

# Process Automation of Demineralization Plant using Delta PLC, Wonderware Intouch and Delta HMI



G. Jayanthi, Arunachalam S, B.Umamaheswari, P.Haritha, N.Balaji

**Abstract**— The proposed project is to design a commercial Programming Logic Controller based automation unit with SCADA and HMI for Demineralization Unit. In Demineralization, the raw water obtained from underground and Lake is treated to meet standard as per usage. Some of the closely monitored are pH, turbidity, etc. The automation tool designed uses DELTA PLC which is interfaced to local HMI which is in-turn connected to Wi-Fi using TP-Link thus supporting Remote Monitoring and Control. For centralized control unit SCADA is used by interfacing PLC with Computer. To match the communication protocol between PLC and SCADA, OPC software called KEPServer is used. Significant improvement in quantity and quality of demineralized water can be achieved. The proposed design is cost effective as it suit for small scale industry.

## I. INTRODUCTION

Reverse Osmosis (RO) is a desalination process which uses semi permeable membrane to remove salts and suspended particles from water. Osmotic Pressure is a natural pressure that helps in maintaining the Ion concentration. An exceeding pressure is applied to the high concentration in order to increase amount of water with low concentration. In this process the salinity of the process solution plays a major role. The porosity of the filter determines the efficiency of the process and so the design must be suitable to permit the solvent particles to pass freely. Certain pre-treatment may be required depending on the water used as input for reverse osmosis. In cases like water containing high concentration Iron when filtered using Reverse Osmosis tube may affects

the tube in a short period of time. This is used for industrial process and potable water.

## II. PROCESS DESCRIPTION

### 2.1 Reverse Osmosis

Osmosis process takes place only when external energy applied to the solution, and it occurs naturally whenever there is a difference in concentration between the two. The semi-permeable sheath that allows water molecules but not the majority of dissolved salts, and microorganism.

Fig 2.1 shows Bi-sectional view of Reverse Osmosis Tube. On the application of pressure to solution, the water molecules are contrived through the semi-permeable membrane and the contaminants are not allowed through.

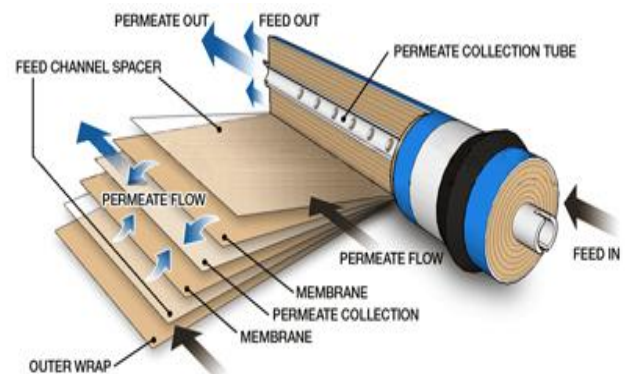


Fig 2.1 Reverse Osmosis Tube Bi-sectional View

Reverse Osmosis water purification process is a simple water filtration method. In this process the high pressure pump increases the pressure due to which the salts get deposited over the semi permeable membrane which is then passed through reject stream. Pure waters are carried by the water streams are called permeate water.

Reverse Osmosis is very essential in treating brackish, surface and ground water for flows applications. Industry that use RO water include pharmaceutical, boiler feed water, food and beverage, metal finishing and semiconductor fabrication. Water is pre-treated using DMF (Dual Media Filter).

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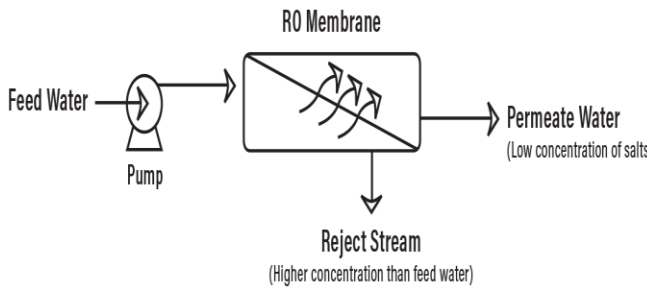


Fig 2.2 Single Stage RO Representation

2.2 Demineralization Process

Demineralization is carried out in order to obtain ion free water for industry uses. The process utilizes an ion exchange resins are eliminate the ionized salts. It does not eliminate organics, virus or bacteria. Electrode ionization is yet another prominent process to fashion deionized water.

