Virtual Instrumentation System Design for a Secured Chemical Process Industry Automation

S. G. Rahul, R. Chitra, Manasa Madabhushi, M. Kavya, and Sraya

Abstract With the development and popularization of technology, virtual instruments are mostly replacing analog device gradually. The measurement and control technology plays an important role in the process of manufacturing industry and scientific research. As time advances, the conventional instruments are emerging in shortage. This study involves the development of virtual instrumentation for process industry automation. In this work, a supervisory monitoring system is developed using LabVIEW software. In today's world, the industrial applications are carried out by controlling remotely. LabVIEW is one of the useful tools for real-time monitoring and controlling of industrial systems. The system fed with having with controllers is used to perform process parameter control, and industry personals can visualize the parameters without visiting the site. Therefore, this system reduces maintenance cost and enhances easy access. Temperature and tank level are key parameters to be monitored in chemical process industries which is considered as an example in this study. Lack of control over any of them will not only affect the component and equipment but also the manpower and, therefore, ultimately resulting in equipment and life loss. Also, to the monitoring and controlling the system, this study also provides an additional security system for the users with e-mail report generation to convey the user about the parametric status.

Keywords LabVIEW · Monitor · Control · Chemical

1 Introduction

Presently, automation is one of the important and useful in many industrial applications. The main problem arises during the designation of engineering systems demanding substantial amounts of hardware circuits leading to more wiring connections [1]. At that case, it is tedious to space the system elements, and the space planning needs improvement. As the technology is improving day by day, the LabVIEW

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software made the engineering design easy, and therefore, the hardware equipment required is decreased since most of the instrumentation system can be designed using software [2]. Process parameter control in chemical industries is always a challenge when the involved process consists of some synthesis of useful and powerful liquid. Any deviation in the process variable is so hazardous leading to substantial loss to life and property [3]. Utilization for process automation and control by wireless means between the LabVIEW and base station has been tremendously growing. Studies have indicated the enhanced performance of plant and machinery without the rise in the reaction time of the function [4]. Various studies are carried out involving LabVIEW in-process monitoring and controlling, and some of the literature studies are discussed as follows. Jianying Liu et al. studied on the position control of a DC servo motor using PID control algorithms. PID controllers are designed and supported by LabVIEW program, and therefore, the real-time position control of the DC servo motor was realized by using DAQ device. All codes are developed on the LabVIEW real-time development system, then download applications to run on the real-time controller of national instruments [5]. Rohit Agrawal et al. carried out their study on temperature and humidity parameters in manufacturing plants and particularly that of electronic assemblies. They have concluded that lack of control over any of them will damage the components resulting in a loss in production. Their work proposed a system to provide remote monitoring of the temperature and humidity at various parts of the plant with the assistance of the wireless sensor network and LabVIEW software platform [6].

In this project, it is aimed to reduce the manual monitoring and control by integrating LabVIEW with the chemical process where the engineer can enable the process of the tank to be controlled at their place [7, 8]. LabVIEW being a graphical programming language, it is easy to design a control system with security-enabled features with a multiple login user to secure the plant access from the unknown users. Temperature and level are key parameters to be taken care of in chemical plants and particularly that of electronic assemblies [9]. Lack of monitoring over any of them will not only affect the components but also the method and the operators' comfort, all ultimately resulting in production loss. This work aims to provide a solution for temperature monitoring in a chemical plant, a chemical tank-level controller followed by a security access system. The study is initially implemented as a software phase due to lack of access to hardware features owing to COVID-19 conditions. The successful results of the software will be enhancing as a hardware phase in the future scope.

