcontroller
- Pressure Sensor
- Gas sensor
- Relay
- LCD display
- Power Supply

6.2 SOFTWARE REQUIREMENTS

- Arduino IDE

7. RESULTS AND DISCUSSION

GPRS / INTERNET LATENCY AND DATA LOSS FROM THE NETWORK VIEW

The possible solution for reducing GPRS/Internet data transmission delay is presented in this section. Unpredictable time delay and data loss are difficult to design at any period of time. The pilot plant's local control unit i.e., PLC is connected to the gateway device which is 2G/3G enabled. The GPRS/Internet is a public and shared resource in which various users transmit data via the GPRS/Internet simultaneously. So, the VPN is implemented between experimental pilot plant and remote end user which ensures a channel for data transmission. This prevents collision of data when two or more remote users receive the data via the same route simultaneously. The real-time implementation of web based remote supervisory control and information system is carried out initially with 2G GPRS environment. The observation is carried out at the remote sites with different time duration i.e. 3 hrs., 6 hrs., 12 hrs. and 24 hrs. during different days. The remote expert user interface process and web-client trend for online analysis of the pilot plant operation. The trend observations show that the data loss at the remote site occurs in many intervals of time and are presented as circular regions. A minimum of 25 seconds to maximum of 240 seconds interval is observed during different hours of continuous remote Safety. The real-time on-line examination is also carried out with the 3G –EDGE in the remote pilot plant gateway device. In 3G environment, the data transfer rate is above 356Kbps - 2Mbps compared to maximum of 56kbps in 2G. The process parameters

on-line trend of the pilot experimental process in the 3G environment. The same procedure was carried as mentioned in the 2G environment for remote observations i.e. 3 hrs., 6 hrs., 12 hrs. and 24 hrs. testing were carried out in the experimental setup. The trend observations show that the data loss at the remote site occurs in a few intervals of time and are presented as circular regions. The data loss interval that lies between 10 seconds to 30 seconds maximum is observed, which clearly indicates the promising performance of the 3G network environment for remote Safety applications.

