

A SCADA System in a Construction Chemicals Manufacturing Plant

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Abstract

Industrial automation systems have been securing their position in the sector day by day. PLC-SCADA systems are frequently used in various fields of industry as they have many advantages like cost reducing solutions, standard product output, minimized error rate, availability of receiving real-time statistical and instantaneous data, operation efficiency and automatic control.

In this study a medium sized construction chemical plant is monitored with SCADA system and its automatic/manual control is provide by PLC command system through SDACA. SCADA program used is Reliance Design 4 and PLC program is ABB Control Builder Plus. Computer communication is through Ethernet. The number of total tag used in the system is 68.

This study can be divided into 3 sections. In the first section general information on PLC, its definition, history, structure and programming languages is provided. In the second section SCADA definition, its advantages and areas of usage and structure were our focus in general. In the third and final section general information on construction chemical plants, detailed information on the software and hardware used in the study and how the system works can be found step by step.

As a result with the automation system obtained, the amount of product produced in an hour and a daily slice of the facility, the amount of electricity consumed and number of workers in the facility has been compared with the predicted values for the system having no automation.

Keywords: PLC, SCADA, Construction Chemicals

1. Introduction

The need for qualified, faultless, and much cheaper production which is required by the current economy has increased the pace of plants' transmission to the automation practices. PLC and SCADA systems are the most commonly used automation systems. All the sectors in industry benefit from automation.

Therefore, the pace and quality of the operation and production increases while the number of industrial and occupational accidents decreases.

The addition of SCADA to the automation systems provides both the ease of use and the opportunity of being able to monitor all the processing and operation courses on the screen.

A control system within the PLC and SCADA systems is a provision to complete the automation; however, it would not be enough by itself. Another significant point here is the correct selection and analysis of field elements. In other words, it is important that on what logical basis that a level measuring sensor will take data and it is also important to ensure the use of this sensor based on needs or the information on the range of the data transferred from a hydraulic pump is also significant.

In this paper, the design and implementation of a SCADA system for construction chemicals manufacturing plant. The composition of construction chemicals is an important issue for the quality of the end product. The sensitive rates of materials to be added to the mixture can not be repeated for each manufacturing operation all the time with traditional manual mixing methods. Therefore, the quality of the end product becomes different for each operation. The construction sector in Turkey developed significantly in the last 25 years. The sector demands high quality chemicals with certain mixture. The quality of the products can be sustained by automation systems which is independent of the operator.

The construction chemical companies in Turkey generally use traditional manual methods to get the end product. The system proposed in this study is one of the first SCADA systems applied in the construction chemicals industry.

1.1. SCADA

The term 'SCADA' is the abbreviation for "Supervisory Control And Data Acquisition". SCADA systems have a master terminal unit, field unit, communication system and a SCADA software. This system is comprised of the following steps:

- Data collection
- Transfer of the collected data to a central system
- Carrying out the necessary analysis and calculations
- Transfer of the information gathered to the screens used by operators

SCADA system is used so as to monitor field equipments or facilities and controls are enabled through automatic commands or commands received from operators. [1,2]

1.2. Programmable logic controller (PLC)

Programmable Logic Controller (PLC) is a microcomputer system which processes the information received from the sensors in line with the program provided and transmits the results to working elements. It was developed in order to overcome negative aspects of relay control systems. PLC was developed in time and its areas of usage were broadened with various industrial control purposes such as sequence control, movement control (linear and rotary motion control), process control (temperature, pressure, humidity, velocity), data management (data collection, monitoring and reporting about the machine or process). [3,4]

2. Construction Chemicals Manufacturing Plant

Construction chemicals sector, has two main product groups. The first group is comprised of filling-additive products which are used for cement, concrete and ready-mixed concrete production. These groups of products are used to overcome problems related to transfer, processing and preservation of concrete under various conditions and to improve strength and durability of the construction. The second group is comprised of filling and adhesive materials which are used for ceramic tile, tile, waterproofing and floor coatings. [5]