Ultra-pure water: It is commonly used in semiconductor industries. Ultrapure water (UPW) has been purified to unusually precise specifications. It contains organic particles and dissolved gases eliminated. This system contain three stages are pretreatment stage, primary stage and polishing stage.

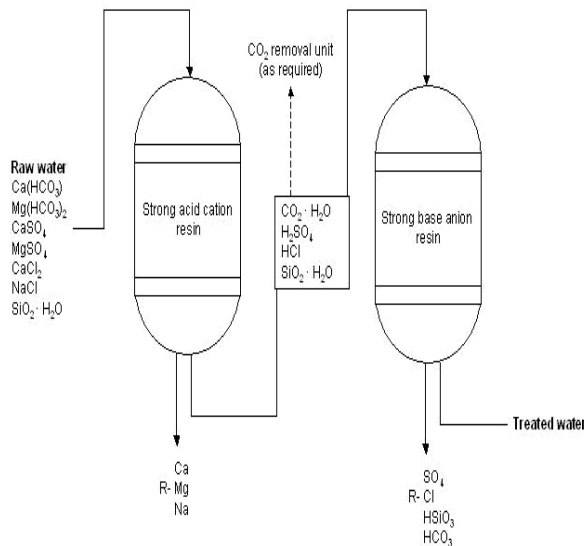


Fig 2.3 Resin systems

Table 2.1 Types of water based on conductivity

QUALITY	ULTRA-PUR E WATER	PURE WATER	PURIFIE D WATER
Typical Resistivity: Or	10-18MΩ	1-10MΩ	1-0.02MΩ
Conductivity:	0.1-0.0555mS/cm	1.0 -0.1 mS/cm	1-50 mS/cm
Produced by:	Polishing mixed-bed e.g. nuclear grade resins	Strongly Basic mixed-bed system	Weakly basic mixed-bed system

Fig 2.3, This system makes use of two vessels of which one is used to hold the cation exchange resin in hydrogen (H+) form and the other for anion resin in the hydroxyl (OH-) form. Water is made to flow across the cation column and as a result hydrogen ions are generated from the cations. The ultimate end product yielded is H2O which is obtained due to the interaction of the decationised water with the hydroxide ions.

III. HARDWARE

3.1 Block Diagram

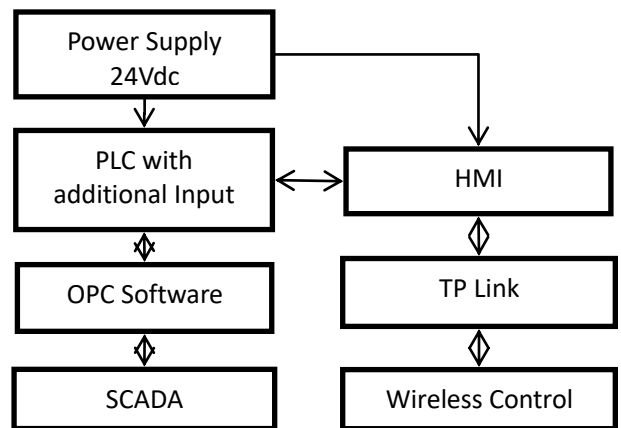


Fig 3.1 Block diagram

Fig 3.1 shows various blocks of the proposed system. Explanation of various blocks is described below.

3.2 PLC

A PLC is a programmable controller used in automation of electromechanical processes in an industry. The advantage of PLC is can handle few hundred I/O, noise reject, and vibration resistant. PLCs are armored for severe conditions using Panel (made up of Stainless steel coated based on environmental condition). The functionality of PLC includes sequential relay control, process control, distributed control system and networking. PLC facility for wide range of input/output (I/O) arrangements, extended temperature range.

IEC 61131-3 is an international standard; PLCs can be programmed by standards base programming languages.

Some of the advantages of using PLC over RELAY are,

1. Increased Reliability
2. More Flexibility
3. Lower Cost
4. Faster Response
5. Easier to troubleshoot
6. Remote control capability
7. Communication Capability

3.2.1 DELTA DVP-14SS2 11T

It is a slim type PLC, it has similar feature of sequential control functions as in case of DVP-SS series PLC with enhanced speed and real time monitoring ability. It has several inbuilt features such as high speed counters and Pulse output, PID auto tuning. 14 emphasis the total number of input and present in the PLC.