2 Temperature Monitoring System

As we know that the temperature is the most crucial parameter in most of the chemical industry, so monitoring the temperature is the most important. Excessive process temperature damages the entire process loop and affects the electronic system leading to hazards. Figure 1 depicts the graphical user interface of the temperature monitoring

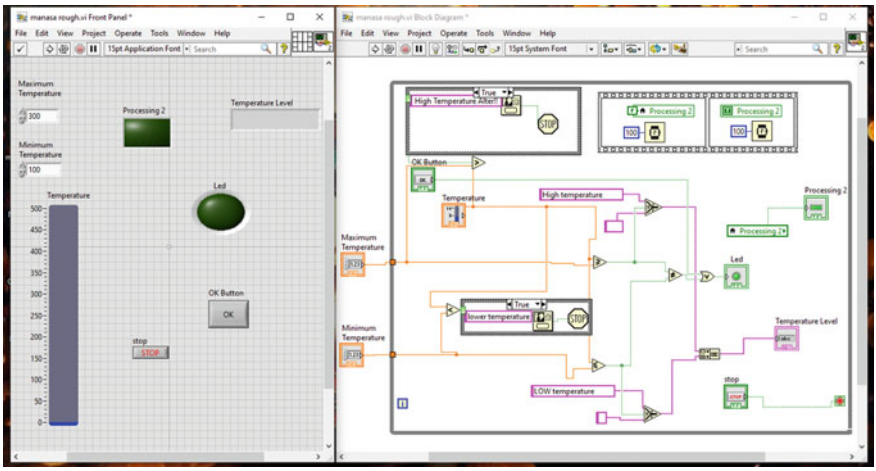

Fig. 1 GUI temperature monitoring system (left) and the block diagram logic (right)

system in the industry which helps to remotely monitor the system.

In the temperature monitoring system, a temperature indicator of certain chemical liquid is presented with the maximum and minimum temperature values. If the temperature is below the required level, a pop-up message indicates as the lower temperature, and if the temperature is greater than the required level, then the engineer gets the pop-up message as a higher temperature indication as shown in Fig. 2. The flowchart depicting in Fig. 3 presents the logic of the temperature monitoring system.

