Industrial Automation Management using SCADA

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Abstract - *Supervisory Control and Data Acquisition (SCADA) systems keep an eye on and manage vital industrial infrastructure. Ensuring the accuracy of measured values and alarm signals conveyed from the field to the SCADA control room or other remote monitoring systems and the correctness of the data displayed is imperative while commissioning or remodeling a substation. The Human Machine Interface (HMI) present in the substation shows the status and alert signals. Generally, an engineer present at the substation triggers an alert on a field device. He confirms that the local HMI is displaying the alert correctly. He then inquiries from the operator present in the control room if the same alert is displayed on the screen in the control room. This makes it a tedious task. Automating substation procedures is the goal of the proposed methodology. The principal objective of the suggested concept is to demonstrate the automation of field devices in a particular controlled system.*

Key Words: Automation, Human Machine Interface, WinCC SCADA, InTouch SCADA, Delta PLC

1. INTRODUCTION

A substation automation system is an assembly of hardware and software parts used for both local and distant electrical system monitoring and control [1]. In addition to automating certain laborious, repetitive, and mistake-prone tasks, a substation automation system also boosts the system's overall productivity and efficiency [2]. An electrical corporation has traditionally prioritized an electrical substation's high availability and continuous operation. More errors result in more customer service interruptions and lower income, which is undesirable for any business. Industrial automation has several benefits that manufacturers, and industrial operations can use to boost operational effectiveness [3]. Data from monitoring helps ensure that new automated solutions achieve their objectives like improved worker safety, increased productivity, higher quality, and better decision making.

A Supervisory Control and Data Acquisition (SCADA) system can automate the supervision task based on predefined parameters and algorithms [6]. It can also gather information from multiple IEDs in an electrical system using various communication methods [14]. Finally, it can control and monitor the IEDs using various visualization technologies [7]. Every substation has a Human Machine Interface (HMI) installed to give operators the local control and monitoring tools that are frequently required for substation configuration, commissioning, or maintenance [8]. Products for substation automation are a group of systems that offer complete automation, protection, and control over electrical substations. By offering quick communications, flexible automation, and rapid protection, these solutions are intended to increase the substation's safety and dependability [9]. They consist of a variety of gadgets, including automation controllers, power quality meters, signaling units, and more.

The aim of the proposed method is to improve systems with SCADA automation with user HMI functions to control and validate various functions of the products. Based on the above information, our objectives are as follows:

1. To design and implement automation for substation automation products.
2. To enhance the automation of an existing system integrated with SCADA.

2. LITERATURE REVIEW

The research papers referred served as a foundation for understanding how to create an HMI screen with WinCC SCADA software. As per the methodology proposed in the research papers, appropriate tag development for the screen elements to mimic the industrial plant's real-time status leads to successful programming of the intended HMI [3]. A reliable connection between the PLC and the HMI is made possible by the tagging system [5]. The manual and automatic modes of operation are availed by pushing the soft-touch controls. Without human interaction, automated mode is guaranteed by proper design [4]. In this project, the automation of the certain industrial processes is implemented with the help of PLC, SCADA and its various properties. Implementation of the process automation is better for increasing the speed of the process, as well as it provides data monitoring and storage.

3. IMPLEMENTATION

3.1 Block diagram of the proposed idea

As shown in Fig -1, the industrial substation incorporates a variety of field devices, such as Sensors, Actuators, Circuit Breakers, etc., and a group of related field devices are connected to a particular Remote Terminal Unit (RTU) [10]. The RTU serves as a gateway to transfer data between the field devices and the SCADA or vice versa. A communication network such as MODBUS, the IEC 60870-5-104 communication protocol, etc [11]. makes this data transfer possible. SCADA master contains the software program that manages the field devices based on the data received. Human Machine Interface (HMI) is used to manage the field using touch controls [12]. Turning ON or OFF the field devices, data collection, monitoring a particular parameter in the field, and checking alert signals in the field are feasible using HMI screens [13].