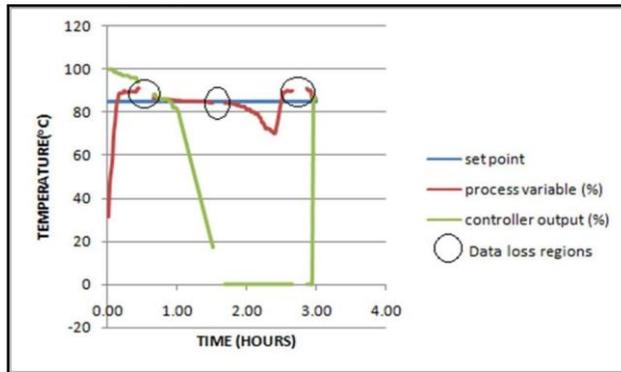


FIG :5 PROCESS TREND OF PILOT PLANT OPERATION IN 2G –GPRS NETWORK ENVIRONMENT – DURATION: 3 HRS

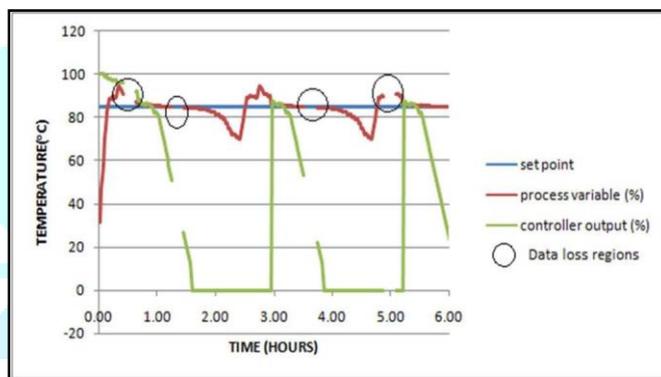


FIG :6 PROCESS TREND OF PILOT PLANT OPERATION IN 2G-NETWORK ENVIRONMENT – DURATION: 6 HRS

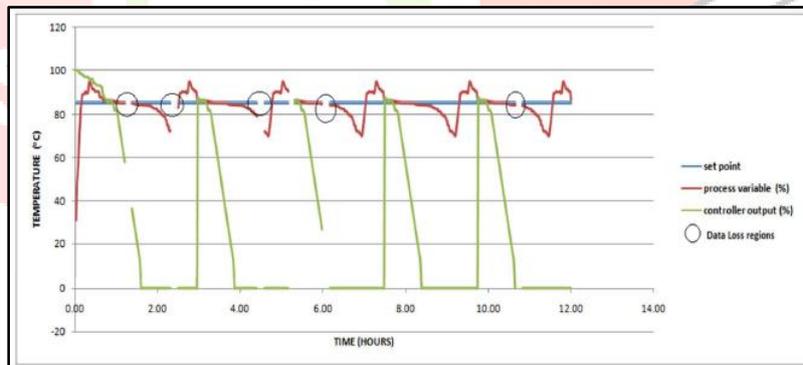


FIG :7 PROCESS TREND OF PILOT PLANT OPERATION IN 2G-NETWORK ENVIRONMENT – DURATION :12 HRS

The actual trend window over the Internet is pictured. Description of various parameters over a time period can be monitored. The report on different process information can be viewed periodically. This option is made available by using a WEB screen and it can be viewed over the Internet from any place.

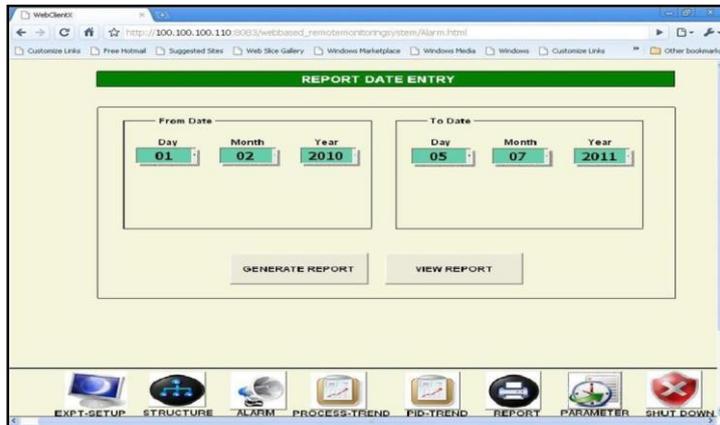


FIG :8 WEB-BASED ON-LINE REPORT OPTION FOR EXPERIMENTAL SETUP VIEWED IN THE WEB BROWSER

The web-based online report of process station appears as in the web-browser environment. The web-based information system uses the stored data to determine the performance of the pilot plant, which makes intelligent discussion regarding the periodical Safety of the entire process variables. The detail of VBA program is available in the Appendix 1. Online Safety of set point value is done and it is noted that when the process variable reaches the set point value, the controller output reaches zero. Any process parameter can be verified successfully and monitored through Internet using the same.

Date & Time	Set Point (Set-1)	Process Variable (PV-1)	Controller Output	Kp	Ti	Td
08/12/2010 08:56:26	69	61	62	31	6	2
08/12/2010 08:56:30	69	61	62	31	6	2
08/12/2010 08:56:35	69	61	62	31	6	2
08/12/2010 08:56:40	69	61	62	31	6	2
08/12/2010 08:56:45	69	61	62	31	6	2
08/12/2010 08:56:50	69	61	62	31	6	2
08/12/2010 08:56:55	69	61	62	31	6	2
08/12/2010 08:57:00	69	70	62	31	6	2
08/12/2010 08:57:05	69	70	62	31	6	2
08/12/2010 08:57:10	69	70	62	31	6	2
08/12/2010 08:57:15	69	70	62	31	6	2
08/12/2010 08:57:20	69	62	62	31	6	2
08/12/2010 08:57:25	69	62	62	31	6	2
08/12/2010 08:57:30	69	62	62	31	6	2
08/12/2010 08:57:35	69	62	62	31	6	2
08/12/2010 08:57:40	69	62	62	31	6	2
08/12/2010 08:57:45	69	62	62	31	6	2
08/12/2010 08:57:50	69	62	62	31	6	2
08/12/2010 08:57:55	69	62	62	31	6	2
08/12/2010 08:58:00	69	62	62	31	6	2
08/12/2010 08:58:05	69	62	62	31	6	2
08/12/2010 08:58:10	69	62	62	31	6	2