3. Automation of Construction Chemicals Manufacturing Plant

3.1. PLC

ABB brand was chosen to be used as PLC. "ABB Control Builder Plus" was chosen as physical design programme whereas "ABB CodeSYS" was decided to be used as PLC software programme. Programming language was written in the logic of "ST" and "CFC".
The appropriate PLC is selected considering the number of motors, valves and sensors in the plant, the number and types of digital and analogue input and outputs to be used in the system, which depend on the selected types of motors, valves and sensors, and PLC voltage and storage requirements as well as telecommunication standards.
Following the identification of all these needs, the following PLC was selected and used for this study and is shown in Figure 1.

- ABB AC500 PM554-ETH V2.1

Technical specifications of the selected PLC are as follows:
128 kB memory, 8 digital inputs, 6 digital outputs, Ethernet port, 24 VDC feeding, 1 RS-485 port, 1 single slot option
The number and variety of I/O modules to be selected vary depending on the PLC which is identified using the Control Builder Plus program.
Since 40 digital inputs, 25 digital outputs as well as 2 analog inputs and 1 analog output are needed by the system; additional modules of 2 DI562 and 3 DO561 have been used.

Figure 1. ABB PLC used to control the operations

3.2. PLC Programming

There are many different options available in PLC programming. Instead of using "ladder programming" which is the most popular PLC programming language, we used "ST" programming language in this study.

This option was chosen since ST programming language strongly resembles to C programming language and provides convenience for follow-up particularly in long and complicated situations.

3.3. SCADA

The SCADA system equipment used in this study is the outcome of a meticulous study. SCADA screen types, communication with the field, software, system features and the equipment used were created considering the requirements of the users of the system, hardware in the plant and system requirements.

3.4. SCADA Software

"Reliance 4" is a SCADA software package designed for the monitoring and control of industrial processes in real time. "Reliance 4 Design" programme was used in this study as the software. [6]

3.5. Building up Main Window and PLC Codes

Operators are able to monitor all the equipments and functioning in a factory on a sole screen and automatically or manually control all equipments and the system along with receiving real time or previous reports and statistics and form and enter prescriptions and do various adjustments for system functioning through the SCADA screen provided in Figure 2.