3.3 HMI - HUMAN MACHINE INTERFACE

Various terminologies used for HMIs (Human Machine Interfaces) are Man-Machine Interfaces (MMIs) and Graphical User Interfaces (GUIs). An HMI interacts with end users through buttons and lights. Text displays and graphical touch screens are available. It is used for simple process control.

Ethernet cables from PLC are used to connect remotely to the desired location.

3.3.1 DELTA HMI DOP B07415

The DOP-B07E415 from Delta Electronics. The Screen Editor software used to program the screen is free and easy to use. It also supports USB Host for direct connection to USB disk, printer and mouse. It has IP rating of 65. Fig 3.2 shows HMI 3D view and Table 3.1 show the HMI specification. Key features are Multilingual, recipes 16/32 bits, data collection, trends, alarms and more.

Table 3.1 HMI specification

Screen size:	7 inches
Resolution & Display:	800 x 480 pixels with TFT LCD, 65536 colors
Serial Ports communication	RS-232, RS-485, RS-422
Data Transfer / download	RS-232, USB, Ethernet
Power supply: 24V DC	24Vdca



Fig 3.2 B07E415

3.4 TP - LINK

TP – LINK is directly connected to HMI via Ethernet cable. TP – Link is used to create a local Wi-Fi network in which if the necessary setting in HMI is enabled then the HMI screen can be accessed in mobile as well. This enables the screen to be viewed in PC also. Thus, it can help in creating a cost effective SCADA screen.

3.5 RELAYS

A relay is an electromechanical switch primarily used as the output switching device in a PLC. A relay switches one or more poles, each of whose contacts can be thrown by energizing the coil in one of two ways, Normally Closed or Normally Open. The main use of relay is that it can be used as a switch for high voltage devices which cannot be directly controlled using PLC.

3.6 SWITCH MODE POWER SUPPLY

As PLC modules don't have internal power supply, PLC components that convert external power to the filtered, low voltage DC usable by the modules constitute the power supply module. It is mounted along the DIN rail and is

usually the first slot in the rack. Power supply to all the modules in that rack is derived from this module. Regulated power supply of 24V dc is required for PLC as well as HMI. 24V dc 2.1A SMPS is selected.

Separate expansion power module is used for every rack that is added. The expansion power supply passes 24V dc field power to the I/O modules to the right of it. One of the main parameters to be taken into account is the current rating to which the supply is given.

IV. SOFTWARE

4.1 WPLSOFT 2.45[1]

WPLSoft is used to communicate and construct programming for the specified process stated above. Programming is done on the Delta PLC Model SS2 which supports 8 Digital Input and 8 Digital Output. The programming can be done in any of the following languages: Ladder Logic, Sequential Flow Chart & Instruction List.

As per requirement the program name and file path are specified as soon as creating a new program. The model of PLC along with Programming which is going to be used. And last Communication protocol is selected.

Here the PLC used is Delta SS2 which is selected and it can contain programming up to 7920 steps in Instruction list format.

4.2 WONDERWARE INTOUCH

SCADA is a graphical representation of the plant or process to be controlled in 2D representation. It helps in easy observation & control and it is user friendly and some may also support interlock which are essential for safety. Interlock also helps in reducing the number of complex errors and is important for certain processes. Some SCADA also support the DBMS thus enhancing productivity and data logging further and future modifications.

4.3 DOPSOFT

HMI screen is created using DOPSoft. It supports 8 layers of protection; 0 being the last and 7 is the highest protective one. With various stages, control is assigned depending on one's area expertise. Online as well as offline simulation is done with the help of DOPSoft.

While creating a new project, the suitable product and the communication protocol is selected.

In DOPSoft,

- Step 1: Select Option
- Step 2: Configuration
- Step 3: Network app
- Step 4: Network Application.
- Step 5: To enable eRemote
- Step 6: To enable port (password is given)
- Step 6: Click OK.

4.4 EREMOTE

Software that facilitates communication between HMI and system with LAN cable thus also enable remote control. Connected HMI can be accessed from remote. While being used remote the local control on the panel is turned off.



