

# Development of Automatic Control Panel for Mixing Equipment

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**Abstract** - The focus of this paper is on the automatic working of control panel for industrial mixer at Unique Mixers and Furnaces Pvt. Ltd. This project includes the improvement in technology as well as in the quantity of their batch production. In traditional system we can control it manually using push buttons but here, the push buttons are replaced by devices like display unit i.e. HMI and PLC with advanced drives system to overcome the problems that are faced in old system. This system work with the combination of hardware and software which help them to extended equipment life through reduced mechanical stress, high efficiency, energy saving and highest possible performance levels along with speed controls.

**Key Words:** Programmable Logic Controller, Variable Frequency Drive, Human-Machine Interface, Power Supply, TIA Portal.

## 1.INTRODUCTION

This paper deals with an automatic control panel which is used to control mixing automation. In industry to achieve an automation in mixing process, an automatic control panel require high technology tools like PLC, VFD and HMI to get rise in production rates. The modernization of the conventional system by replacing the command parts like relays, contactors, timers by a modern tool like Programmable logic controller, to run the motor at various speed VFD is used and Monitoring systems get information from a motor and VFD's which help to assure the balanced flow of production, this can be achieved by using HMI system. The primary reason for upgrading the system is less maintenance, time saving, fast and accurate production rates, increase in batch wise production and to overcome the problem of synchronization. By implementing this project allows simple operation, decreases manpower and precision work.

## 2.PROBLEM FORMULATION

In today's industrial sector there are various factors like power or energy consumption, production & workers which affect the expenses of the industry. To reduce the operating cost and to increase the savings we have to work on the above factors. Energy consumption is an important area for cost reductions, since cost of energy is increasing day by day thereby harming both financial and environmental factors. There is need to save the electricity for our future generation, as the flow of energy is unidirectional in nature and is not cyclic. So, it is necessary that energy should be saved and overall efficiency of the system is maintained. In

manual panel, sometime there are mechanical problems like problem in giving command manually, motors run at fixed speed etc. Such problems we can avoid with using an automatic control panel.

## 3.PROBLEM SOLUTION

The survey reveals that solution of all the above problems can be achieved by using PLC, VFD and HMI in control panel which provide easy access and control to handle industrial mixer. All of this great expansion of automation offers advanced technological methods which will results to reduce the faults and energy consumption and also reduced costs of production to improve their profitability and efficiency.

## 4.METHODOLOGY

According to our ladder logic diagram which installed in programmable logic controller will control all the process of mixing automation.

This program is editable by programmer as well as easy to maintain.

So here in this project all the process of mixing automation performs as below;

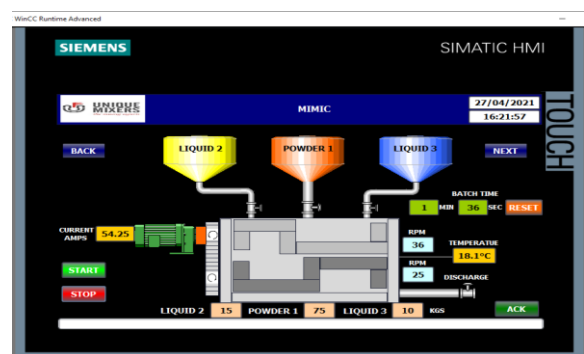


Fig 1. HMI Menu Screen

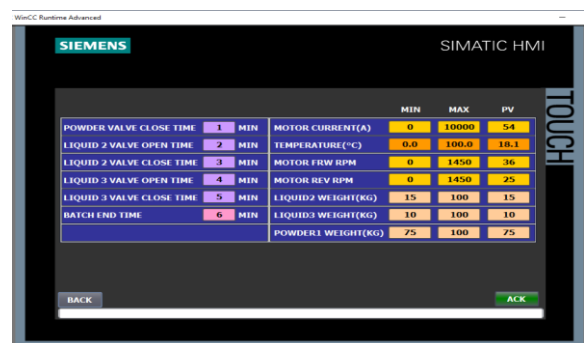


Fig 2. HMI Setting Screen

Mixing process will start as motor start. As motor started valve of powder tank will become open and allows powder to comes into the mixer from powder tank. The opening/closing time of valve we can control via timer which we can modify using HMI screen as shown in above figure.