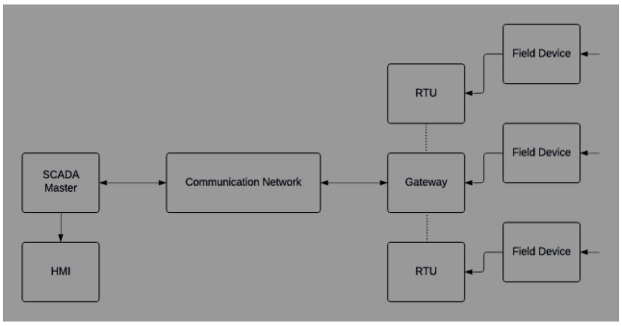

Fig -1: Block diagram for industrial automation management using SCADA.

3.2 Virtual simulations in SCADA

A simple digital system consisting of a lamp and a switch is designed as shown in Fig -2(a) and Fig -2(b). The function of this controlled system is to turn ON a lamp using a switch.

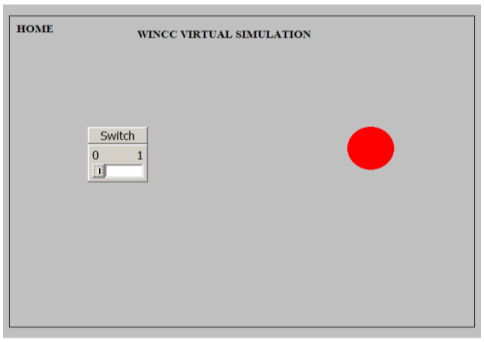

Fig -2(a): Runtime page of the virtual simulation when the value chosen on the switch is "0".

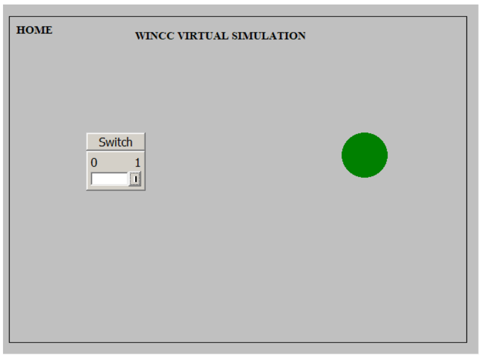

Fig -2(b): Runtime page of the virtual simulation when the value chosen on the switch is "1".

A simple analog system consisting of a slider and a bar is designed as shown in Fig -3. The function of this controlled system is to display the value selected using a slider on the bar.

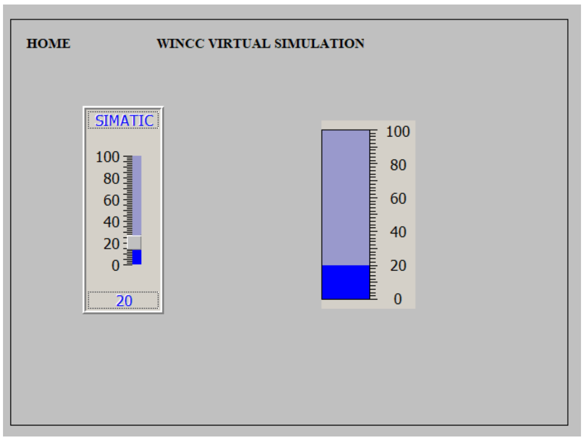

Fig -3: Runtime page of the virtual simulation when the value 20 is selected on the slider.

A simple animation is designed as shown in Fig -4, wherein a ball is moved by a certain distance with the help of a slider.

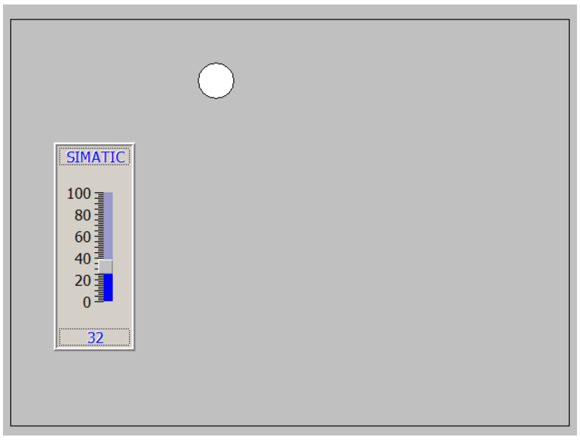

Fig -4: Runtime page of the virtual simulation when value in between 0 to 100 is selected on the slider.

