PROGRAMMABLE LOGIC CONTROL (PLC) BASED AUTOMATION MODEL FOR IRRIGATION AND FERTIGATION CONTROL

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ABSTRACT

This paper describes an automation model developed for irrigation and fertigation around Programmable Logic Control (PLC) Allen Bradley, Micrologix1200C. Design of process flow uses same line to deliver fertilizers through drip lines. User friendly Human Machine Interface (HMI) screens devised in RSView32 allow operator to monitor and control process. Model is having characteristic features of point level sensing, rainfall detection, distribution line pressure detection and pump control action.

Keywords – Automation, Fertigation, HMI, Irrigation, PLC.

I INTRODUCTION

Agriculture sector is of course an attention gaining field for most of the countries in the world. Role of agriculture is termed as 'engine of growth'. So development in this domain affects directly or indirectly GDP per capita implies the rate of development of country too. Nowadays farmers generally prefer modern irrigation methods viz. Sprinkler or drip. These are tested & proven for efficient usage of water resources over conventional flooding methods. The most highlighting virtues about automation are improved usage of resources and quality of products, enhanced efficiency as well as optimization of man power. So the farming today, along with modernized irrigation methods and integrated with automation can remarkably become fruitful. To grab these advantages of both automation and modern irrigation systems, this paper puts forward an automation model which is based on Programmable Logic Control (PLC). PLC is robust and real time expert control system. Having own asset of rules, it can be used for logic development & to design finite control action. So this model is built around PLC. Further this paper describes each aspect of automation model by means of sensors, control logic, actuators, Human Machine Interface (HMI) and process flow.

II MATERIALS & METHODS

2.1 Detectors & Sensors

2.1.1 Float type level detectors

According to the position of float it shows make & break type point detection of level in the tank.

2.1.2 Bourdon tube pressure gauge

2.1.3 Rain detector

This detects sprinkles of water fall on the surface through its comb like structure imprinted on PCB.

2.2 Controlling Module & Software

2.2.1 Programmable Logic Control PLC - Allen Bradley Micrologix 1200C.

2.2.2 SCADA(Supervisory Control & Data Acquisition System)

2.2.3 RSlogix500, Ladder logic development environment

2.2.4 RSView32, to design SCADA mimic screens.

2.3 Actuators

2.3.1 Solenoid operated normally close (NC) type control valves

2.3.2 Motor operated stirrer

2.3.3 Pumps

2.4 Miscellaneous

2.4.1 Fertilizer tank

2.4.2 Water storage tank

2.4.3 Suitable piping & cabling arrangement

III DESIGN OF PROCESS

Drip irrigation method has been chosen in this process as it is possible to impart fertilizers from the same line. Primary source of water can be wells, river or canal which is available from that the pump1 lifts water to water storage tank provided. This tank is provided putting forward the usage of water for animal husbandry. This tank is provided with high & low level detectors L1 & L2. Pump2 and Sequential operation of valves V1, V2 & V3 directs flow of water either towards fertilizer tank or from fertilizer tank or towards field as per the selected mode (1 or 2) from control panel.