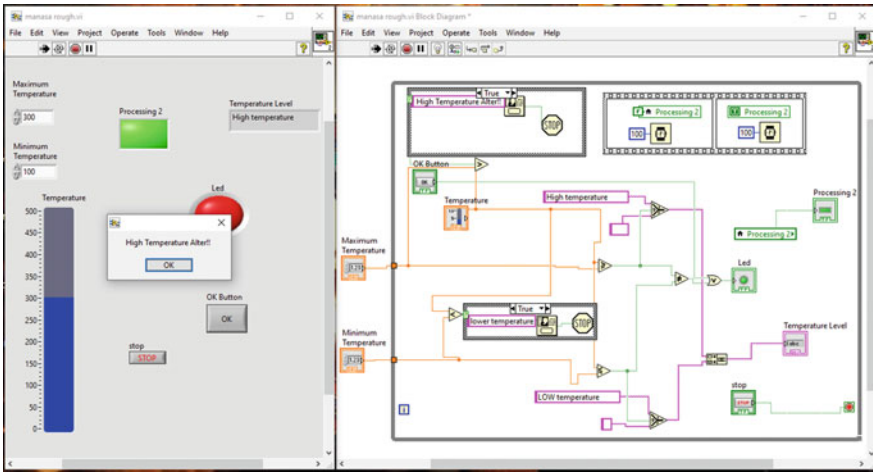

Fig. 2 GUI temperature monitoring system indicating high-temperature warning

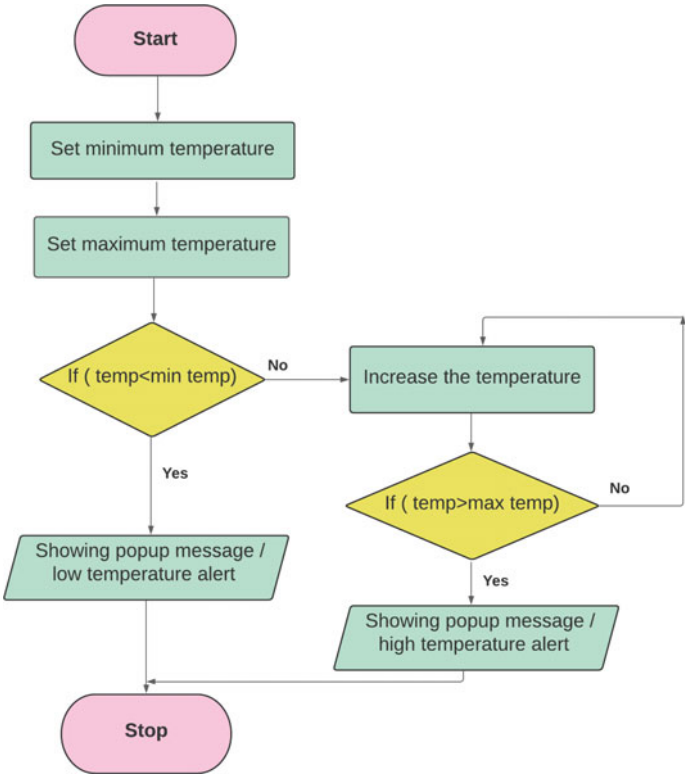

Fig. 3 Flowchart of the temperature monitoring

3 Tank-Level Controller

A tank-level control using PID controller describes the liquid-level control system deployed in many process control applications. The conventional proportional-integral-derivative (PID) controller is more reliable for single parameter control. The responses of the PID controller are verified through LabVIEW simulation [10]. From the simulation and various study results, it is observed that the PID controller gives superior performance than other controllers. Most times, the chemicals will be processed by mixing treatment within the tanks, but always the tank level must be controlled and regulated. Plant engineers need to understand the functioning of the control system. The design and analysis of conventional control systems are supported by their mathematical PID models [11].

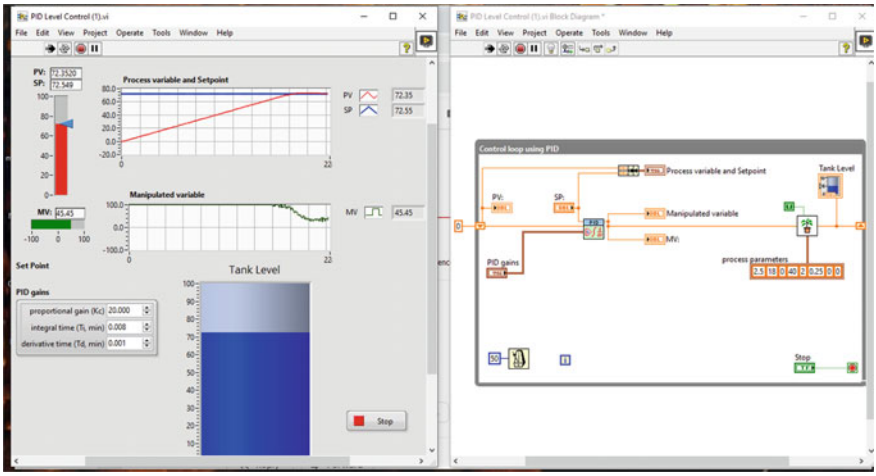

Fig. 4 PID for chemical plant-level control

3.1 Tank-Level Controller

A PID controller usually called a three-term controller is a control loop scheme which deploys a feedback unit and is preferred in industrial control systems. A PID controller continuously computes error value $e(t)$ as the difference between the desired setpoint and measured process variable (say, tank level). The PID tank-level control scheme is depicted in Fig. 4. The controller is tuned by Zeigler-Nichols tuning method, and it follows the desired setpoint.

3.2 Security Using Username and Password

Security plays a major role in the industries as it safeguards the industry from the external user who tries to hack. In this work, a security-based system which is designed using 2-D array which contains the username and password of the certain users who frequently come to the industry and in order to check whether the person's username and password are correct or not. If the login credential of the user matches, then the user gets the authentication to tank parameters which are depicted in. Else, no access is provided (Fig. 6).