An animation is designed as shown in Fig -5, wherein a container is moved a certain distance with the help of a conveyor belt using a slider. One more animation is designed wherein a container is moved up with the help of a conveyor belt using a slider as shown in Fig -6 using the visibility concept. Screen activation is designed wherein, after pressing a button, "Screen 2" gets activated from the "Home" screen as shown in Fig -7(a) and Fig -7(b).

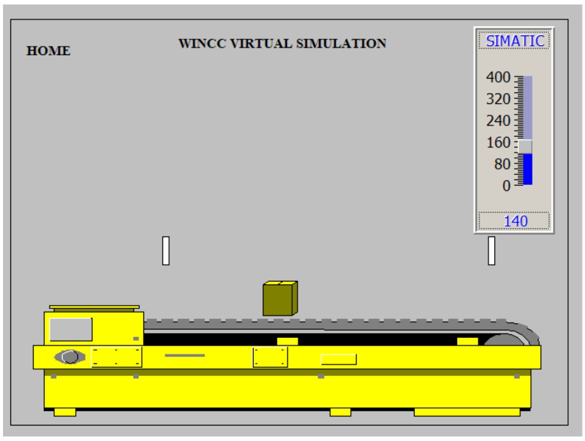

Fig -5: Runtime page of the virtual simulation when the slider is between 0 and 400.

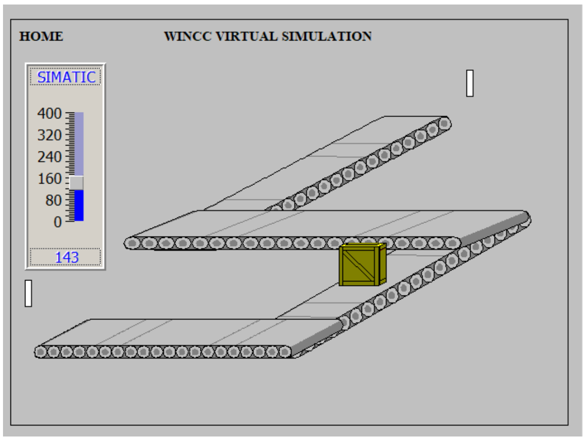

Fig -6: Runtime simulation when the slider is within the range of 101 to 200.

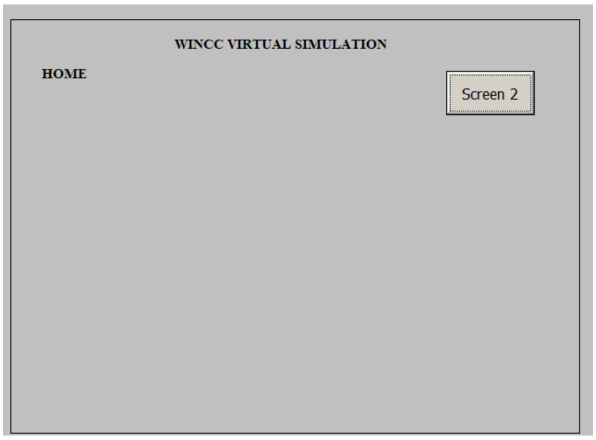

Fig -7(a): Runtime simulation showing "Home" screen.

Fig -7(b): Runtime simulation showing "Screen 2" when the button is clicked.

Real-time monitoring of a physical quantity using graphical representation can be achieved using "Trends" [15]. Two sliders have been chosen, one for the temperature and the other for the pressure. As per the level shown on the sliders, the data is shown as a plot on the graph as can be seen in Fig -8.