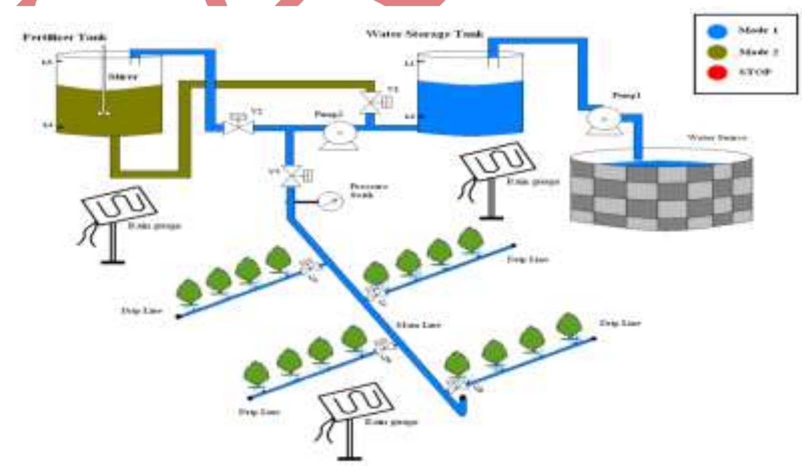


Fig.1 Process Flow Diagram

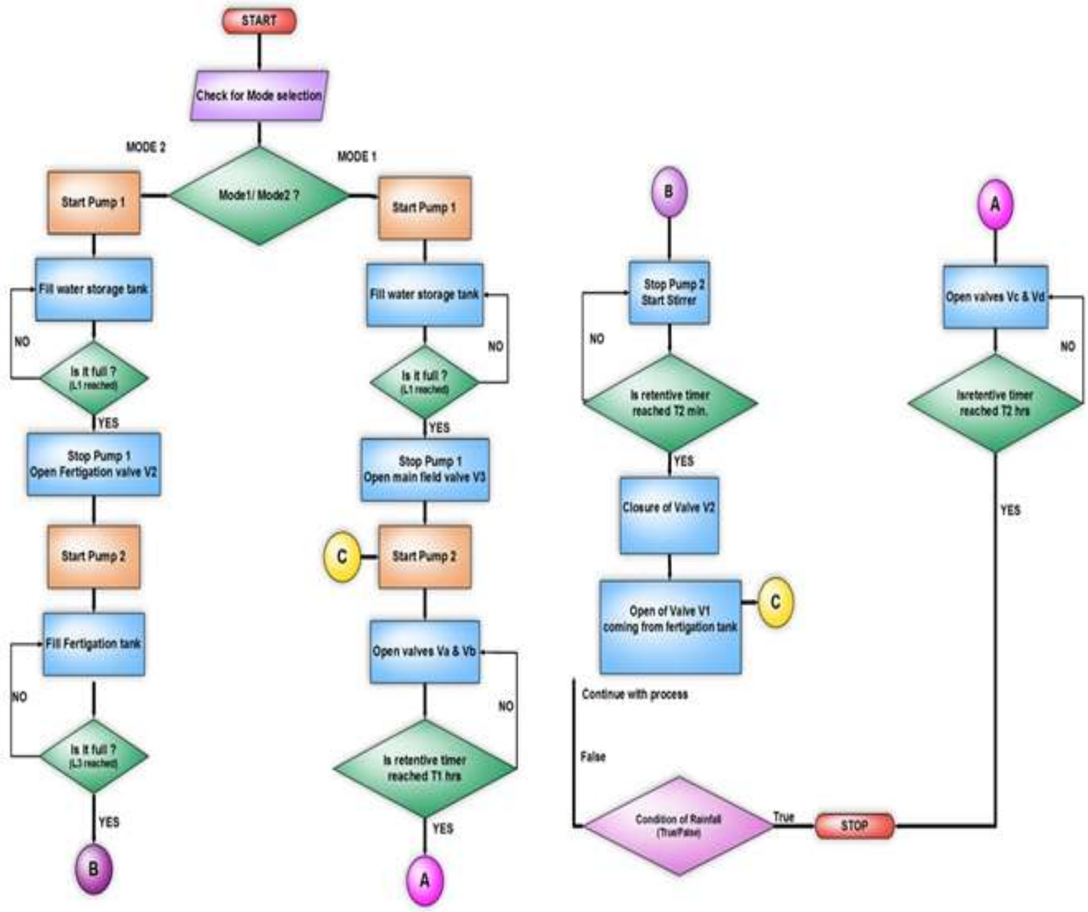
Fertilizer tank too is equipped with level detectors L3, L4 and Stirrer to solubilize fertilizers preferably all inorganic ones. Valve V3 discharges into the main channel having a pressure gauge downstream which goes in the field. Gauge visualizes line pressure suitable to start dripping down the line. Valves Va, Vb, Vc & Vd controls the flow to allow it to start drips in the desired part of field for desired time interval. This model is applicable for very large field areas also which implies extended time of irrigation. Considering potential climatic changes & rainfall conditions, network of rain gauges is integrated with the control system to trip the process. Three buttons are provided on the hardware control panel as well as on SCADA screen using which operator can either select the desired mode or stops the whole process at any instance of time.

