Automation of mixing tank system in STTN-BATAN mini plant using DCS Centum VP

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Abstract. Mixing tank system is main part of STTN-BATAN mini plant which functions to mix two liquid materials from tank 1 and tank 2 into tank 3. At present, process in mixing tank system has not fully worked automatically. Where, operator must be operated one by one for the process sequence. This results in the mixing process become less homogeneous. The purpose of this research is to build an automation of mixing tank system in STTN-BATAN mini plant using DCS Centum VP software to get better homogeneous. This research began with the creation of new project in Centum VP software, creating HMI displays, DCS programming, and automation testing in STTN-BATAN mini plant. Before optimization, it was shown that the average excess fluid from tank-1 to tank-3 is 6.252 mmH₂O, from tank-2 to tank-3 is 5.272 mmH₂O. After optimization, better results are obtained. It was shown that the average excess liquid from tank-1 to tank-3 is 1.178 mmH₂O, from tank-2 to tank-3 is 1.33 mmH₂O.

1. Introduction

Mixing process is random distribution of materials, wherein one ingredient spreads into another material and vice versa, while the materials are previously separated in two or more phases which eventually form a more uniform (homogeneous) result [1].

Figure 1. Mini plant of STTN-BATAN.
DCS is a system that consists of various functions that are used to control various process variables and process unit operations into controllers that are centralized in the control room with various controlling, monitoring and optimization functions.

STTN-BATAN provides a DCS (Distributed Control System) learning laboratory [2] [3] which is equipped with a mini plant to simulate process in industry. The process simulated in mini plant is the process of mixing 2 pieces of liquid material which is controlled using DCS. At present, the system in the STTN-BATAN mini plant has not fully worked automatically. Where, operator must be operated one by one for the process sequence. This results in the mixing process become less homogeneous. From the description above, it is necessary to build automation of mixing tank system in STTN-BATAN mini plant so that the mixing results are more homogeneous.

2. Research Methods

2.1. Designing System
Designing system include of identification DCS mini plant architectural and block diagram of level control on tank-1, and tank-2. Tank-3 only used to collect liquid from tank-1 and tank-2. The mixing tank system has P&ID as shown in Figure 2. This system consists of 6 transmitters, 3 pumps, and 3 control valves.

![Figure 2. P&ID of mixing tank system.](image)

In mixing tank system, parameter will be controlled are level parameters in tank-1, and tank-2. Block diagram of level control in tank-1 and tank-2 is same, which is shown in Figure 3.

![Figure 3. Block diagram of level control in tank-1 and tank-2.](image)

Level control in tank-1, and tank-2 used Direct action control, where the MV (Manipulated Value) will increase if PV (Proccess Value) > SV (Set Value). In this control, the input value (setpoint) will be corrected to the PV value (Process Value) of the transmitter level. This correction value will be forwarded to the PID controller which will then send a signal to the pump to increase the pump's rpm value. The pump rpm value will affect the tank level in tank-1 or tank-2. The water level value measured by the transmitter level will be feedback again so that the stability of the control system is obtained.
2.2. Creating Project on Centum VP
Project of mixing system automation used Centum VP V.5.02 software [4] [5]. Creating a project on Centum VP consists of several stages including registration of project details, FCS registration, HIS registration, addition of nodes, and registration of input / output modules. The FCS used in this study has the AFV10D type. The list of input / output modules used is shown in Table 1.

Table 1. List of Input / Output Modules

| Slot | IOM Type  | Number of Channel | Description           |
|------|-----------|-------------------|-----------------------|
| 5    | AAI143-H53| 16                | Analog input module   |
| 6    | AAI543-H53| 16                | Analog output module  |
| 7    | ADV151-P00| 32                | Digital input module  |
| 8    | ADV551-P00| 32                | Digital output module |

2.3. Creating HMI and Programming DCS Centum VP
Creating HMI (Human Machine Interface) used tool called graphic builder and based on p&cid of the mixing tank system. In this project, two windows are made, the "main" window and the "settings" window. The "main" window is a display of the HMI mixing tank system, and the "setting" window is to enter the desired values.

Control Drawing is tool in Centum VP that used to create a program. In this research, 2 main programs have been created. There are 2 filling programs from tank-1 and tank-2 to tank-3, which are alternately and simultaneously. This is help operator to choose filling process alternately or simultaneously.
Flowchart of tank-3 filling program alternately, it is shown in Figure 4.

Figure 4. Flowchart of tank-3 filling program alternately.
For flowchart of tank-3 filling program simultaneously, shown in Figure 5.