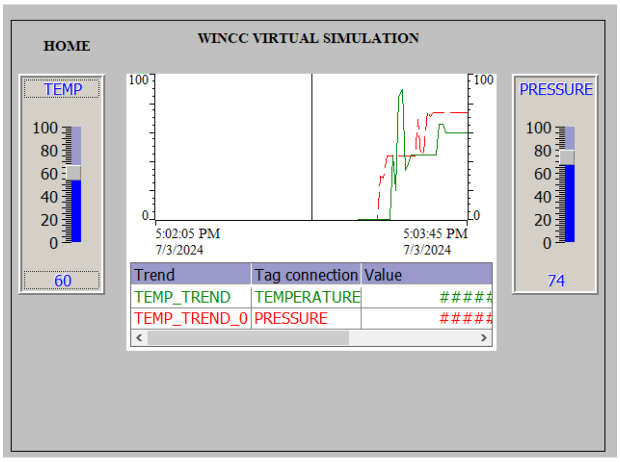

Fig -8: The temperature and pressure real-time graphical representation.

A virtual simulation is created, as shown in Fig -9, wherein a motor turns ON when the switch is turned ON, and once the motor turns ON, an alarm is shown that "The motor is ON". A simple animation is designed as shown in Fig -10(a) and Fig -10(b), wherein a ball is vanished on pressing the "VANISH" button.

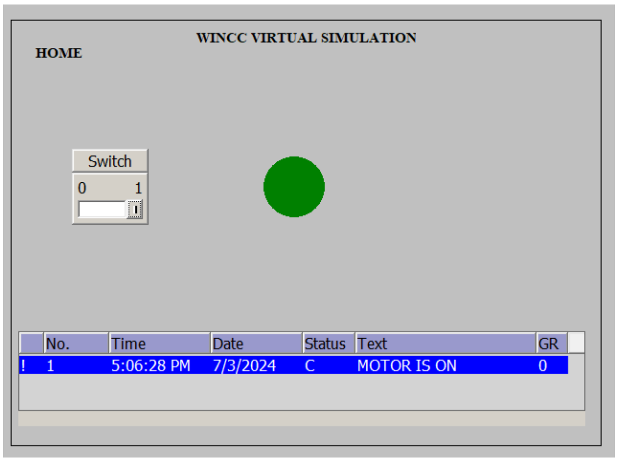

Fig -9: Runtime simulation when the switch is turned ON.

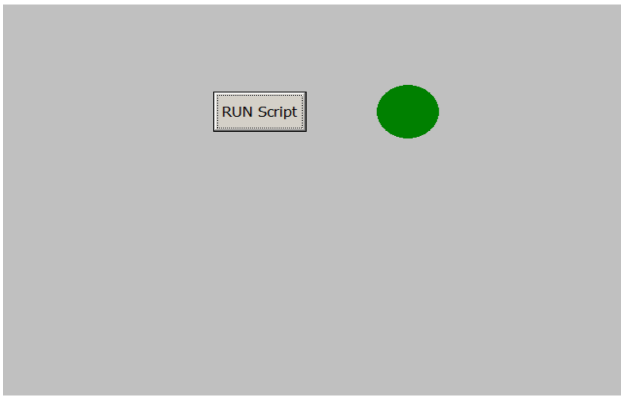

Fig -10(a): Runtime simulation when the button is yet to be pressed.

Fig -10(b): Runtime simulation when the button pressed.

3.3 Design of a heat exchanger system

A heat exchanger is a system that transfers heat from one medium to another. When the two objects are stored isolated from their surroundings in a heat-resistant box, the heat lost via the warm object is equal to the warmth received by the cold object, and the heat transfer takes place until the temperature of each object turns equal [16]. This is referred to as the principle of heat exchange. The design of the heat exchanger system has been shown in Fig -11.

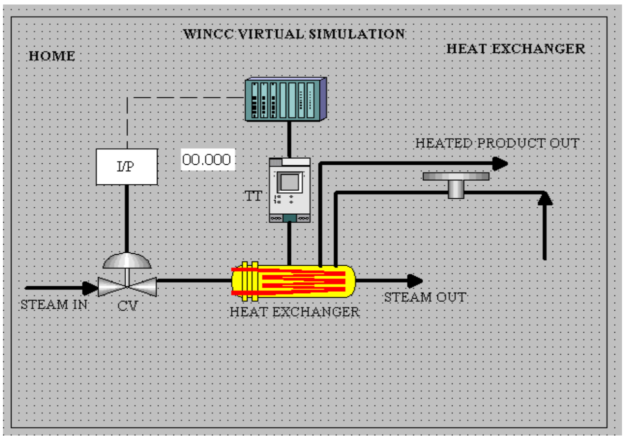

Fig -11: Design of the heat exchanger system in WinCC SCADA.