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It also provides various security level making it possible for various level of control. eRemote facilitates the HTTP protocol thus the sharing the screen to multiple personnel local network is possible.

## 4.5 KEPSERVER

KEPServer is a OPC software that help in converting one type of standard communication to other standard based on international standard which are based on OPC UA. Thus greatly promoting wide range of interface such as external

database thus helping in data analysis of signals. Similarly here it used to convert Delta communication standard to WonderWare standard thus help in easy interface

## V. RESULTS AND CONCLUSION

### 5.1 Results

A Graphical User Interface for the feed preparation unit was prepared.

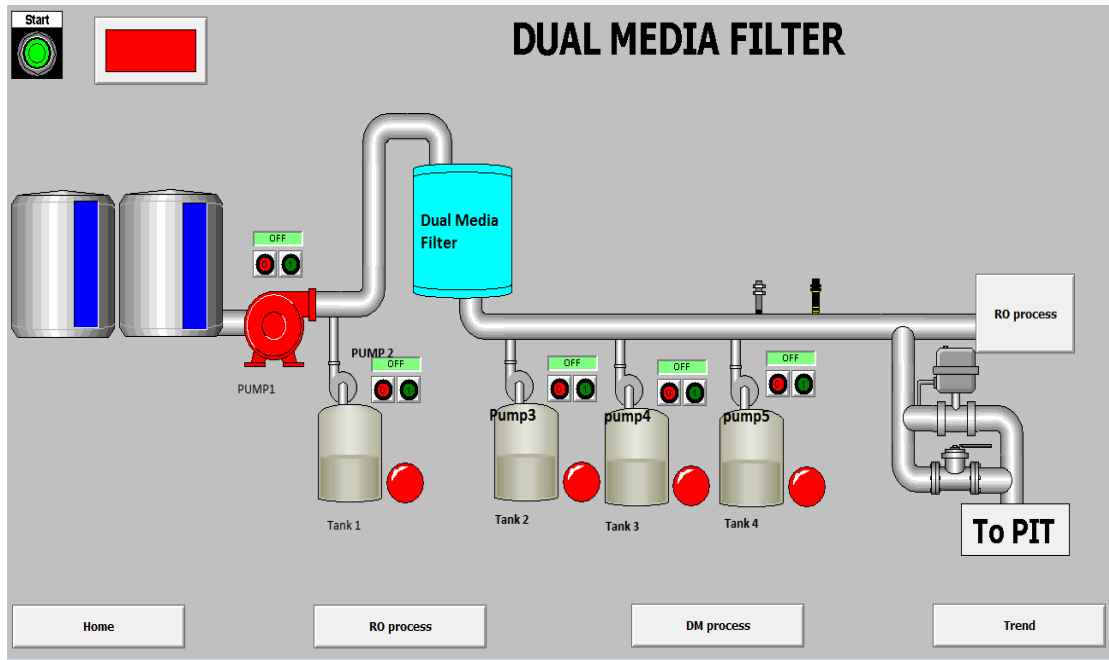


Fig 5.1 Dual Media Filter – Pretreatment of water

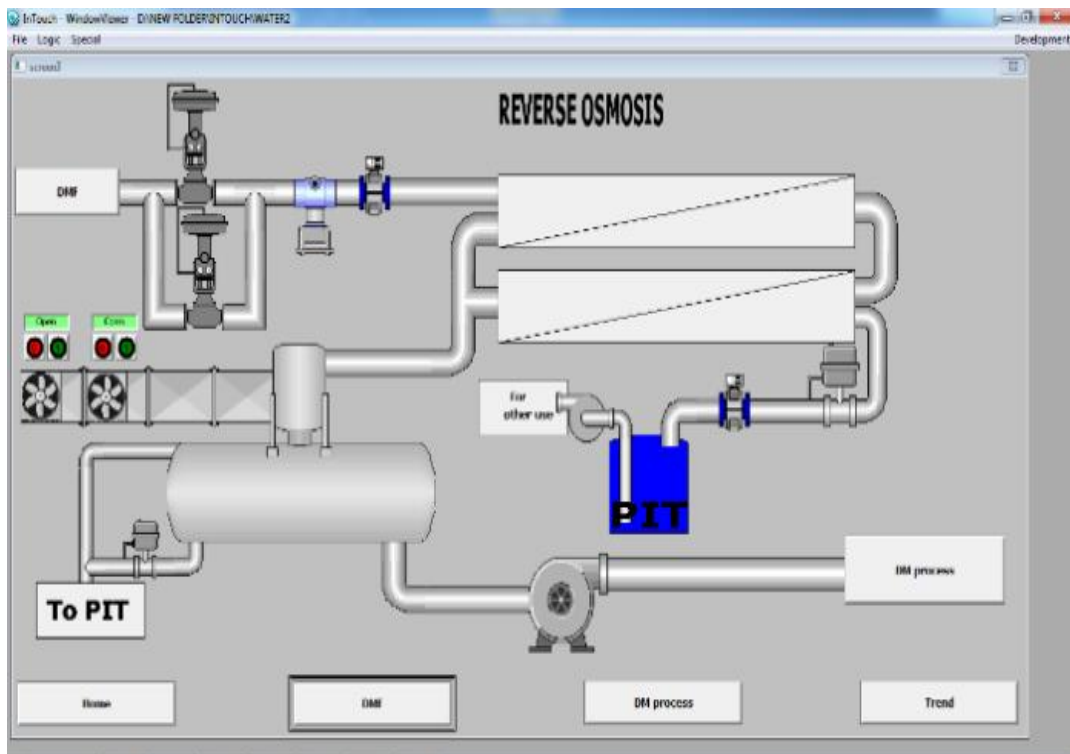
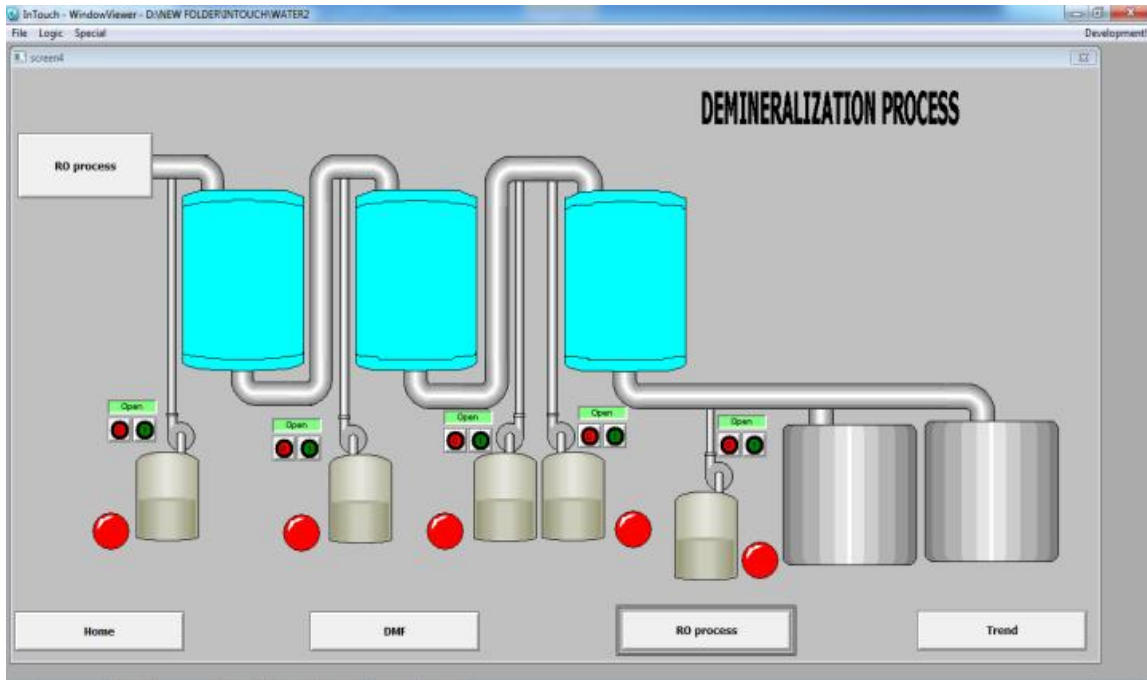
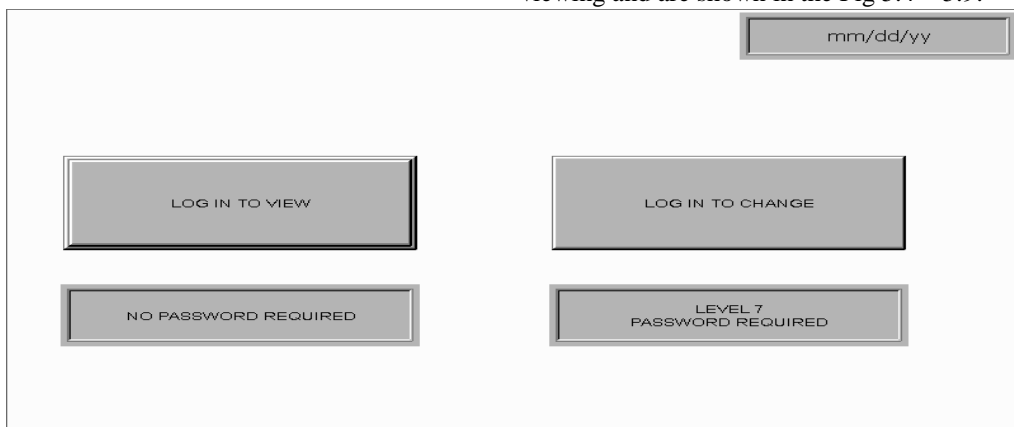