Mode 1: Only for Irrigation

Mode 2: Fertigation

Stop : Will stop the process

IV . FLOWCHART



4.1 Mode of Irrigation

4.1.1 Process initiates feeding the input to the PLC by selecting required Mode of operation. Farmer (operator) can easily select desired mode from either hardware panel or SCADA screen on dedicated desktop Fig.4

4.1.2 Mode 1 will allow user to set purely Irrigation scheme designed for that field. On the other hand, user can choose Mode 2 if fertilizers are to be given. STOP button halts the process.

4.1.3 Obeying the given mode, PLC will start executing the program written in Ladder logic language exactly reflects same as the flowchart above. PLC will execute code rung by rung.

4.1.4 For the input Mode 1, control will check for the condition whether the water storage tank is full or not. This has been achieved using float type level detectors L1 & L2. Float is lifted by rising water level and it gives continuity signal to controller.

4.1.5 Pump1 will start to fill the tank gradually.

4.1.6 When tank will be filled Level detector L1 sends the signal to PLC which stops Pump1. This tank can be used as spare water supply facility apart from main water source. It is well used for animal husbandry or other emergency cause. Irrespective of any mode PLC will always check for the fulfilment of this water storage.

4.1.7 After it has been done, main field valve V3 will be opened. All valves used are solenoid operated & normally closed type DC valves.

4.1.8 Pump2 will start for the sake of water distribution to the field. Capacity of pump has been chosen in such way that it is able to develop sufficient pressure head in the line downstream to run drippers.

4.1.9 After that the valves Va & Vb will open. Actually opening of main field valve V3, starting of pump2 & action of Va, Vb valves occurs almost at same instance with few milliseconds time gap. Valves Va & Vb delivers water to different portions of field. The model described in this paper is designed in such way that at a time opening of these valves can retain pressure head necessary to drip.

4.1.10 PLC will start timer T1 as programmed in Ladder logic. Time is set as required for the portion of the field watered by Va & Vb. This timer is Retentive type of timer. It holds the time if power supply goes off & resumes from last stored value which solves the issue of uncertain power shut off on fields.

4.1.11 When timer resets, control logic closes Va & Vb and opens the set of valves Vc & Vd which waters for another two blocks in the field.

4.1.12 Retentive timer T2 measures the time estimated to water the blocks in the field covered by Vc & Vd.

4.1.13 When times up, it resets and drives the control to halt the process.

4.2 Mode of Fertigation

4.2.1 This automation model also serves the purpose of to give fertilizers with proper control algorithm through the same line which is being used for irrigation using Mode2. Almost all inorganic fertilizers show good solubility in water. Amount and type of fertilizers to be given to farm can vary with climatic conditions, type of crop and growth pattern of plants. Calculated quantum of fertilizers considering all these factors is poured in fertilizer tank.

4.2.2 Initiation of fertigation mode is done by pressing Mode2 from either hardware panel or SCADA screen. Two distinct subroutines are developed in Ladder logic to keep both logics separate and proper use of interlocks is done in the rungs of Ladder logic to reduce the effect of chattering on electromechanical systems like pumps and valves etc.

4.2.3 When PLC detects the bit set for Mode2 and it will execute the program from point 1.1.4 to 1.1.6 indeed which is to check the level of water storage tank.

4.2.4 After that valve V2 is opened this directs water flow in fertilizer tank.

4.2.5 Pump 2 starts & it lifts water from water storage tank to fertilizer tank.

4.2.6 PLC will check whether the level has reached up to L3. L3 & L4 both are float type point level detectors whose signal gives the indication of continuity.

4.2.7 When the condition falls true pump2 is stopped. Valve V1 is closed and stirrer starts rotating which triggers retentive timer. This timer is set with predefined time needed to solubilize fertilizers satisfactorily.