3.4 Design of a chemical reactor

A closed container wherein a chemical reaction is carried out is a chemical reactor. Industries have to make sure that the reaction takes place as efficiently as possible towards the required output, leading to the best yield. Energy input, energy disposal, the cost of the raw materials, cost of labor, and other charges are all part of the regular operational expenses [17]. The reactants and the products are usually fluids (gases or liquids). The design of the chemical reactor has been shown in Fig -12.

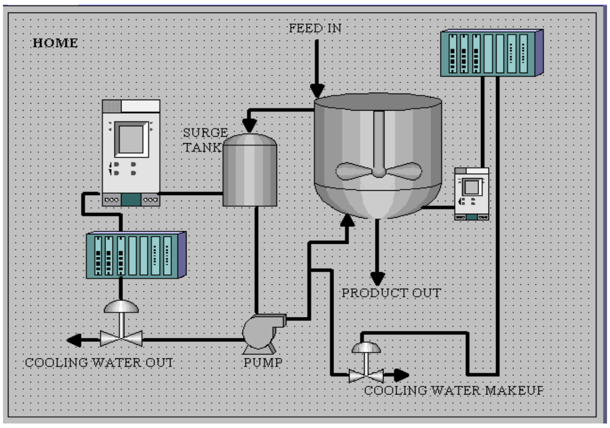

Fig -12: Design of the chemical reactor in WinCC SCADA.

3.5 Paint colour process in WinCC SCADA

A paint colour process has been designed where we can obtain the desired colour by selecting a suitable level of the red, green, and blue colours [19]. The design is shown in Fig -13(a). It possesses the following properties:

- Upon the selection of a suitable level of red, green and blue colour, and after pressing the button "Mix", the required colour is obtained, which is shown on the home screen as shown in Fig -13(b).

- The input RGB values are also displayed on the home screen as can be seen in Figure 13(b).
- An alarm is generated when the colour mixing is over and the colour is ready as shown in Figure 13(c).
- If the amount of colour in the red, green or blue tank reduces, then an error is shown that the tank is empty as shown in Figure 13(d).
- Real-time data and time are displayed on the home screen as can be seen in Figure 13(a).
- Four graphical views are used to track the amount of usage of the RGB colours as well as the level of the output colour as shown in Figure 13(e).

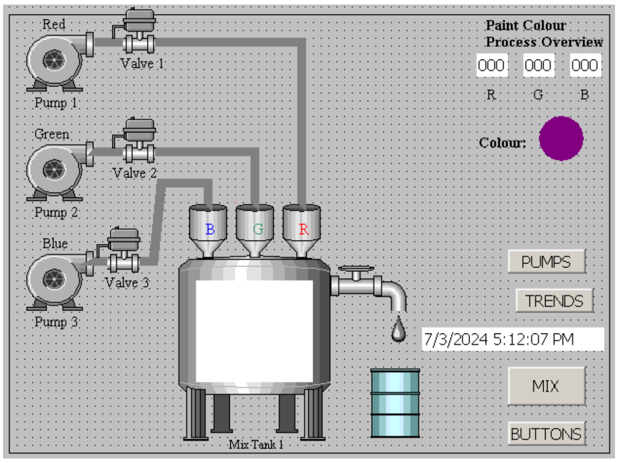

Fig -13(a): Design of the paint colour process in WinCC SCADA.