Fig 5.2 Reverse Osmosis Followed by Degasser unit

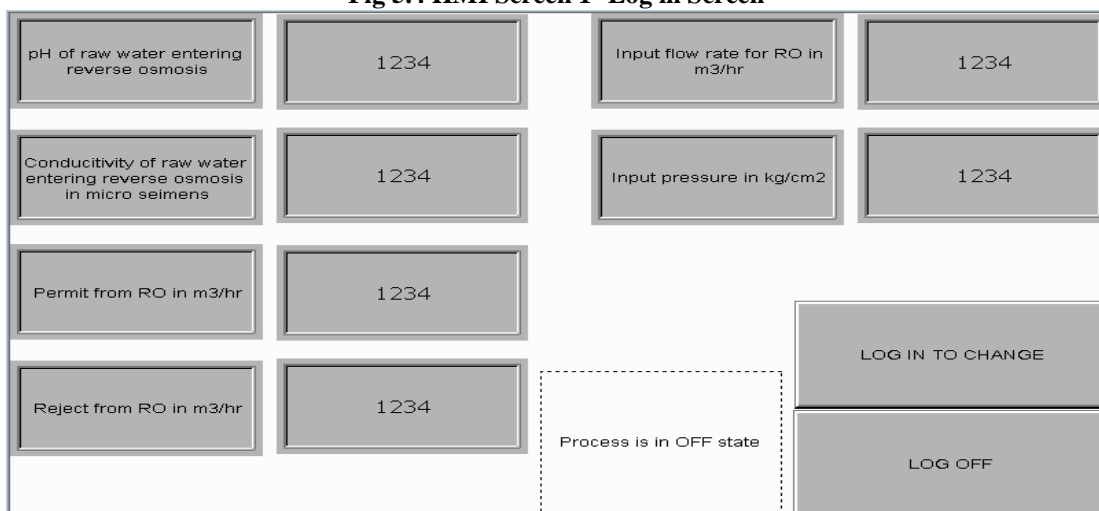


**Fig 5.3 Demineralization Unit**

The Following are the HMI screen created for remote viewing and are shown in the Fig 5.4 – 5.9.