4.2.8 At times up, reset bit of timer closes valve V1. It is necessary to avoid re-flow of water towards fertilizer tank again when pump sends mixture of water & fertilizers in the drip lines.

4.2.9 Valves V2 and V3 are set open & pump2 will start running. Beauty of this model is the same pump will send water towards fertilizer tank & draws fertilizer solution & water from water storage tank simultaneously. So that the mixture of water plus fertilizers is formed within the distribution line itself.

4.2.10 After this, control logic is designed to execute the steps from 1.1.9 to 1.1.13 which in nothing but the batch of irrigation which efficiently delivers fertilizers to the all blocks in field through drippers integrated with regulated action of valves in field.

4.3 Rainfall Detection

4.3.1 These sensors are integrated in this model keeping the possibility of weather change if area of field in relatively too large which substantially increases the time for irrigation more than 6 to 8 hrs. These detectors are having a couple of comb like structures fits in to each other with some gap & imprinted on printed circuit board. When water droplets fall gives continuity.

4.3.2 Many such detectors are connected in AND logic to rectify the chance of false detection of rainfall due to water spillage or sprinkles.

4.3.3 When system is in running mode, PLC continuously monitors the signal from rain detectors. If all the detectors are got waterfall on it they will give positive logic true condition which eventually gives true value even after ANDing operation.

4.3.4 On detection of this signal PLC drives controls out of subroutine which is being executed and halts the process.

V DESIGN OF HARDWARE

Connection of hardware components is depicted in Fig.2. Start signal for mode1, 2 & stop is connected to I:0/0, I:0/1 & I:0/7 input channels of PLC Micrologix 1200C through a hardware control panel and also will reflects on SCADA mimic screen HMI (Human Machine Interface) on a dedicated desktop which is optional. Operator can manually press the push buttons on control panel or just click on the icon of buttons on SCADA Main screen Fig.4.

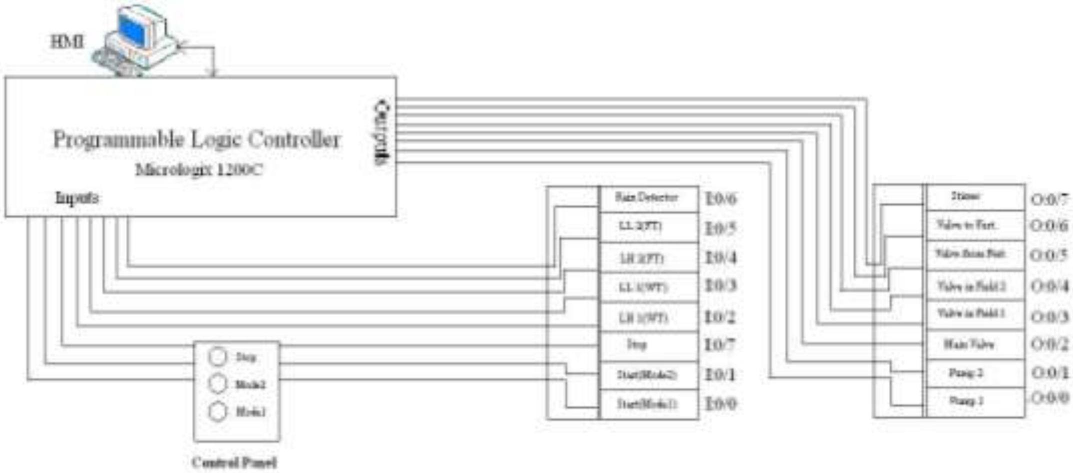


Fig.2 Hardware Wiring Diagram

Similarly other actuating components are connected to 8 channel output card of PLC. Valves in Field1 implies set of valves Va & Vb and valves in Field2 implies set of valves Vc & Vd which are connected to O:0/3 & O:0/4 output channels of PLC respectively.

Human Machine Interface (HMI) is having user friendly and self explanatory mimic screens. Operator can easily control and monitor whole process in real time. There are three screens. First shows overall process scenario and other two individually depict Irrigation & Fertigation process.