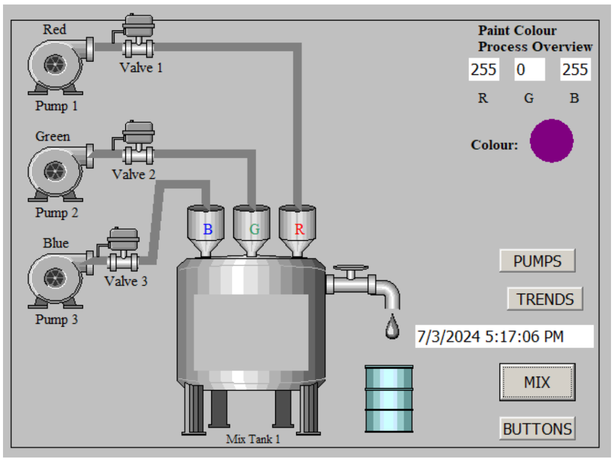

Fig -13(b): The desired colour details are shown on the home screen.

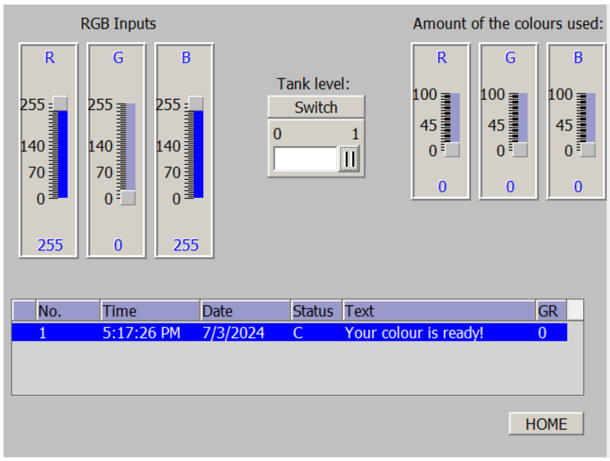

Fig -13(c): Alarm generated when the colour is ready.

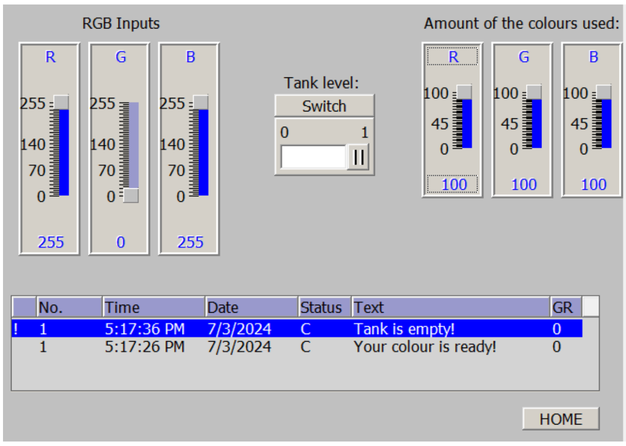

Fig -13(d): Alarm generated when the red, green or blue tank usage reaches above 85%.

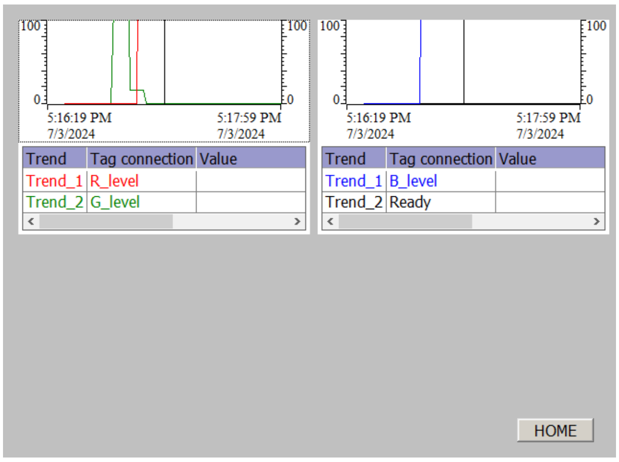

Fig -13(e): Real-time graphical representation of the amount of the RGB colour used and the colour generated.

3.6 Paint colour making process in InTouch SCADA

A paint colour making process as shown in Fig -14, has been designed wherein with the use of the three primary colours - red, green and blue, the required colour is formed. The required colour input is given using the PLC input buttons and accordingly the valves of the primary colour tanks are turned ON for a suitable amount of duration, such that the required colour is obtained [18]. Once the colour gets ready, an alarm is shown on the SCADA window.