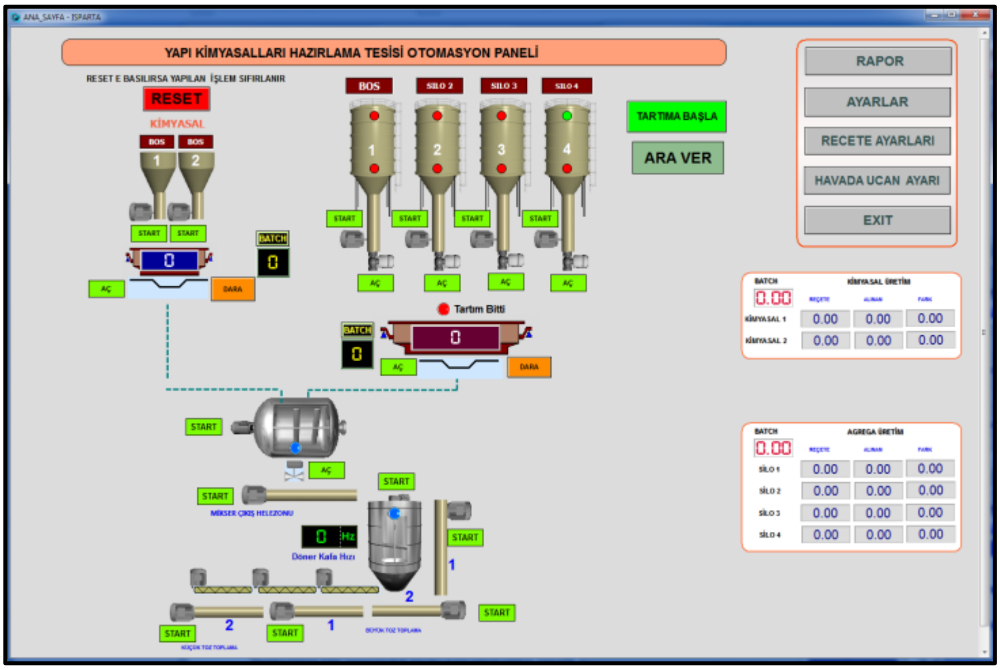

Figure 2. SCADA main screen

In short, the system functions as follows: there are two groups of silos in the system. In the 1st group there are 2 silos which have chemical materials inside. Other group has 4 silos and is named as aggregate. These silos have structural materials. When the operator selects one of the existing prescriptions or on his/her own will adjusts and presses "start weighing" button and if all the other conditions are provided (that is, silos have the materials and system has power etc.) weighing starts.
Weighing starts simultaneously for two groups. Weighing processes continue by weighing from only one silo each time until all the silos are weighed and prescriptions which show how much materials will be received from each silo are taken into account.
After weighing is finished, materials on conveyors are poured into the mixer one by one starting from the material in the aggregate silos. Upon pouring process is completed, mixer starts to rotate and carries on until the pre-defined mixing time is over.
When mixing process is completed, the valve under the mixer is opened and the mixed material is poured into the conveyor. Materials are then poured into the rotating head from this conveyor. However, there is a precondition for this process to continue, which is the information about the fullness. If the information about the fullness is received, materials in the conveyor are suspended and not poured into the rotating head. If the information about the fullness is not received for 15 seconds then conveyors are run and materials are poured into the rotating head. This process carries on until the new information about the fullness is received or all the material is poured into the rotating head.
In the meanwhile, second group of materials whose weighing process has been completed and which is hold in the conveyor is poured into the mixer when it is empty.
First group of materials which has been mixed in the rotating head for a while is then poured from the rotating head to be packed later. Packaging process is semi-automatic. Packaging is completed through conveyors and workers' help.

