

Continuous Stirred Tank Reactor Based Blender Controlled Application using PLC

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Abstract - The OIL MOVEMENT & STORAGE unit comprises of two Blenders for Euro 2 and Euro3 grades, inputs from 6 storage tanks, Naptha sink, storage reservoirs etc. An overview of the study includes the study of the present system and attempts towards enhancements of the same using PLC. The major advantage of using PLC is that we can easily understand and reprogram and number of input parameters can easily added. The second part deals with the implementation of study into fabrication of the prototype of OM/S and execution of simultaneous control of 3 parameters (Temperature, Flow, and Level). A ladder diagram is designed for the same.

1.INTRODUCTION

The scope of this paper is that we can maintain maximum reliability, easily reprogrammed with programming unit, Complete Automation, availability of unlimited number of NO/NC contacts for inputs/outputs, easy installation, power consumption is very low and no special programming skill required by maintenance personnel.

2.HARD WARE DESCRIPTION

2.1 OIL Movement And Storage - The OIL MOVEMENT & STORAGE OM/S) unit in CPCL is the place where Blending Automation is executed. This unit deals with Blending of Motor Spirit (MS) and High Speed Diesel (HSD). Our study of OM/S extends to the MS Blending part. The following is the Block Diagram of OM/S unit. The Block Diagram depicts the arrangement of the following parts:

- 1) Streams from Various Plants
- 2) Blender Plant
- 3) Analyzer
- 4) DCS
- 5) Display Stations

2.2 Motor And Blending - Blending is an attractive solution for those refiners who have the ability to blend different crude types to provide a consistent and optimal feedstock to refinery operations. Optimal crude purchasing

is an effective method to improve refinery profits. In general the blending rule is nonlinear; it can be regarded as a linear mixing rule adding a nonlinear term.

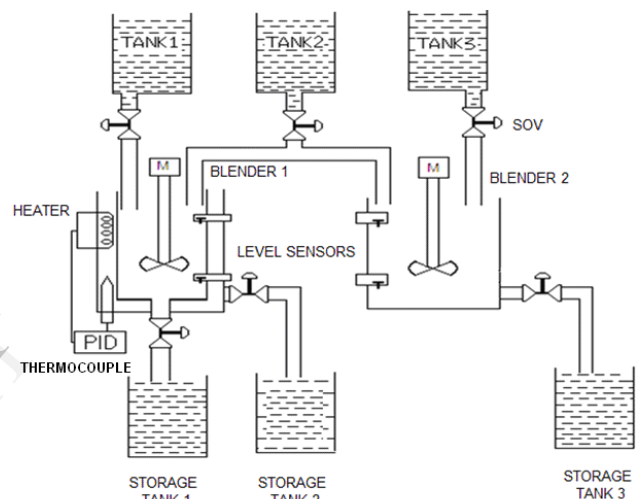


Fig.1 Basic model of CSTR.

3.EXPLANATION

Motor Spirit (MS) is commonly known as fuel oil. It is marketed to the city as Petrol. The Primary objective of the MS Blending is to produce a high end product from its low end counterpart through cracking. This is done to achieve the International Standards set for the correct composition and quality of the petrol. Consequently, this is done to improve the performance and engage more mileage value for the vehicles. The driving force of the blending process comprises any numerical factor that the blender seeks to Maximize (e.g. profits), minimize (e.g. costs), or achieve (e.g. a target level of production or a minimum/maximum specification point). For achieving these standards, petrol companies must ensure the proper blending of MS. MS Blending is executed in an intricate system of inlet pipes, blenders and control valves. The pipes feed the various input components like Naptha, Reformate to name a few. The pipes extend from the storage tanks of respective blending component. The pipes are fitted with desired control valves and specific positions to regulate the flow of the

supply. All the components are mixed in the blenders positioned at the end of all the inlet pipes. The Blending is initiated in this part and the blend mixture is extracted and sent to several storage tanks. From the storage tanks, samples might be tested for marketing and export of the Motor Spirit.