After desired time interval powder valve become closed and second valve will get open allows liquid 2 to enter into the vessel for mixing process.

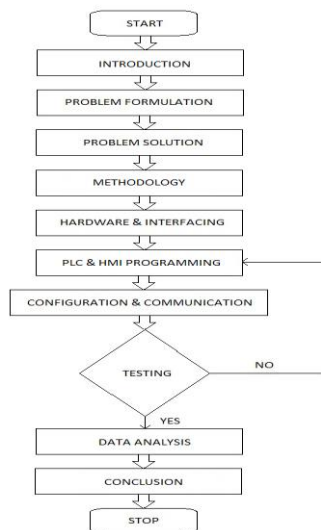
Similarly, after specified time duration second valve also get closed and third valve will become open allows liquid 3 to enter into the vessel for mixing process.

After specified time duration as valve 3 get closed and after mixing process completed it will follow the discharge.

At the end one batch will complete after discharge process. For such kind of operation we need to enter only desired time interval with suitable data to allow process of mixing automation.

All the above process will be performed automatically.

## 5.METHODOLOGY ADOPTED



## 6.HARDWARE DESCRIPTION

### 6.1 Siemens PLC and it's operation:

Scanning Cycle -

A PLC (Programmable Logic Controller) is a real computer, which is also capable of receiving data via its inputs their sending command by its outputs.

A PLC works by continually scanning a program. We can think of this scan cycle as consisting of 3 important steps. There are typically more than 3 but we can focus on the important parts and not worry about the others. Typically, the others are checking the system and updating the current internal counter and timer values.

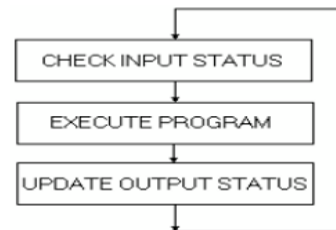


Fig 3. PLC Scan Cycle

Step 1: Snapshot of the status of its inputs

Step 2: Program execution

Step 3: Output's activation or deactivation

At the end of Step 3, the Controller returns to Step 1, and so on.

### Step 1 – Check Input Status

First the PLC takes a look at each input to determine if it is on or off. In other words, is the sensor connected to the first input on? How about the second input? How about the third... It records this data into its memory to be used during the next step.

### Step 2 – Execute Program

The PLC executes your program one instruction at a time. Maybe our program said that if the first input was on then it should turn on the first output. Since it already knows which inputs are on/off from the previous step it will be able to decide whether the first output should be turned on based on the state of the first input. It will store the execution finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step.

Based on the example in step 2 it would now turn on the first output because the first input was on and your program said to turn on the first output when this condition is true results for use later during the next step.

### Step 3 – Update Output Status

Finally, the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step. Based on the example in step 2 it would now turn on the first output because the first input was on and your program said to turn on the first output when this condition is true.

### 6.2 Principle of Operation – Variable Frequency Drive:

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor.

An AC induction motor is constructed with a rotor that has windings which intersect the rotating magnetic field generated by the stator windings.

At full load speed, the rotor turns slightly slower than the synchronous speed of the motor. This is because the magnetic field causes currents to flow in the rotor windings and produces a torque which turns the rotor so if the rotor turns at the same speed as the magnetic field, there would be no relative motion between the rotor and the magnetic field, and no torque would be produced.

The amount of speed by which the rotor lags the rotating magnetic field is known as the slip of the motor. The higher the slip, the more torque is produced by the motor.

The speed at which the magnetic field rotates depends on the number of poles or coils distributed around the stator and the frequency of the supply current. This is called the synchronous speed.

$$\text{Synchronous Speed} = \frac{120 \times \text{Frequency}}{\text{Number of Poles}}$$

Typical AC induction motor speeds are 3600, 1800, 1200, and 900 RPM.

Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, Micro-drive, and inverter.

### 6.3 Functions of HMI:

HMIs allow operators to start and stop cycles, adjust set points, and perform other functions required to adjust and interact with a control process. Because the HMI is software based, they replace physical wires and controls with software parameters, allowing them to be adapted and adjusted very easily.