3.5.1. Weighing Starts

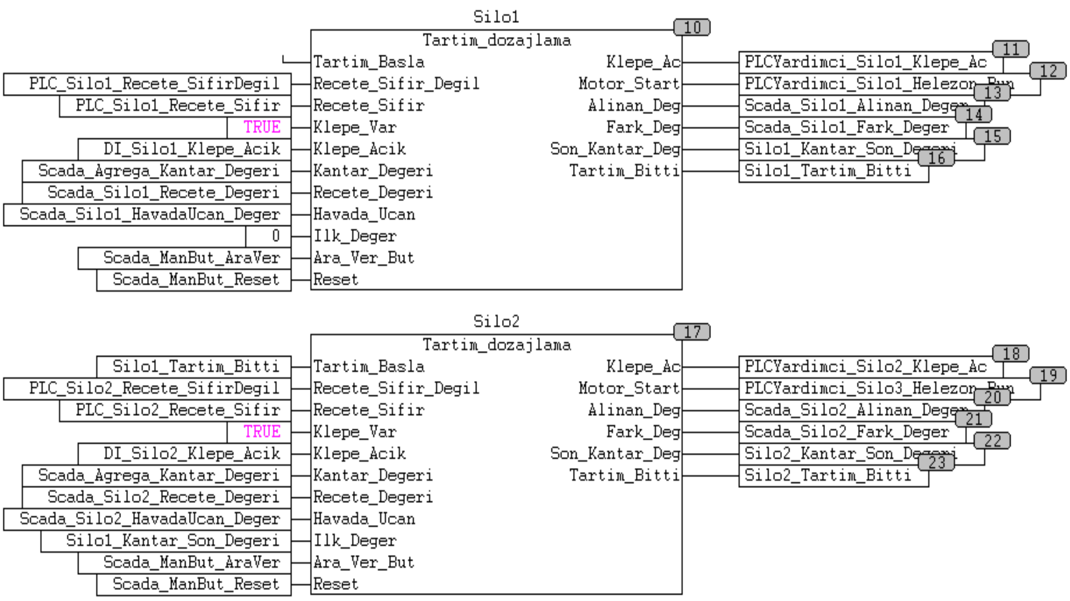

Figure 3. Function block of the weighing

After "start weighing" command is received, weighing process in silos starts respectively as mentioned before. In the Figure 3 above, you can see the PLC program which is written in order to control weighing process of the function blocks. As the bits seen at the left side of the block are sets, bits at the right side form sets in turn. As seen on the right side, first silo valve is opened to start weighing. Then, spiral shaped engine is run. Received value, the difference between and scale value information are identified and weighing stops when the desirable value is obtained.
Silos can work in turn through setting 'Silo1_Tartım_Bitti' (Silo1_Weighing_Finished) bit as one of the inlet bits of Silo2 block. Similarly 'Silo2_Tartım_Bitti' bit is a requisite to start Silo3 block.

3.5.2. Pouring from the scale to the mixer

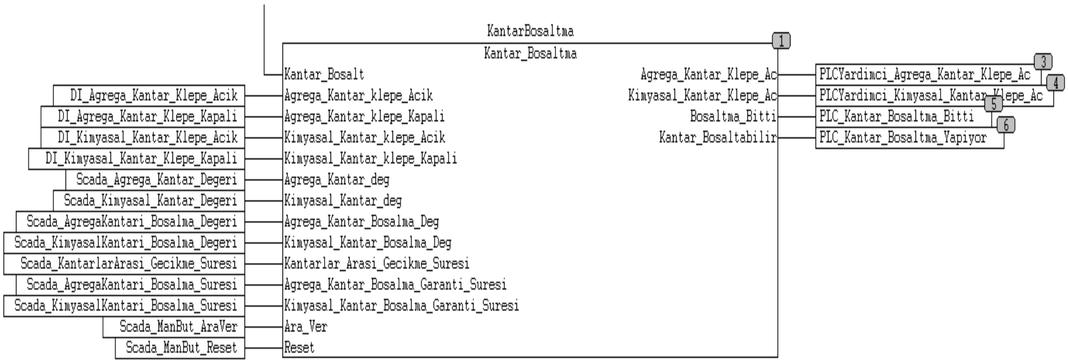

Figure 4. Function block of the pouring process to the mixer

One of the most important issues is the necessity to pour aggregate materials first during the process of pouring the materials to the mixer. As chemical materials are adhesive and fluid, we do not want them to be poured from the mixer first and stick to the surface of the mixer. Therefore aggregates are completed first. Moreover, when materials in the scale reach a certain level (to the basis weight determined by the operator or 100 grams etc.), scale valve is suspended for as long as desired and then closed. The reason why is that materials that can stay on the surface of the scale even if the valve is open should not cause the process to enter into an infinite loop. After the valves are closed the mixer starts the mixing process.

3.5.3. Blending Process in the Mixer

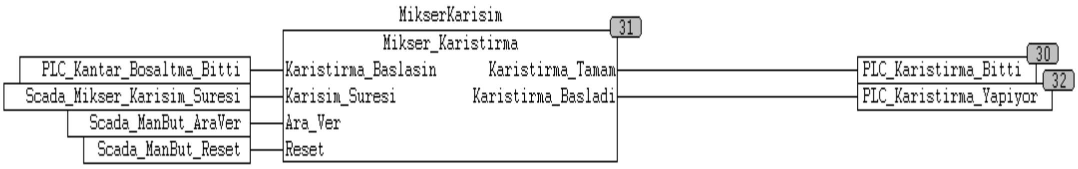

Figure 5. Function block of the blending process

After the scale is poured into the mixer, the blending process in the mixer continues as long as it is prescribed. This process is a pre-requisite of the process of pouring from the mixer. No pouring from the mixer can take place before the mixing is completed. Figure 5 shows the function block of the blending process above.