3.2 Continuous Stirred Tank Reactor Based Blender Control - The prototype is fabricated on the basis of its relational construction detail with MS BLENDING Plant from OM/S unit. The tank reactors are fitted with stirrers, making their function as that of a Blender. There are 3 input feeds arising from separate input tanks. One blender is made of steel, while the other one is made of plastic. Temperature, Level and Flow are the respective parameters controlled in these reactors. The Blender 1 which is made of steel has dual-jacket configuration. parameters are subjected to control in this Blender. Temperature Control is exercised by the use of PID along with Thermocouple. A heating element is fitted in between the jackets. Flow of various fluids is controlled by the use of solenoid valves (SOV) at strategic positions. The fluids which are controlled by SOV valves are Input Feeds, Inner Jacket Fluid, and Blend Mixture. A stirrer with motor is mounted at the opening of Blender, consequently inserted into the mixture for mixing.

4. BLOCK DIAGRAM

BLOCK DIAGRAM EXPLANATION - The various parts are

- 1) Two main tanks with a stirrer each
- 2) Sensors
- 3) Heater
- 4) Stirrers
- 5) Solenoid valves
- 6) Programmable logic controller

4.1 Tanks with stirrers: - These are the main tanks in which the Input liquids from their storage tanks are mixed together by means of the stirrer. The stirrer is connected to a motor in such a way that it can be able to rotate in a constant speed for proper mixing of the blend mixture.

4.2 Sensors:

The main purpose of the sensors is to measure the temperature inside the tank and also whether the liquid inside the main blender tank is in the lower level or in the higher level.

4.3 Heater - Heater is used to heat the inner jacket liquid, indirectly heating the blend mixture inside the main tank, so that the liquids are at optimum temperature for proper blend quality.

4.4 Solenoid valve:

The solenoid valve is used to control the flow of the liquids from various tanks to flow in a correct proportion. So that the desired amount of Blend mixture liquid can

be obtained.

4.5 Programmable Logic Controller:

The most important part which is needed for the controlling and complete automation of entire process is the Programmable Logic Controller (PLC). The whole process is monitored by means of the ladder logic diagram which is fed in to it through the interfacing software.

5. CONSTRUCTION OF CSTR BASED BLENDER

5.1 Sensor Used

Temperature sensor: Thermocouple

Type: "J"

Range: -40 to +750 deg.

Sensitivity: 50 $\mu\text{V}/^\circ\text{C}$

Level sensor: Float switch

Type: NO (Normally open)

5.2 Thermocouple: - When any conductor (such as a metal) is subjected to a thermal gradient, it will generate a voltage. This is known as the thermoelectric effect or Seebeck effect. This concludes the working principle of thermocouple. It is important to note that thermocouples measure the temperature difference between two points, not absolute temperature. A thermocouple can produce current, which means it can be used to drive some processes directly, without the need for extra circuitry and power sources. Here the thermocouple is immersed into the inner jacket liquid which surrounds the main tank in order to heat the blend mixture, as shown in the figure. It will transmit the temperature measurement continuously to the PID controller.

5.3 Float switch: A float switch is a device used to sense the level of liquid within a tank. The switch may actuate a pump, an indicator, an alarm, or other device. The most common type of float switch is a float raising a rod that actuates a micro switch. Float switches are often adjustable and can include substantial hysteresis. That is, the switch's "turn on" point may be much higher than the "shut off" point. This minimizes the on-off cycling of the associated.

5.4 PID Controller with Thermocouple: The PID Controller is connected the Thermocouple, Heater and PLC. The Thermocouple used is J-type Thermocouple with working range of 0 to 750 deg C. The Heater is connected to the PID Controller, where the Set point for the exothermic reaction is given. When the set point is reached the PID controller will make the heater to stop Heating. There will be less error in the PID controller comparing to the other controllers. The PID Controller is of "SELEC" make.

5.5 Solenoid Valves Detail: A solenoid valve is an electromechanical valve for use with liquid or gas controlled by running or stopping an electrical current through a solenoid, which is a coil of wire, thus changing the state of the valve. Solenoid valves are the most frequently used control elements in fluidics. A solenoid

valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically.

Solenoids offer fast and safe switching, high reliability, long service life

5.6Stirrer with Motor:- The Stirrer is supported by a Geared Motor which is of "IDEAL" make.