VI . DESIGN OF SOFTWARE

The automation model described in this paper is developed around PLC Micrologix 1200C (Allen Bradley make).

6.1 RSLogix500

This software provides program development environment to write Ladder logic routines. It is IEC-1131 compliant ladder logic coding package & supports Micrologix family processors of Allen Bradley.

Brief procedure followed to create PLC ladder diagram

6.1.1 Launching RSLinx we can select drivers to set communication between PLC controller & system. 'Who Active' pane will show peripherals communicated.

6.1.2 Clicking on 'New' new project can be created. At this step processor has to be chosen from dropdown list.

6.1.3 Rung by rung program can be written following the flowchart 4 for this model. From the tool bar desired contacts (NO, NC etc.) & special purpose logics like timers, counters, conditional jump etc. can be selected by drag drop action.

6.1.4 Program can be loaded in the microprocessor of PLC by clicking 'Download'.

6.1.5 'Go online' gives facility to visualize status of each logical block in rung online.

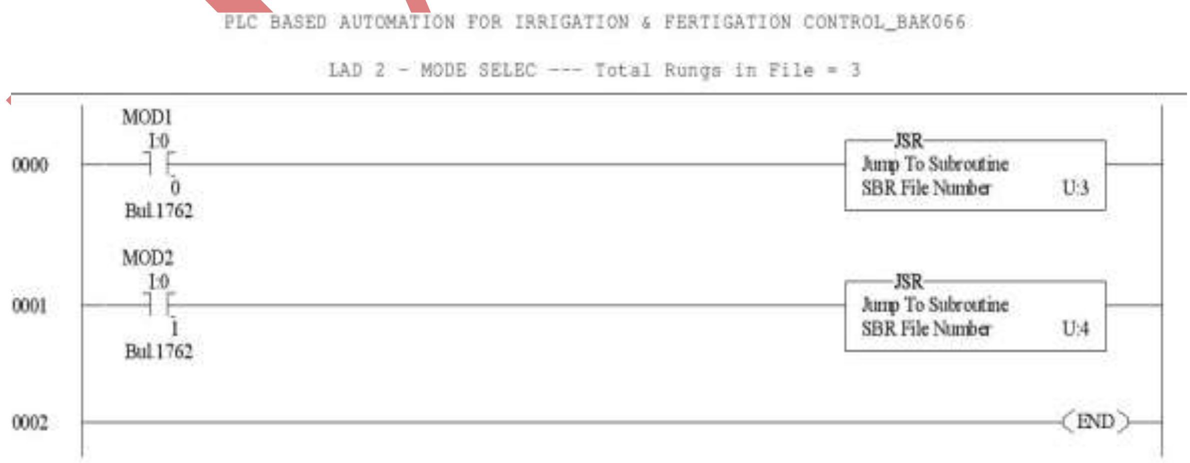


Fig.3 Visualization Of Ladder Logic Developed In Rslogix500

Ladder logic for Mode selection is depicted in Fig.3. I:0/0 & I:0/1 are normally open (NO) contacts. Two separate subroutines for Irrigation and Fertigation mode are stored in U:3 and U:4 data files respectively following exactly same as flowchart 4.

6.2 RSView32

Using this software monitoring and control of whole process is done. It has feature of interaction between Microsoft systems, Rockwell automation products and other third party devices. Fig.4, Fig.5 and Fig.6 are showing screens designed for control and monitoring purpose which renders user friendly Human machine Interface (HMI).

VII. RESULTS AND DISCUSSION

7.1 Trend of HMI mimic screens developed can be seen in Fig.4, Fig.5 and Fig.6. Visualization of total process reflects in Fig.4. When operator clicks Mode1 or Mode2, PLC seems to be executing respective routines flawlessly. Clicking on STOP pane stops the process at the same instance.

7.2 Interconnectivity of screens

Interlinking amongst HMI screens works spontaneously so that user can roam through real time ongoing process, can monitor & control without actual physical presence on field. Of course, wastage of time and human efforts are minimised.