![Flowchart of tank-3 filling program simultaneously](image)

**Figure 5.** Flowchart of tank-3 filling program simultaneously.

2.4. **Testing Automation System in STTN-BATAN Mini Plant**

Start-up testing is to observe time required and error/excess liquid before and after optimization from tank 1 and tank 2 to tank 3. Response time testing for level control is to observe settling time and steady state error [6] [7] used default PID mode (Kp=100; Ki=20; Kd=0) which will then be compared with PID variation values.

3. **Result And Discussion**

Display HMI for the settings window is used to input values before it is executed. Display HMI for main window is main HMI that describes real condition of mini plant. Automation of mixing tank system is executed by pressing start button in main HMI.
In main HMI, There are 2 graphic of response time to look at flow and level. Actual value will follow to set value, shown in Figure 8 and Figure 9. Level control in tank-1 and tank-2 used Kp=100; ki=20; and Kd=0 (PID default).
From response time LIC01 and LIC02, the first liquid level condition is 600 mmH₂O and the SV is 500 mmH₂O. From graphic response time have shown that PV toward to SV, but still have undershoot. Data of automation system before optimization from tank-1 and tank-2 to tank-3 are shown in Table 2.

Table 2. Testing of tank-1 and tank-2 before optimization

| No. | Liquid Level (mmH₂O) | Time Required (minutes) |
|-----|----------------------|-------------------------|
|     | Tank-1               | Tank-2                  | Tank-1 to Tank-3 | Tank-2 to Tank-3 |
| 1   | 600.37               | 599.68                  | -                | -                |
| 2   | 493.80               | 493.94                  | 01:57.26         | 01:49.00         |
| 3   | 387.71               | 389.08                  | 01:56.72         | 01:50.09         |
| 4   | 281.95               | 283.69                  | 01:56.05         | 01:50.82         |
| 5   | 175.26               | 178.80                  | 01:56.39         | 01:49.90         |
| 6   | 69.11                | 73.32                   | 01:57.02         | 01:48.97         |
|     |                      |                         |Average Time =    |                   |
|     |                      |                         | 01:56.69         | 01:49.75         |

When the liquid level will be poured from each tank is 100 mmH₂O, the average excess liquid from tank-1 is 6.252 mmH₂O, while for the average excess liquid from tank-2 is 5.272 mmH₂O. This difference in excess fluid can be caused by differences in pipe length. The pipe length from tank-1 to tank-3 is 472 cm, while the pipe length from tank-2 to tank-3 is 680 cm. When the pipe length is longer, there will be less flow of liquid entering tank-3.

Data of automation system after optimization from tank-1 and tank-2 to tank-3 are shown in Table 3.

Table 3. Testing of tank-1 and tank-2 after optimization

| No. | Liquid Level (mmH₂O) | Time Required (minutes) |
|-----|----------------------|-------------------------|
|     | Tank-1               | Tank-2                  | Tank-1 to Tank-3 | Tank-2 to Tank-3 |
| 1   | 601.07               | 601.72                  | -                | -                |
| 2   | 498.81               | 499.55                  | 02:02.06         | 01:50.27         |
| 3   | 397.51               | 398.27                  | 02:01.73         | 01:51.24         |
| 4   | 296.35               | 297.06                  | 02:02.35         | 01:51.82         |
| 5   | 195.58               | 196.80                  | 02:01.39         | 01:52.10         |
| 6   | 95.18                | 95.07                   | 02:02.70         | 01:52.25         |
|     |                      |                         |Average Time      |                   |
|     |                      |                         | 02:02.46         | 01:51.54         |
When the liquid level will be poured from tank is 100 mmH\textsubscript{2}O, the average excess liquid from tank-1 is 1.178 mmH\textsubscript{2}O, and for the average excess liquid from tank-2 is 1.33 mmH\textsubscript{2}O. This shows better results, but empirical optimization cannot be used if the desired liquid level is less than 100 mmH\textsubscript{2}O due to technical matters in the field.

4. Conclusion
a. Automation of mixing tank system at STTN-BATAN mini plant has been built, with the level control in tank-1 and tank-2 used for filling process.
b. Before optimization, the actual value from tank-1 is 106.252 mmH\textsubscript{2}O and the actual value from tank-2 is 105.272 mmH\textsubscript{2}O.
c. After optimization, the results are better than before. The actual value from tank-1 is 101.178 mmH\textsubscript{2}O and the actual value from tank-2 is 101.33 mmH\textsubscript{2}O.

5. References
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