Input Voltage : 12 VDC

Current carrying Capacity : 500 mA

Speed : 10 rpm

6. PROGRAMMABLE LOGIC CONTROLLER

6.1 Introduction :

A Programmable Logic Controller (PLC) is a solid state device designed to perform logic functions previously accomplished by electromechanical relays. A

Programmable Logic Controllers are used for the control and operation of a manufacturing process equipment and machinery. The Programmable Logic Controller is basically a computer designed for use in machine control- Unlike a computer it has been designed to operate in the industrial environment and is equipped with special, input/output interfaces and a control programming language. Control engineering has evolved over time. In the past humans were the main methods for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions.

PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come. Most of this is because of the advantages they offer.

Cost effective for controlling complex systems.

Flexible and can be reapplied to control other systems quickly and easily. Computational abilities allow more sophisticated control. Trouble shooting aids make programming easier.

PLC hardware: The configuration of the PLC refers to the packaging of the components. Typical configuration are listed below from largest to smallest as shown in Figure

Rack - A rack is often large (up to 18" by 10") and can hold multiple cards. When necessary, multiple racks can be connected together. These tend to be the highest cost, but also the most flexible and easy to maintain.

Power Supply - This can be built into the PLC or be an external unit. Common voltage levels required by the PLC (with and without the power supply) are 24Vdc, 120Vac, 220Vac.

CPU (Central Processing Unit) - This is a computer where ladder logic is stored and processed.

I/O (Input/output) - A number of input/output terminals must be provided so that the PLC can monitor the process and initiate actions.

Mini - These are similar in function to PLC racks, but about half the Size.

Micro - These units can be as small as a deck of cards. They tend to have fixed quantities of I/O and limited abilities, but cost will be the lowest.

Software - Software based PLC requires a computer with an interface card, but allows the PLC to be connected to sensor and other PLCs across a network.

6.2INPUTS AND OUTPUTS: Inputs to and outputs from a PLC are necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types.

Logical

Continuous

Consider the example of a light bulb. If it can only be turned on or off, it is logical control. If the light can be dimmed to different levels, it is continuous. Continuous values seem more intuitive, but logical values are preferred because they allow more certainty, and simplify control. As a result most controls applications (and PLCs) use logical inputs and outputs for most applications.

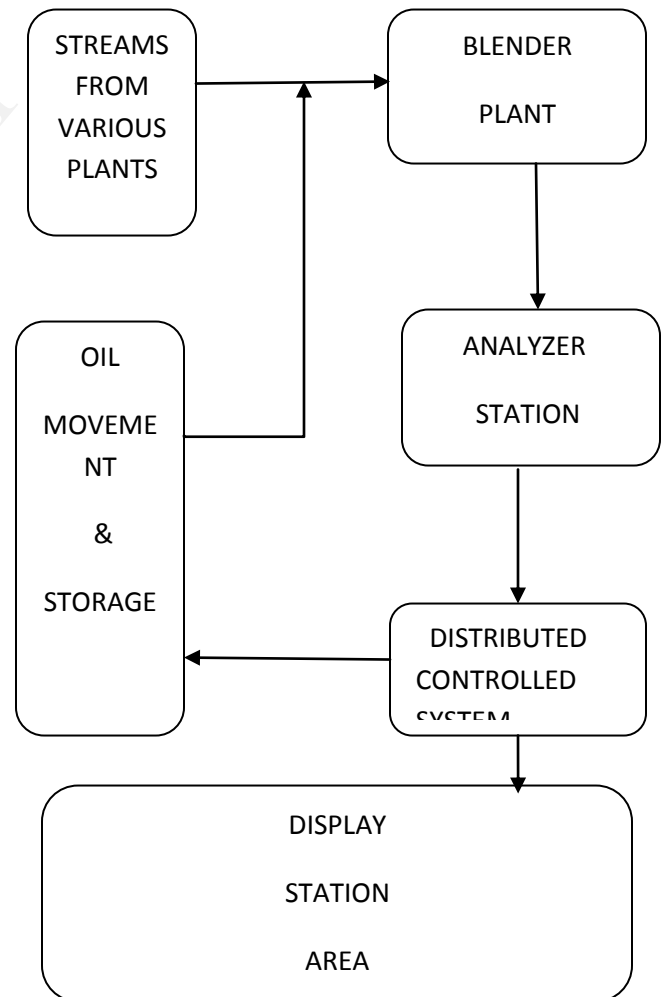


Fig.2. Block diagram of a Oil Movement & Storage Plant

6.3 Basic types of a programming languages: The modern PLC is required to do more and more in terms of operator interfacing, communications, data acquisition and supervisory control, Greater demand is required of the language that implements these functions. Basically four types of languages are used for programming.