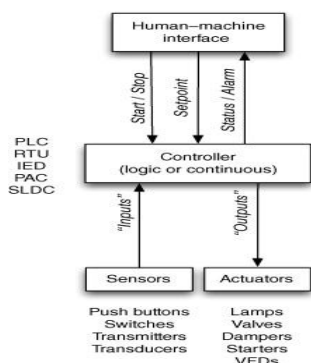


Fig 4. Function of HMI

### Functions:

**Monitoring:** It is the ability to obtain and display plant data in real time. This data can be displayed as numbers, text or graphics that allow a reading easier to interpret.

**Supervision:** This function allows, together with the monitoring, the possibility of adjusting the working conditions of the process directly from the computer.

**Alarm:** It is the ability to recognize exceptional events within the process and report them.

**Control:** It is the ability to apply algorithms that adjust the values of the process and thus maintain these values within certain limits.

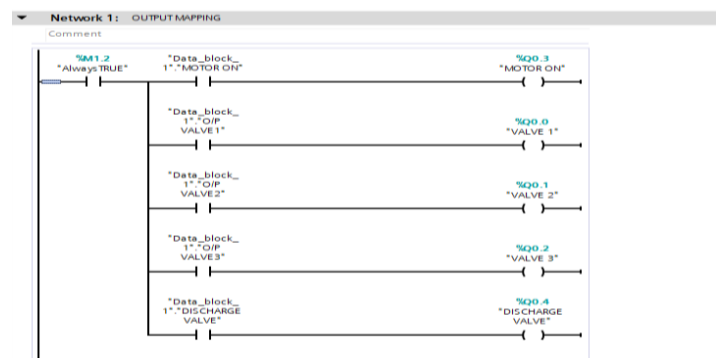
**Historian:** It is the ability to display and store in files, process data at a certain frequency. This storage of data is a powerful tool for the optimization and correction of processes.

## 7.SOFTWARE DESCRIPTION

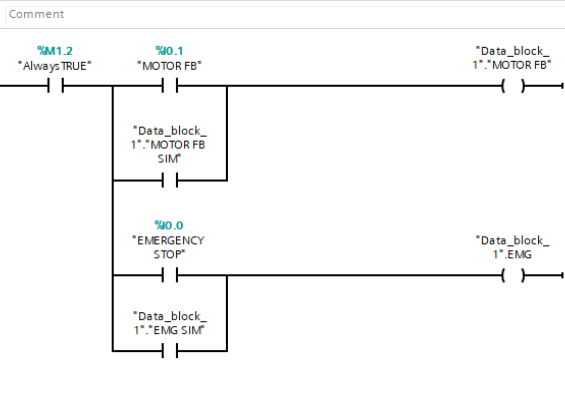


For PLC Programming as well as for Simulation the software used is "Totally Integrated Automation Portal" which is also known as TIA Portal developed by Siemens for automation.

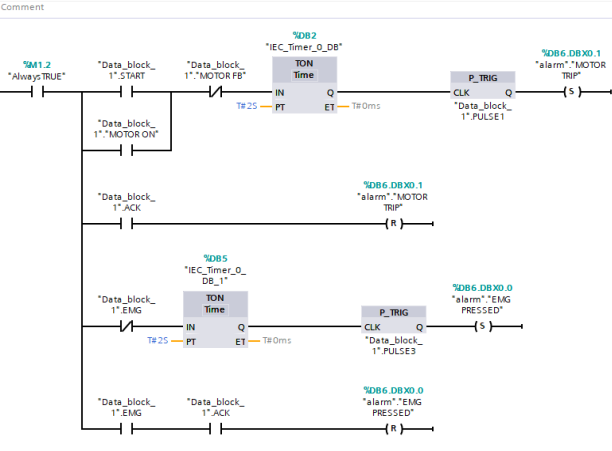
### 7.1 Ladder Logic Diagram:



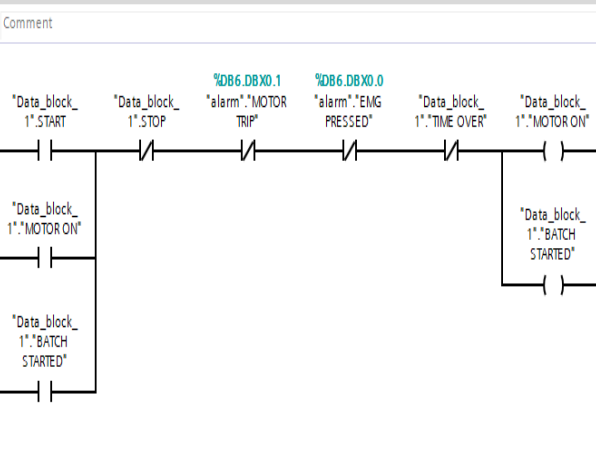
**Network 2: INPUT MAPPING**



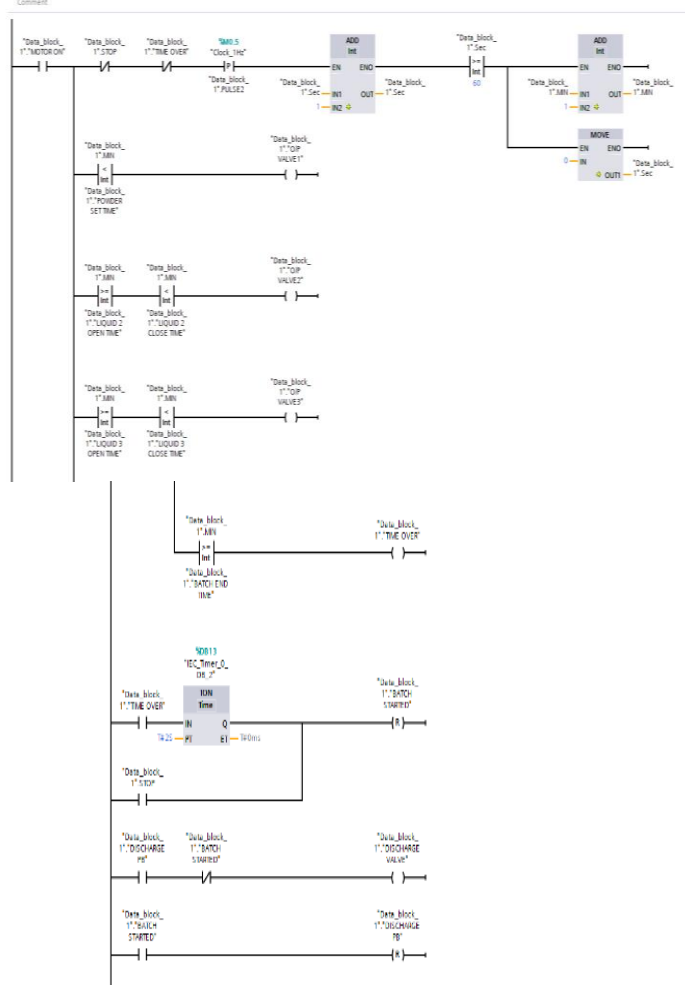
**Network 3: ALARM**



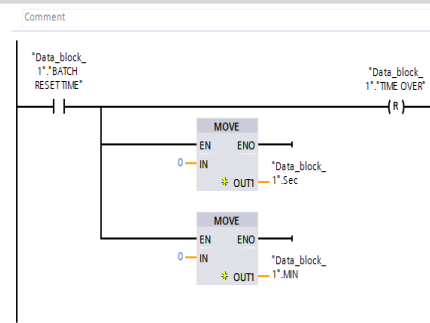
**Network 4: START LOGIC**



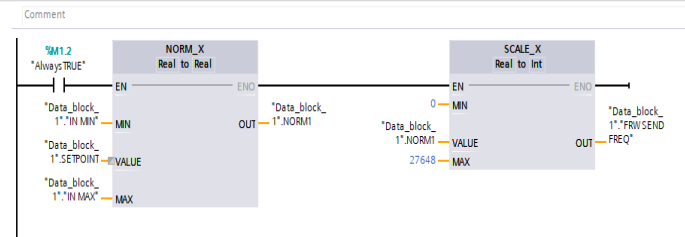
**Network 5: BATCH LOGIC**



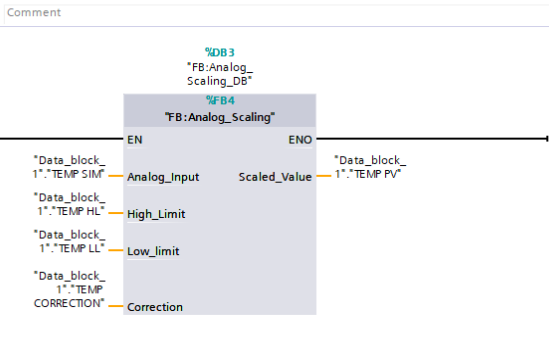
**Network 6: BATCH RESET TIME**



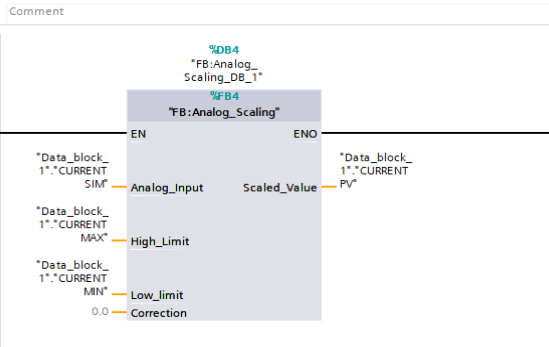
**Network 7: VFD**



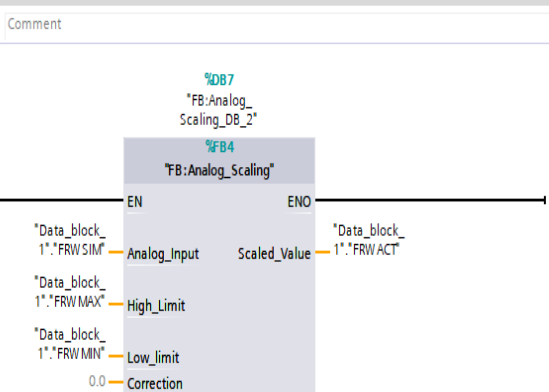
**Network 8: TEMPERATURE**



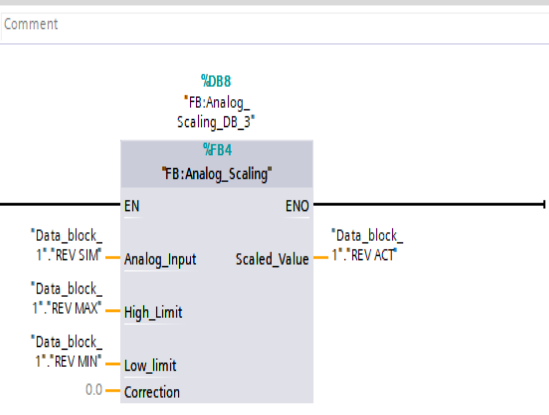
**Network 9: CURRENT**



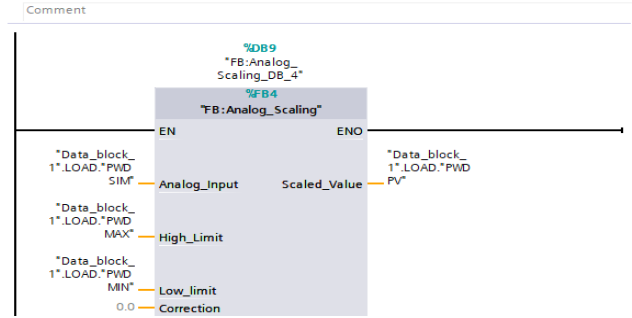
**Network 10: MOTOR FORWARD RPM**



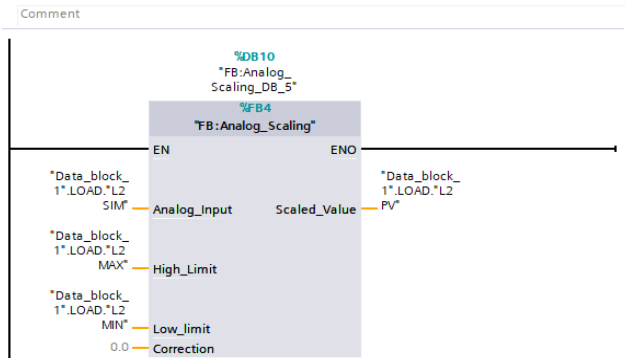
**Network 11: MOTOR REVERSE RPM**



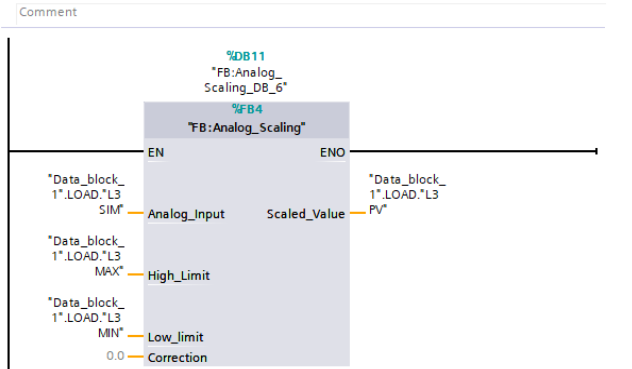
**Network 12: WEIGHT OF POWDER VESSEL**



**Network 13: WEIGHT OF LIQUID2 VESSEL**



**Network 14: WEIGHT OF LIQUID 3 VESSEL**



**7.2 Ladder Logic Description:**

**Network 1 – Output Mapping**

%Q0.0 to %Q0.4 is the hardware PLC output which cannot be used repeatedly in different network due to program scan. To use interlock of outputs we need to create a “Data block” address so we can use in other network also for interlock purpose.

**Network 2 – Input Mapping**

Same as output %I0.0 to %I0.1 is PLC hardware input so need to mapping this address.