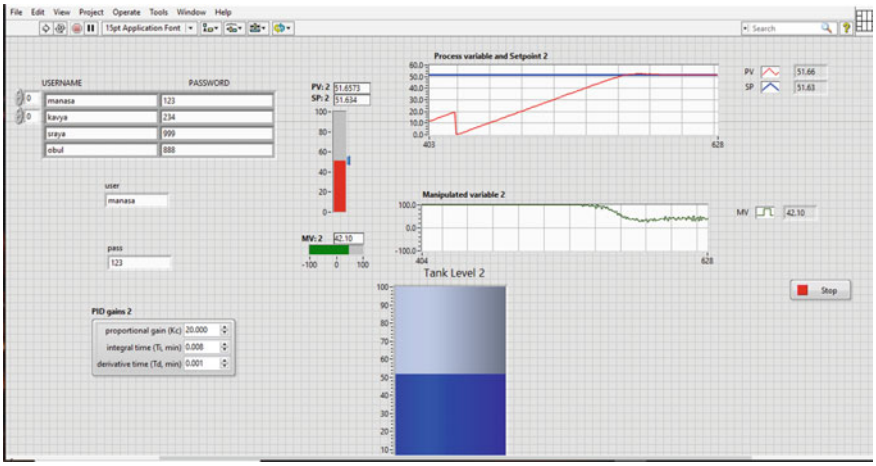

Fig. 5 Block diagram of the username and password for security

3.3 E-mail Alert Generation

When the tank level is greater than the required level, the higher authority gets the intimation regarding the high alert, and it helps the user to know that danger that takes places. The port number SMTP server to whom the e-mail is to be sent can be configured. After configuration, email reports can be viewed as shown in Figs. 6 and 7.

The logic of the concept discussed above is depicted in Fig. 8.