- □ Boolean language
- □ High level languages
- □ State languages
- □ Ladder languages

6.3.1 Boolean language: This language is generally used in very small PLCs. Boolean uses AND of NOT, STORE and RECALL instructions in order to describe the program logic.

This language is not easy to debug unless a single stopping feature is provided that slows down program execution.

6.3.2 High level language: These languages can be very powerful and are identical to the languages used by computers. They exhibit excellent flow control and functionality and provide for the accessing of many different types of variables. They also offer reasonable speed. Although some PLC's allow the user to, be written in these high level languages, most PLC's offer this kind of language support through an intelligent support through an intelligent coprocessor module.

6.3.3 State language: As an example, sequence function charts (SFCS) allow the program to be expressed in terms of the machine or process states and the I/O conditions needed to one transition from one state to the next. State languages can be a valuable aid in designing large and complex control programs.

6.3.4 Ladder language: It provides graphic display of program execution by showing power flow through the ladder diagram, thereby making it easier to debug. It is readily understood and maintained by skilled workers familiar with relay logic. It generates more readable programs for sequence control and also simplifies training.

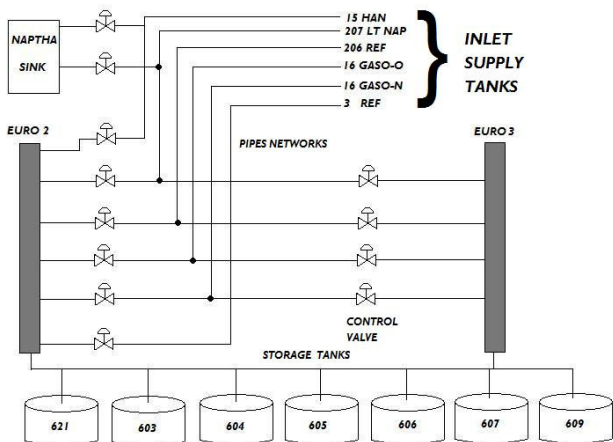


Fig.3 Areas controlled by PLC.

6.4 PLC Programming: The two most common language structures are ladder diagram language and Boolean language. The ladder diagram language is basically a symbolic set of instruction used to create the controller program. These ladder instructions are arranged to obtain the desired control logic that is to be entered into the memory of the PLC. The main symbols that are used in a PLC programming language are shown below:

Typically represents any input to control logic-normally open contact Typically represents any input to control logic-normally closed contact. Typically represents any outputs that is controlled by combination of input logic – coil. It should be noted in a PLC ladder programming that continuous path is required for logic continuity, and to energies the output. A ladder diagram can be represented as shown below:

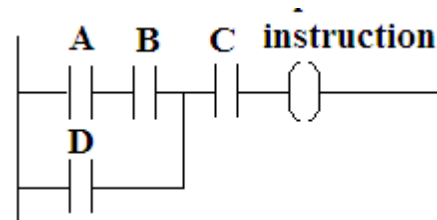


Fig.4 A Ladder Diagram Example

The main function logic ladder diagram is to control outputs based on the input conditions. This control is accomplished through the use of what is referred to as a ladder rung. For an output to be activated or energized at least one left to right path of the contact must be closed. A complete closed path is referred to as having logic continuity. When logic exists in at least one path, the rung condition is said to be true. The rung condition is false if no path has continuity.

6.5 Advantages of PLC over PC: A Programmable Logic Controller, PLC or Programmable Controller is a digital computer used

]for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a *hard* real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

The PLC is designed to operate in the industrial environment with wide range of ambient temperature and humidity. The hardware and software of PLCs are designed for easy use by plant electricians and technicians.