Also, for simulation purpose we have taken additional “Data block” to force while using online simulation mode.

%I0.1 is motor feedback which is come from drive to PLC to check motor trip or not.

%I0.0 is emergency stop comes from field or operating panel.



In case of emergency whole system should stop.

### Network 3 – Alarm

It is used to generate alarm on HMI also stop the system if alarm comes in running condition.

Line 1 of this network is when motor start button pressed from HMI, it will check for motor feedback, if not come up to 2 seconds timer, then it will generate an alarm as motor trip. Line 2 – If acknowledge pressed from HMI as alarm come so it will reset or stop alarm.

Line 3 – If emergency is pressed it will wait till 2 seconds, then it will generate alarm.

As emergency released and acknowledge button pressed via HMI it will reset the alarm.

### Network 4 – Start logic

This network is written to start motor.

The motor output will only start if all alarm or stop-button is not pressed.

All interlock is present in this network also the time over as if batch is over then time over bit will become true and need to reset batch to start a new batch.

### Network 5 – Batch logic

Line 1 – As the motor output is Start & Stop and time over bit is not true the time will start for which Add block is used. If value or count goes above “60” the comparator will compare and move 1 in another Add block (Min. calculate) also move 0 in (Second calculate Add block).

“So, this line is timer of batch”

Line 2 – It compares current time with set time of valve 1 to open as current time become greater then set time of valve 1, the valve 1 will close.

Line 3 – In this too, compare is used to open valve 2 as current time should be greater than liquid 2 open time and current time should be less than liquid 2 close time. In between this valve 2 will open.

Line 4 – Same as liquid 2, In between liquid 3 open time and liquid 3 close time the valve 3 will open.

Line 5 – As current time becomes greater than batch end time, output time over will become true.

Line 6 – As time over the 2 second timer is used then batch start button will reset. So, we can start new batch or also batch stop if pressed the process will stop and batch start will reset.

Line 7 – In this batch, discharge will start if discharge button is pressed from HMI and batch is not in process.

Line 8 – As batch starts the discharge should be close. so, if this line started then discharge will automatically become reset.