When clicked on 'TO PANEL SCREEN' pane on main screen it opens individual mimic screens of irrigation or fertigation. 'Process' pane on both the screens toggles between same two. 'Main Screen' button will lead user to return on total process screen.

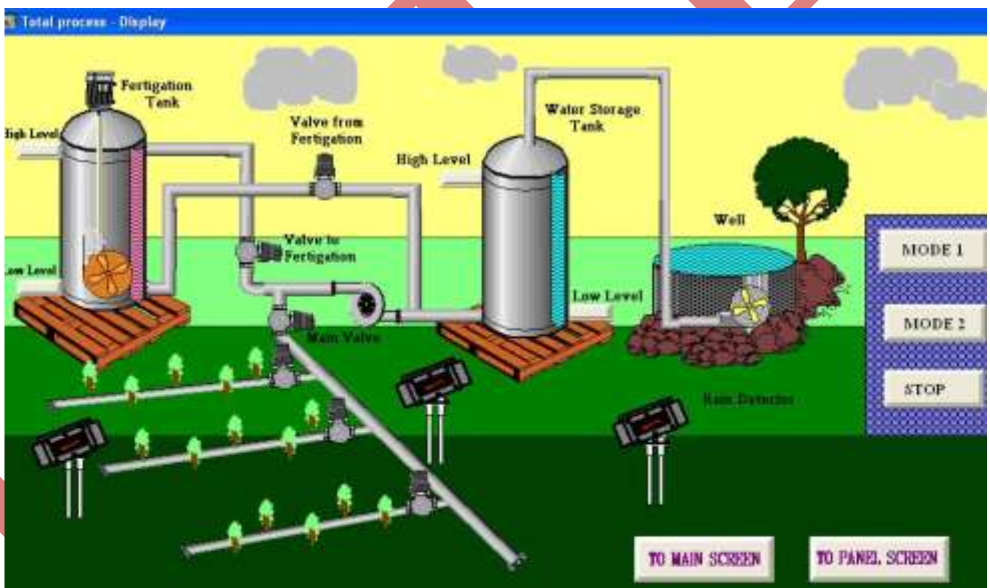


Fig.4 Main HMI Screen Whole Process

7.3 Real time indication

Each representation of signals (High, Low levels) and components (valves, pump) on the HMI screens show their instantaneous status in different colours. Red shows OFF status & green shows ON or running status. This facility furnishes operator with the status of each device in the field sitting at one place.

7.4 Hardware panel shown in Fig.2 also has been observed working flawlessly. In some cases where it is not possible to provide dedicated system with HMI screens or occurrence of communication failure between system and PLC is observed, operator can choose mode or stop process using the push buttons provided on this panel.

7.5 Where there is need to count the time, retentive timer logic blocks are used. In case of power failure which is quite obvious in the fields these timers seem to hold last instance of time and start from there itself on acquiring power supply. It avoids timer reset on power failure and subsequent restart of selected mode from beginning.

7.6 It is clearly observed that rain detection logic works omitting possibility of false detection. Series connection of rain detectors facilitates AND logic so, logic to trip the process is executed upon delivering true condition from each detector.