The PLC comes in programmed relay ladder logic or other easily learned languages. Troubleshooting is simplified by the design of most PLCs because they include fault indicators and written fault information displayed on the programmer screen. The modular interfaces for connecting the field devices are actually a part of the PLC and are easily connected and replaced.

6.6 PLC Specification.

- Make : MM3010 SELEC
- Input Voltage : 24 VDC
- Output Voltage : 24 VDC
- Voltage : 230 VAC
- Memory : 32 KB
- Processor : 16 bit
- Digital inputs : 11
- Digital outputs : 8



Fig. 5 A rack type PLC

7. PLC TERMINOLOGY

7.1 Scan time - A PLC program is generally executed repeatedly as long as the controlled system is running. The status of physical input points is copied to an area of memory accessible to the processor, sometimes called the "I/O Image Table". The program is then run from its first

instruction rung down to the last rung. It takes some time for the processor of the PLC to evaluate all the rungs and update the I/O image table with the status of outputs. This scan time may be a few milliseconds for a small program or on a fast processor, but older PLCs running very large programs could take much longer (say, up to 100 ms) to execute the program. If the scan time was too long, the response of the PLC to process conditions would be too slow to be useful.

As PLCs became more advanced, methods were developed to change the sequence of ladder execution, and subroutines were implemented. This simplified programming and could also be used to save scan time for high-speed processes; for example, parts of the program used only for setting up the machine could be segregated from those parts required to operate at higher speed.

Special-purpose I/O modules, such as timer modules or counter modules, can be used where the scan time of the processor is too long to reliably pick up, for example, counting pulses and interpreting quadrature from a shaft encoder. The relatively slow PLC can still interpret the counted values to control a machine, but the accumulation of pulses is done by a dedicated module that is unaffected by the speed of the program execution.

7.2 System scale - A small PLC will have a fixed number of connections built in for inputs and outputs. Typically, expansions are available if the base model has insufficient I/O.

Modular PLCs have a chassis (also called a rack) into which are placed modules with different functions. The processor and selection of I/O modules are customized for the particular application. Several racks can be administered by a single processor, and may have thousands of inputs and outputs. A special high speed serial I/O link is used so that racks can be distributed away from the processor, reducing the wiring costs for large plants.

7.3 User interface - PLCs may need to interact with people for the purpose of configuration, alarm reporting or everyday control. A human-machine interface (HMI) is employed for this purpose. HMIs are also referred to as man-machine interfaces (MMIs) and graphical user interface (GUIs). A simple system may use buttons and

lights to interact with the user. Text displays are available as well as graphical touch screens. More complex systems use programming and monitoring software installed on a computer, with the PLC connected via a communication interface.

A microcontroller-based design would be appropriate where hundreds or thousands of units will be produced and so the development cost (design of power supplies, input/output hardware and necessary testing and certification) can be spread over many sales, and where the end-user would not need to alter the control. Automotive applications are an example; millions of units are built each year, and very few end-users alter the programming of these controllers. However, some specialty vehicles such as transit buses economically use PLCs instead of custom-designed controls, because the volumes are low and the development cost would be uneconomical.

Very complex process control, such as used in the chemical industry, may require algorithms and performance beyond the capability of even high-performance PLCs. Very high-speed or precision controls may also require.

8 RESULT AND CONCLUSION OF PAPER

8.1 Summary of the paper

1. Exposed towards various international standards followed at m/s CPCL, both for design philosophy and installation.
2. Studied and observed the working of oil movement and storage plant and analyser.
3. Fabrication of prototype of OM/S was done.
4. Studied and designed ladder logic for simultaneous control of 3 parameters (temperature, level, and flow) in the 2 blenders using programmable logic controller using selec software.
5. Interfaced the prototype with the PLC and achieved the working status of the same.

8.2 Conclusion of the paper :

The Fabrication of the MS Blending plant prototype was done successfully with implementation of the study regarding the issue. The prototype was designed in order to work in Total Automation. We have fulfilled our intention to ascertain the simultaneous control of 3 parameters of the reaction mixture using Programmable Logic Controller.

8.3 Applications of the project :

Chemical Industries
Oil & Gas Industries
Process Automation
Pharmaceutical Industries

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