**Fig 5.4 HMI Screen 1- Log in Screen**



**Fig 5.5 HMI Screen 2 - Process data view**

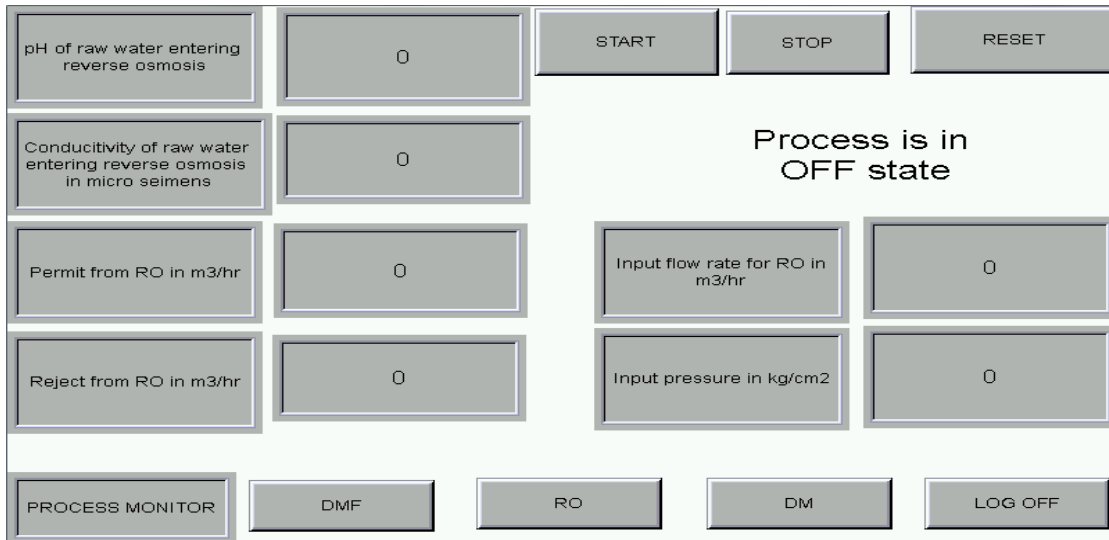


Fig 5.6 HMI Screen 3-Process parameter after Log in

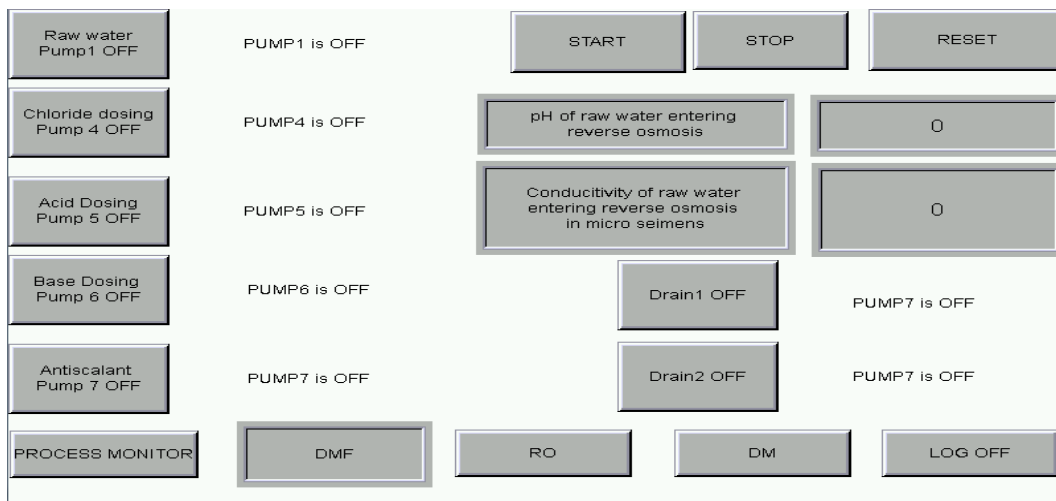


Fig 5.7 HMI Screen 4 - DMF status display

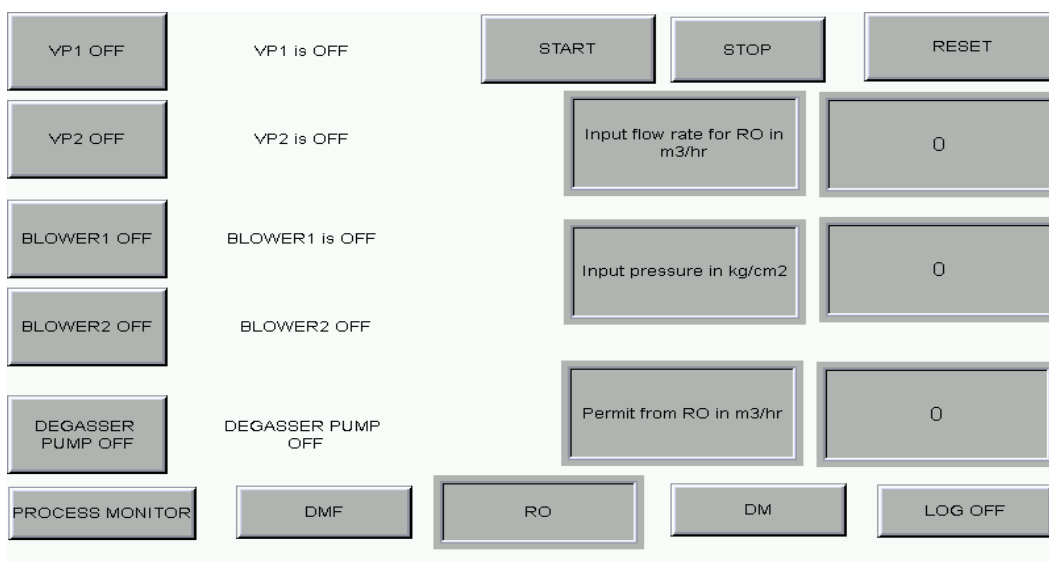


Fig 5.8 HMI Screen 5 - RO Process data display

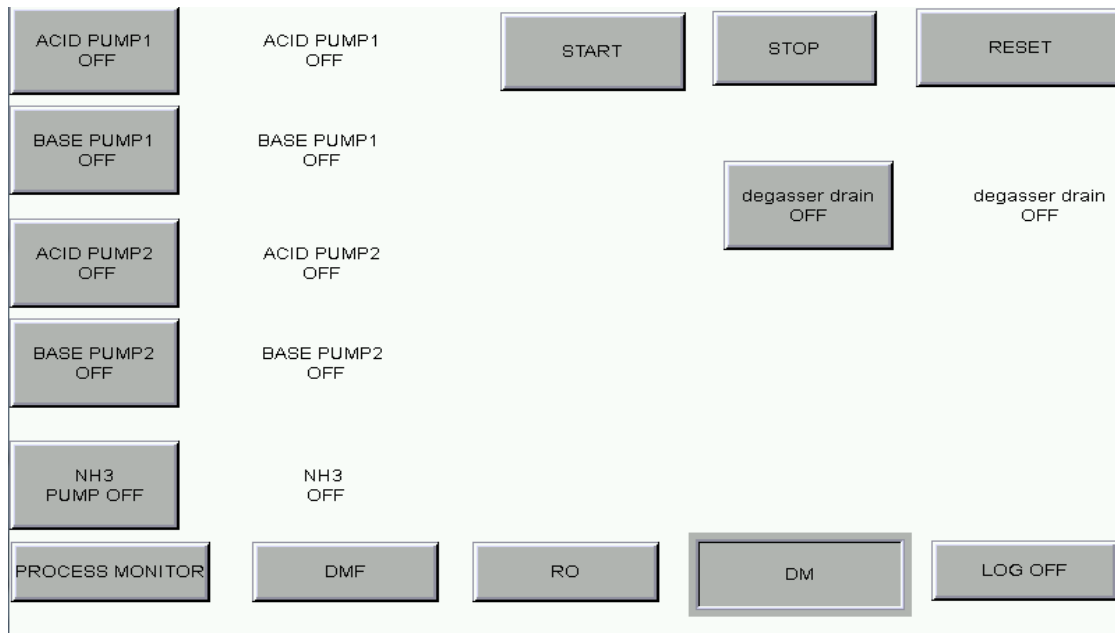


Fig 5.9 HMI Screen 6 - DM Status Display

5.2 Conclusion

Using the proposed design for the plant can redesigned and altered based on requirement of industry and can be altered easily to meet with budget of company. Better performance of human work force is achieved. Since, the process data are shared simultaneously thus reducing the communication gap. It is possible to include alarm well thus personnel can know what had happened as well. Various level of security is possible in HMI and hence various level of access can be designed. Since HMI can be designed to Control VFD as well from remote location.

5.2.1 Future Scope

The same procedure can be followed to design remote control unit for various process. Sharing of Data can be done via internet instead of local Wi-Fi. Thus, promoting IIoT (Industry 4.0) and it also helps in data mining and data retrieval for future use. It helps in increasing the efficiency and also helps in understanding the process more efficiently and external parameters can be determined and it influence can also be found.

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