3.5.4. Pouring Process from the Mixer

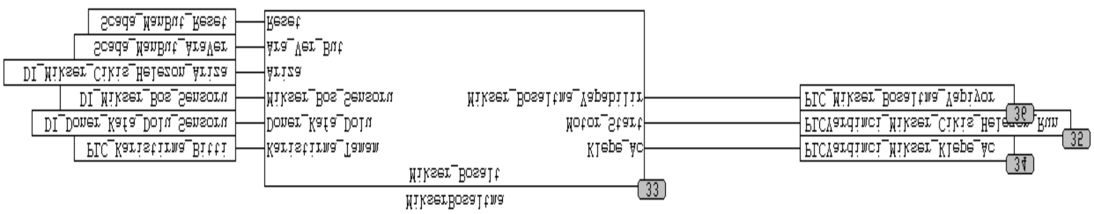

Figure 6. Function block of the pouring process from the mixer

Process of pouring from the mixer starts after the mixing is finished. The pre-requisites for this process include running the spiral shaped engine, not having pressed the button of "pause", not having pressed the button of "reset" and seeing that rotating head full sensor is not activated. Otherwise, pouring process does not start. The function block of the pouring process from the mixer is shown in Figure 6 above.

3.5.5. Rotating Head, Dust Absorption and Packaging Processes

If the engine of rotating head is not defective, the process takes place and remains in the position of "run". The "run" position here means that the spiral shaped engine of the rotating head is run. After the spiral shaped engine is run, this process is followed by dust absorption process and running the conveyors which will carry out the packaging. Operator needs to issue a command for these processes. There are two dust collecting systems and 3 conveyor bands within the system.

3.6. Building up Auxiliary Windows

These windows are created to help the operator do various adjustments and settings outside the home page. Settings include settings for recipes, inflight settings, time and weighing settings and calibration settings.

3.6.1. Settings

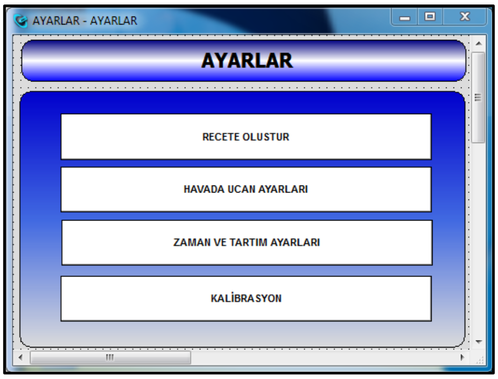

Figure 7. Settings window

This auxiliary window (Figure 7) asks the user in which field he/she wants to do the configurations. The user may switch to various configuration windows using this auxiliary window. These windows appear as follows in turn:

- Create a recipe
- Inflight settings
- Time and weighing settings
- Calibration.

3.6.2. Create Recipe

Figure 8. Recipe window

This auxiliary window (Figure 8) is the one used by the operators to create recipes. The value of materials to be received from silos is written in the relevant part of the windows in kilogram when creating the recipe. Then, the recipe is uploaded to the system by pressing the button of "Reçeteyi Sisteme Yükle". The recipe uploaded to the system is implemented if "Tartıma Başla" button is pressed.