FIG:9 WEB-BASED ONLINE PROCESS INFORMATION REPORT VIEWED IN WEB BROWSER ENVIRONMENT



FIG :10 PHOTOGRAPH OF REAL-TIME EXPERIMENTAL PILOT PLANT AND DCS

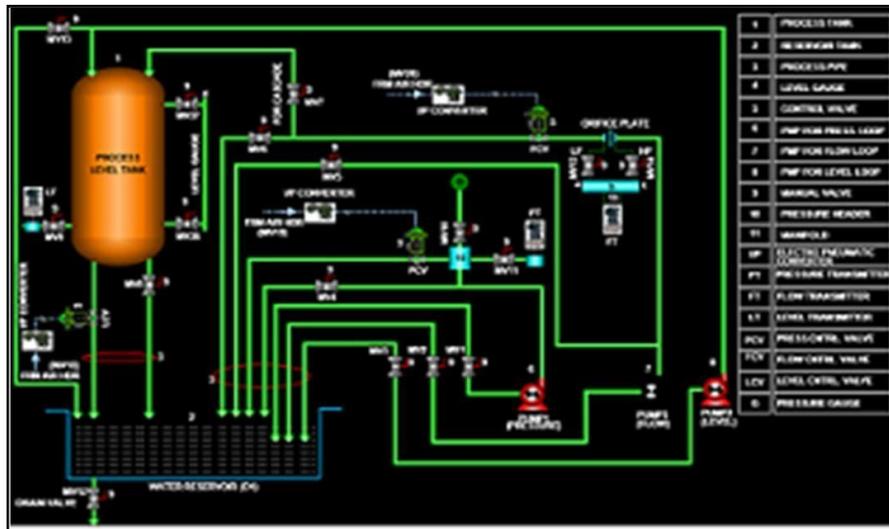


FIG:11 DCS: PILOT PLANT OVERALL PROCESS AND CONTROL SCREEN

8.CONCLUSION

We propose the above-mentioned WEB configuration will help plant engineers to provide the system details with mandatory fields to the remote support expert. The DCS operational backup file information is retrieved by Visual Basic Application (VBA) and it is formulated as a structured report for the support maintenance team. The technical implementation challenges are as follows: acquiring the required data from large volume file; interfacing with e-mail application tool; and automatic e-mail sending authentication. The periodically generated reports have to be sent automatically to the respective e-mail recipient. Since, the architecture is proposed with GPRS enabled configuration, it is difficult to use the automatic e-mail through public e-mail service application providers. At times, due to mobile operator conjunction and heavy network traffic the information report may not be sent successfully. So, it is proposed to use Outlook e-mail application to send automatic email to the respective support team.

9. REFERENCE

- 1 Alkar, A.Z. and Buhur, U. "An Internet based wireless home automation system for multifunctional devices", IEEE transactions on Consumer Electronics, Vol. 51, pp. 1169-74, 2005.
- 2 Altun, Z.G., Topaloglu, U.M., Saygin, A.V. and Bayrak, C. "Process control via Internet", Journal of Integrated Design & Process Science, Vol. 5, pp. 111-122, 2001.
- 3 Aretz, K., Haardt, M., Konhauer, W. and Mohr, W. "The future wireless communications beyond the third generation", Computer Networks, Vol. 37, pp. 83-92, 2001.
- 4 Aydogmus, Z. and Aydogmus, O. "A Web-Based Remote Access Laboratory Using SCADA", IEEE Transactions on Education, Vol. 52, No. 1, pp. 126-132, 2009.
- 5 Bae, Y.H., Lee, S.H., Kim, H.C., Lee, B.R., Jang, J. and Lee, J. "A real-time intelligent multiple fault diagnostic system", Journal of Advanced Manufacturing Technology, Vol.29, No.5, pp.590-597, 2005.
- 6 Bayindir, R. and Cetinceviz, Y. "A water pumping control system with a programmable logic controller (PLC) and industrial wireless modules for industrial plants-an experimental setup", ISA Transactions, Vol. 50, pp. 321- 328, 2011.
- 7 Bertocco, M., Ferraris, F., Offelli, C. and Parvis, M. "A client-server architecture for distributed measurement systems", IEEE Transactions on Instrumentation and Measurement, Vol. 47, No. 5, pp. 1143-1148, 1998.
- 8 Boyer, S.A. SCADA: Supervisory Control and Data Acquisition, ISA Press, 2010.
- 9 Byrne, J., Heavey, C. and Byrne, P.J. 'A review of Web-based simulation and supporting tools', Simulation Modelling Practice and Theory, Vol. 18, pp. 253-276, 2010.
- 10 Chang, W.F., Wu, W.C. and Chiu, C.W. "Development of a web- based remote load supervision and control system", Electrical Power and Energy Systems, Vol. 28, pp. 401-407, 2006.