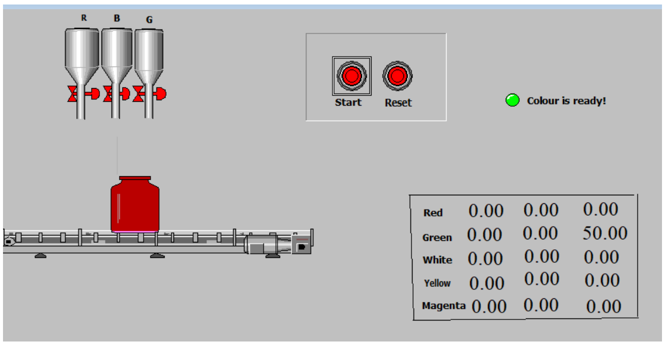

Fig -14: Paint colour making process in InTouch SCADA.

3.7 Water level monitoring system in InTouch SCADA

A system has been designed using two reservoir tanks as shown in Fig -15. One tank is on the ground and the other is an underground tank. When the user drains the water from the ground-level tank, and the water reaches its low limit sensor, the pump starts and the water from the underground reservoir starts flowing in the ground-level tank till the water level in tank reached the high-level sensor. If the underground tank water level reaches below its low-level sensor while the water is getting filled from the underground tank into the ground-level tank, then the pump automatically stops to prevent dry running of the pump [20].

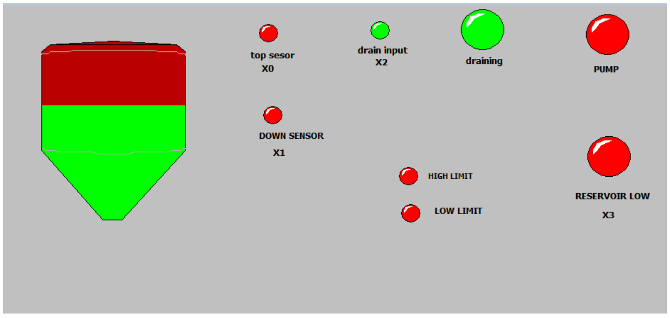

Fig -15: Water level monitoring system in InTouch SCADA.

4. CONCLUSIONS

In this research, the automation of the substation procedures have been accomplished for certain field procedures. The design of digital and analog systems, animations using a ball or a conveyor belt and a container, use of the visibility concept, screen activation, use of trends in real-time observation of the parameters, alarms and Visual Basic scripting has been accomplished in WinCC SCADA software. In addition to that, heat exchanger system, chemical reactor and paint color process has also been designed using the various properties of the WinCC SCADA software.

SCADA is a technology that gives manufacturers and industrial organizations control over machinery and operations by fusing hardware and software. Process-related data is collected by the system from various devices and equipment inside the operation, whether they are dispersed throughout multiple sites or a single facility. The data is then used by SCADA operators and supervisors to keep an eye on processes, maintain and enhance productivity, boost quality and profitability, cut down on waste, and swiftly and effectively identify issues and emergencies. SCADA systems are used in a vast variety of companies and sectors worldwide, ranging from small businesses to some of the biggest. For businesses to effectively manage, regulate, and keep an eye on physical operations taking place at one or more locations, SCADA systems are essential.

REFERENCES

[1] Dimitris Mourtzis, John Angelopoulos, Nikos Panopoulos. (2023). ”The Future of the Human-Machine Interface (HMI) in Society 5.0”. Future Internet 2023, (https://doi.org/10.3390/fi15050162).

[2] Erwin, N., Francis, H., Ofosu, R. A. (February 2014). ”Developing a Human Machine Interface (HMI) for Industrial Automated System using Siemens Simatic WinCC Flexible Advanced Software”. Journal of Engineering Trends in Computing and Information Sciences, Vol. 5, No. 2 (ISSN 2079-8407).