3.6.3. Inflight Settings

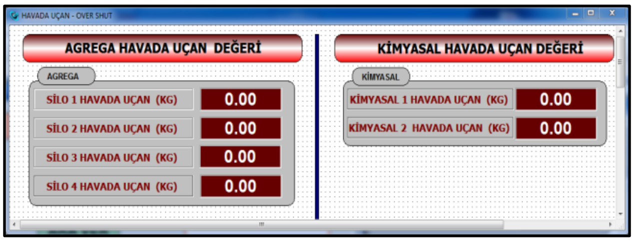

Figure 9. Inflight window

This auxiliary window (Figure 9) ensures that the inflight value of materials in each silo is determined in kilogram. Since some of the material is turned into dust during pouring from silos, a difference is created between received value and poured value. In order to avoid problems that may be created by this difference in the system, the value which is entered as "inflight" is added to poured value and that is how the received value is calculated. In short, "inflight" value is created to eliminate error margin.

3.6.4. Time and Weighing Settings

Figure 10. Time and weighing window

3.6.5. Calibration

Figure 11. Calibration window

Weighing value is obtained through load cells on the scales; however it is needed to carry out another calculation here. The Figure 11 shows the calibration window. Analogue values communicated by load cells vary between 0 and 27648. These values may decrease or increase depending on the weight of the materials on the scale. This value is seen as "Kantar Ham Değer" on the window. When there is no material on the scale, in other words, when the scale is empty, the analogue value read on the window is "Kantar Dara Değeri". It is necessary to find calibration value in order to calculate how much material is available on the scale, in other words, it is necessary to know how many kilograms cause how much increase in the analogue value. To find this out, a material of known weight in kilograms is placed on the scale. Then the value of increase added to the raw value is subtracted from the tare weight and the result is divided by the weight of the material placed on the scale which is in kilogram. The result is the “Kalibrasyon Değeri”. “Kantar Gerçek Değeri” is equal to the result obtained when the calibration value is multiplied by the raw value, in other words, to the actual weight of the material.

4. Conclusion

Construction chemicals production plants are the combination of electromechanical systems which are comprised of giant silos, conveyors, mixers, rotating heads, dust absorption units and packaging units.
This study handles the application of industrial SCADA systems on construction chemicals production plants. It is critically important both for the producers and the customers to ensure that the ratio of compounds within the construction chemical that is desired to be prepared is same for each product. Therefore, SCADA systems are indispensable for plants which produce more than 500 packages and hundreds of kilograms of product on a daily basis since such systems ensure reliability and efficiency, provide opportunities of instant monitoring for the whole plant and instant intervention for any part of the plant, enable running retrospective analyses in a sound manner and make it possible to conduct instantaneous stock control.
Mentioning about the facility, after the automation system provided, electrical consumption becomes 150 kWh and the daily consumption is 1200 kWh if the 8-hours work considered. The production values are 2.5 tons/h and 20 tons/day again considering 8-hours work. This means 800 packages (25 kg per package approximately) construction chemical product is produced daily.
Only 5 workers work in the facility after the system set up, one of them is in the MTU (Master Terminal Unit), one is responsible from quality control of the products and prepares the prescriptions, 2 of them are in the packaging area and one is using forklift to transport the packages to the storage yard.
If there is no automation system in the facility, production will held manually and 4 more workers will needed. These workers will have worked in the manufacturing yard, 2 of them in the aggregate materials silos and the other 2 of them in the chemical materials silos and their duties will have been weighing and mixing the materials.
It is given by the facility that 1 worker’s cost as 1500 TL in a month and it becomes 6000 TL for 4 workers. Considering the automation system’s total cost as 72 000 TL (60000 TL + VAT), it is easily estimated as investment amortized itself in one year even if only considering workers’ cost.
The other consideration is in the rate of production. Although 5 workers work in the facility instead of 9 workers, there is up to %75 increase in the production rate. This huge difference is mainly due to the weighing time. In the automated system weighing time is about 8-9 minutes per prescription, this time becomes 26-27 minutes in manual work. We also know that the rest of the procedure takes 15-16 minutes. So if we compare the production speed of automated system and manual system, it is estimated that the automated system is %75 quicker. Means 800 packages product produced in a month in automated system instead of 450 packages.

5. References

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