### Network 6 – Batch reset time

Batch reset timer button is pressed then it will move 0 in sec. timer Add block and Min. timer Add block also reset the timer over bit.

### Network 7 – VFD (Variable Frequency Drive)

Here, Scaling is done using NORM\_X and SCALE\_X block. Which is inbuilt block of software for VFD.

In NORM\_X – We need to set min. and max. value as per VFD name plate or motor name plate. Setpoint is decided by user to run at what frequency. The output of this is used in SCALE\_X block in which 0 to 27648 count is scaled and goes to VFD as count.

### Network 8 – Temperature

This block is also used as scaling. It can be used Repeatedly for any scaling due to its high accuracy. Based on formula “ $y = mx + c$ ” or “ $y_2 - y_1 = (x_2 - x_1)m + c$ ” to calculate any value in between range.

For temperature set High limit and Low limit as per requirement which can be settable through HMI also (temp. simulation) is used instead of real input due to simulation purpose.

Output of this block is used to show required temperature in HMI.

### Network 9 – Current

For Current set High limit and Low limit as per requirement which can be settable through HMI also (current simulation) is used instead of real input due to simulation purpose.

Output of this block is used to show required current in HMI.

### Network 10 – Motor forward Rpm

For motor forward Rpm set High limit and Low limit as per requirement which can be settable through HMI also (motor fwd Rpm simulation) is used instead of real input due to simulation purpose.

Output of this block is used to show required motor fwd Rpm in HMI.

### Network 11 – Motor reverse Rpm

For motor reverse Rpm set High limit and Low limit as per requirement which can be settable through HMI also (motor rev Rpm simulation) is used instead of real input due to simulation purpose.

Output of this block is used to show required motor rev Rpm in HMI.

### Network 12 – Weight of powder vessel

In this block we can set suitable value of number for powder for mixing process.

This modification can be done by using HMI screen.

Output of this block is used to show value of powder added in to the vessel in HMI.

### Network 13 – Weight of liquid 2 vessel

In this block we can set suitable value of number for liquid 2 for mixing process.

This modification can be done by using HMI screen.

Output of this block is used to show value of liquid 2 added in to the vessel in HMI.

### Network 14 – Weight of liquid 3 vessel

In this block we can set suitable value of number for liquid 3 for mixing process.

This modification can be done by using HMI screen.

Output of this block is used to show value of liquid 3 added in to the vessel in HMI.

## 8. RESULT



Fig 5. Automatic Control Panel

Here, we successfully developed an automatic control panel as we designed the HMI screen and developed a PLC program which is required to simulate and control industrial mixer automatically. With this panel we can successfully handle the industrial mixer.

## 9.CONCLUSION

We have shown that in automatic control panel how modern devices like HMI and PLC help us to control industrial mixer successfully. Programmable logic controllers are a flexible and easily adaptable to typical industrial equipment such as the industrial mixer. These controllers are programmed by using a programming language called Ladder logic language. This language is easy to understand and is used by engineers and technicians thus can be changed to suit any particular need. HMI provides easy access to operator to handle mixing process also HMI screen provides real time data and updates time to time. The Industrial mixer is one of the several applications of the programmable logic controller to the control of an industrial process. This helps to eliminate huge costs.

## 10.REFERENCES

- [1] UNIQUE MIXERS AND FURNACES PVT. LTD.
- [2] Okoli F. I., Onubogu J. O., Okezie C. C., Okorogu V. N. International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319-9598, Volume-1 Issue-2, January 2013.

- [3] Bismah Hasan, Syed Sheraz-ul-Hasan Mohani, Syed Saiq Hussain, Sajid Yasin, Waqar Ahmed Alvi & Osama Saeed. Implementation of Supervisory Control and Data Acquisition - SCADA on a PLC and VFD Controlled Digital Mixing Plant Using TIA Portal.
- [4] Zhiqiang Wang 1\*, Xiaomei Wu 2, Dongmei Zhang 1, Fang Liu 1 of Scholars Journal of Engineering and Technology (SJET) ISSN 2321-435X
- [5] Dheerendra Yadav and Keerti Sharma International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622. (ICETMEE- 13th-14th March 2014)

## BIOGRAPHIES



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