[3] Groumpos, P. P. (2021). ”A Critical Historical and Scientific Overview of all Industrial Revolutions”. 20th IFAC Conference on Technology, Culture, and International Stability TECIS 2021, Volume 54, Issue 13, Pages 464-471 (https://doi.org/10.1016/j.ifacol.2021.10.492).

[4] Houda, M., Zouhaira, A., Olfa, E. (February 2023). ”Human Machine Interface Design of Industrial Automated Machine using SIMATIC SCADA System”. International Journal of Industrial Engineering, 30(2), 435-450, 2023, ISSN: ISSN 1943-670X, (DOI: 10.23055/ijietap.2023.30.2.8561)

[5] Htet, H. A., Thae, T. E. (August 2019). ”Simulation and Implementation of PLC based for Nonstop Filling Process using PLCSIM and HMI”. International Journal Of Creative and Innovative Research In All Studies (IJCIRAS), Vol. 2, Issue 3 (ISSN (O) - 2581-5334).

[6] Liang Wang, Xiuting Wang. (2012). ”Research on the SCADA System Constructing Methodology Based on SOA”. 2012 International Workshop on Information and Electronics Engineering (IWIEE),

(doi:10.1016/j.proeng.2012.01.535). ETC Engg. Dept., GEC - 2023-24 Page i Industrial Automation Management using SCADA.

[7] Matei, G., Ales, J., Peter, H. (2019). "Automation of SCADA System Development". ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 2 (ISSN: 2067-3809).

[8] Mihai, I., Gheorghe-Daniel, A., Nicolae, M. (May 2009). "SCADA system for a central heating and power plant". 5th International Symposium on Applied Computational Intelligence and Informatics (SACI '09). Timisoara, Romania: (DOI:10.1109/SACI.2009.5136232).

[9] Piyush Kumar Prajapati, Lalitesh Kumar. (Novembe 2018). "Application based Study of the Architecture of a SCADA System and Operational Stages ". International Conference on Advances in Engineering Science and Management. Agra: (ISBN: 978-81-931974-0-0) T R Publication.

[10] Shahid Ali, Ruchita Dahiya. (December 2019). "Importance of Manual and Automation Testing". 9th International Conference on Advances in Computing and Information Technology (p. (DOI:10.5121/csit.2019.91719)).

[11] Anon. "Industrial Automation Solutions- Human Machine Interface", www.ti.com/general/docs/ge tliteature.tsp, 2011.

[12] Siemens AG., "PC-based Automation Plant Visualisation with WinCC Flexible and Visual Basic.NET",www.support.automation.siemens.co m/WW/view/en/, 2011.

[13] Anon., "Designing Effective Control Interface Systems", www.ewark.com/pdfs/techarticles /ea, 2012.

[14] Anon. (2011b) ,"Krono Tech Instrumentation and Control", www.kronotech.com/HMI/advantages.ht m, 2011.

[15] Kalogeraki, E.-M.; Papastergiou, S.; Mouratidi, H. and Polemi, N.: A Novel Risk Assessment Methodology for SCADA Maritime Logistics Environments. Appl. Sci., 8 (1477), 1-32, 2018.

[16] Siemens AG. SIMATIC HMI WinCC V7.4 - Getting Started. Entry ID: A5E37531782-AA, 236 pages, February 2016.

[17] Ujvarosi, A.: Evolution of SCADA systems. Bulletin of the Transilvania University of Braşov, 9(58), No. 1, 63-68, 2016.

[18] M. Elango, Shantanu L. Kulkarni, "DEVELOPMENT OF PLC BASED CONTROLLER FOR BOTTLE FILLING MACHINE", International Journal Of Innovations In Engineering Research And Technology, [ijiert] issn: 2394-3696 volume 3, issue4, apr.-2016.

[19] Tanmay Sharma1, Dhruvi Dave2 and Hinal Shah3,"Implementation of Automatic Color Mixing and Filling Using PLC & SCADA", ISSN 2278-6856Volume 6, ,Issue 3, May- June 2017.

[20] Agarwal, T. and Fatima, Z. (2002). Master Station Architecture of a SCADA System. IETE Journal of Education, 43(3): 121-126, https://doi.org/10.1080/09747338.2002.11415771.