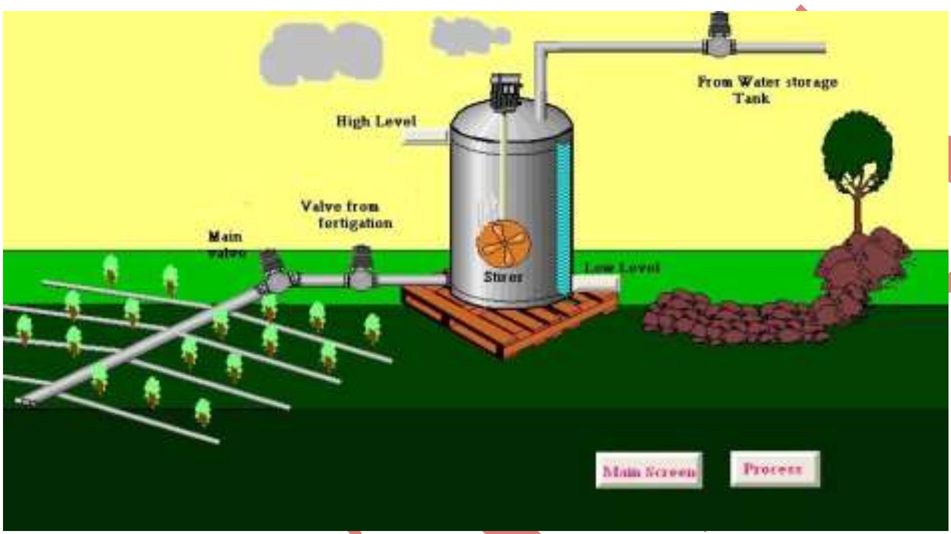


Fig.5 Fertigation Process Screen

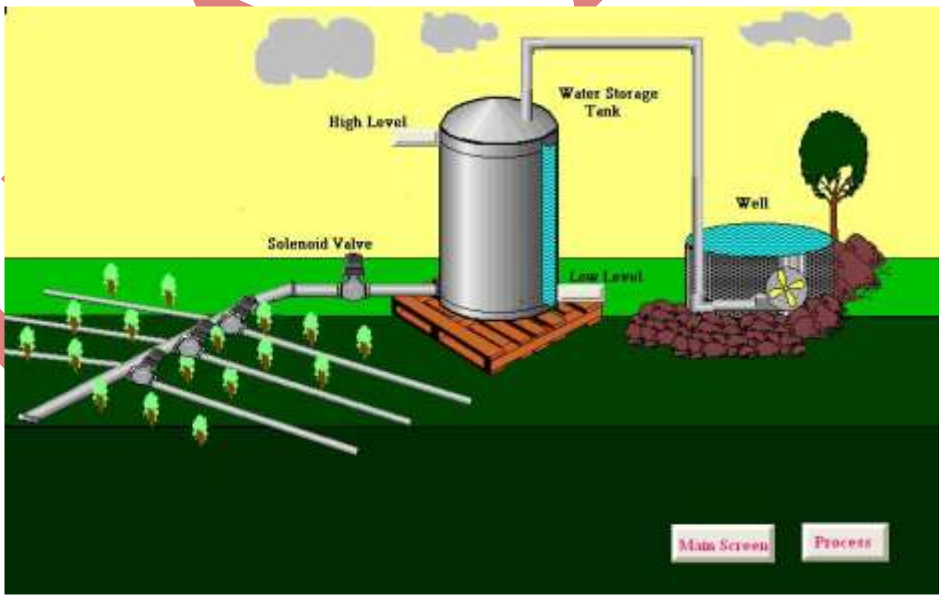


Fig.6 Irrigation Process Screen

VIII . CONCLUSION

This paper gives a trustworthy automation model for Irrigation and fertigation as well through the same water distribution line. Block of field downstream to valves Va, Vb, Vc or Vd can be of farmer interest, either green houses or open cultivated land. So this model has flexibility to work efficiently for open cultivation land, large gardens & yards as well as green houses. It can be implemented for large cultivation area fields. So farm personnel can set free from labour work like attending the valves in the field, open it & after few hours again go back and close. HMI screens give clear insight of ongoing process to operator so single person can monitor & control distribution of water or fertilizers over whole field. So provides substantial cut off in labour cost. This model trickily removes unwanted automation part compared with some systems already present in market so is cost effective and relatively cheap. For example, some automation systems designed for fertigation checks PH of soil and decide which of the fertilizers have to be given from the already kept set of different fertilizers in tanks. This unnecessarily adds cost of multiple fertilizer tanks, their valves & piping design and most important ratio control logic to the model. In practice no farmer fully relies on such system to give fertilizers. They generally use their own experience and methods to decide quantum of fertilizers to be given, here our model allows farmers to take their own call and dump desired amount in to dedicated fertilizer tank. Another facility which makes this model flexible regarding cost is requirement of HMI screens on the dedicated desktops. It can be left on user interest. Control over process is as easy as from hardware panels without HMI screens.

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