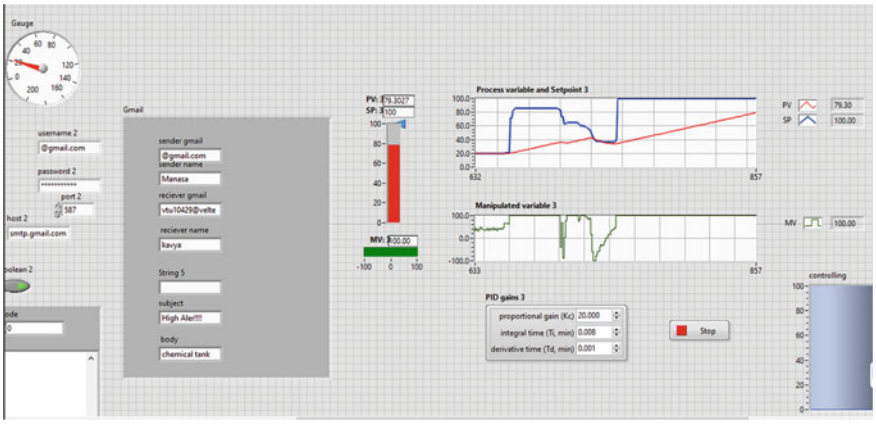

Fig. 6 Updated secured tank-level control using PID

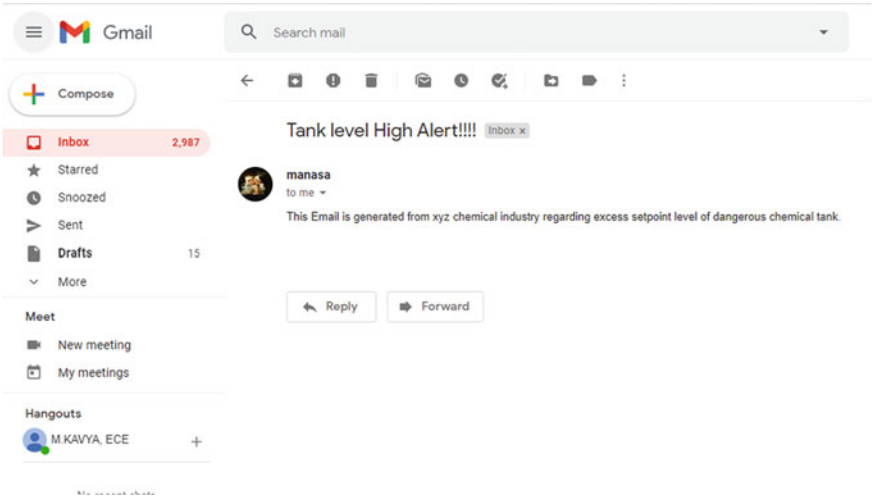

Fig. 7 E-mail alert to the industry personnel

4 Conclusions

Nowadays, most of the process industries are computerized. Earlier monitoring was done manually, and with the advancement in instrumentation system, technology has moved toward computerized supervisory monitoring and control. In this study, LabVIEW is implemented to simulate a level control of a chemical process industry and inform the industry personnel to take appropriate measures when there is any parameter over-limit which can prevent any harm to property and life. In this project, it is mainly aimed to control the level of the tank for the excess chemical and provide a security system to grant access to the user by restricting with username and password credentials thereby preventing the access to unknown users. This system also provides an email report to the safety team to notify regarding the excess and uncontrollable process parameters in the industry, so it helps engineers to and rescue from the industry hazards. This study is initially implemented as a software phase owing to hardware accessibility issues due to COVID-19, and in the future scope, it is to be developed into a hardware project.

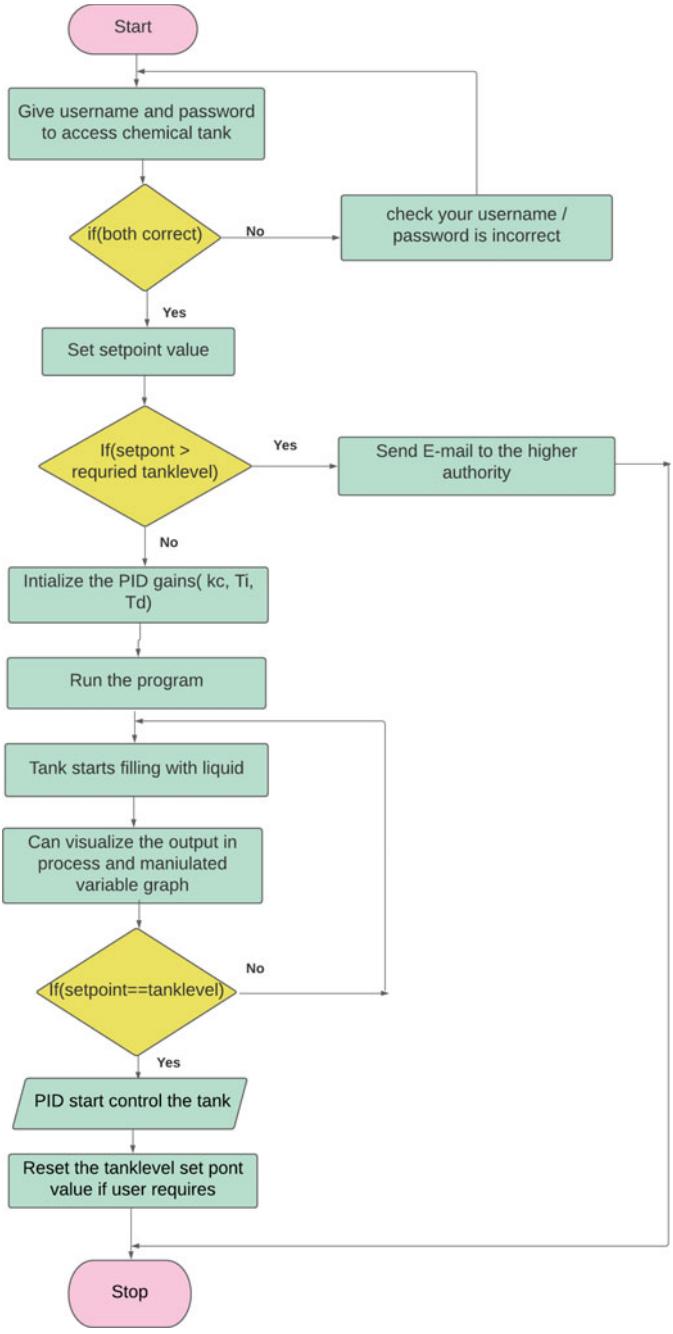

Fig. 8 Flowchart depicting secured tank-level control scheme

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