Design & Control of Batch Process for Agrochemicals Using PLC

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***Abstract:*PTCL (Pretilachlor) is one of the pesticides using in agriculture to kill the insects in crops. It has 7 batch processes like PEDA formation, PEDA workup, DEA recovery, PEDA fractionation, PTCL reaction, PTCL workup, and PTCL final concentration. After completion of all these stages Pretilachlor final product will be obtained, which is a raw product for some another venders to manufacture another type of chemicals. These batch processes are going to be implemented using Allen Bradley (PLC). The software using to develop the ladder logics is RSlogix. Actually these reactions are implemented in industries using DCS with software DeltaV. In these processes the total no. of inputs and outputs are 90 including both analog and digital. For simulation convenience all type of I/O's are considered as digital only.**

***Keywords:*AB PLC, Ladder Logic Diagram, RSlogix 500 Software, Pretilachlor (PTCL), SOP, DCS.**

I. INTRODUCTION

A Programmable logic controller (PLC) is a device that was invented to replace the necessary sequential relay circuits for relay control. A relay acts as an electromagnetic switch. A relay may be defined as an electrically actuated contact maker or breaker. It consists of an iron bar with a through a base and a movable contact through iron. When voltage is applied to the coil, a magnetic field is generated. This magnetic field sucks the contact of the relay in causing them to make a connection. They allow current to flow between two points thereby closing the circuit. When the switch is open, no current can flow through the coil

Causing the magnetic field to build up. The PLC was first developed for General Motors Corporation in

1968 to eliminate costly scrapping of assembly line relays during model Changeovers. By 1971, PLC was being used in applications outside automobile industry. As per NEMA standards, a programmable logic controller (PLC) may be defined as a digital electronic apparatus, which uses a programmable memory for storing instructions to implement specific functions such as logic, sequencing, timing, counting and arithmetic, to control machines and processes.

II. ARCHITECTURE OF PLC

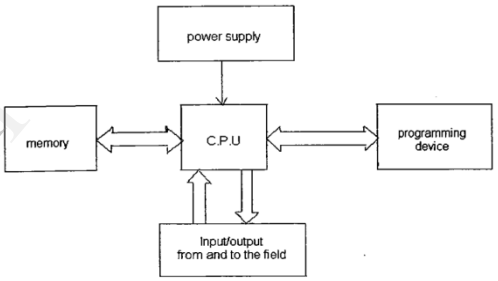

Fig 2.1 PLC Block diagram

Here the central processing unit is considered to be the heart of the programmable logic controller. We can program the PLC in the field itself. This can be done using a programming device which can be a hand held computer or a personal computer. The communication with the system will be a serial communication using a RS-232 or RS-485 cable. The control program is stored memory. The external power supply module caters the need of all the modules. It directly controls the outputs taking into consideration of the various inputs.
Programmable logic controllers (PLC) have been evolved out from Relay logic circuits (RLC).
The relay logic circuits are hard wired. When the process became complicated and [automation level increased so did the circuits. There RLC's had many drawbacks. Viz.,
1. Circuits were bulky.
2. Troubleshooting was very difficult
3. Inflexible.

III. PTCL BATCH PROCESS USING PLC

PTCL (Pretilachlor) is one of the pesticides manufacturing in the NACL (Nagarjuna Agrichem Ltd) using DCS. It has

7 stages to get the final product. Those 7 stages explained below.

STAGE 1

PEDA Formation is the first process for PRETILACHLOR. In this process DEA and CPE are using as raw materials. Add the raw materials in the ratio as per the size of the batch i.e. volume of the reactor. After addition process allow the steam to circulate around the reactor until reach the temperature 75°C and close the reactor vent valve. Continue heating still reaching temperature 140°C and close the steam supply. And maintain the temperature 170°C for 16 hrs. and transfer the reactant mass to next reactor for next process.

Table 3.1 Standard Operating Procedure (SOP) of PEDA Formation

S. No	OPERATIONS
1	Receiving the RM for PEDA reaction
2	Check and ensure that the reactorR-916 are empty, bottom valve is closed and reactor ready for use
3	Charge recovered DEA from CT-903 to MT-915 Qty : 3528 kgs
4	Charge fresh DEA from bulk tank / drums toMT-915.Approx Qty : 1156.68 kgs
5	Charge CPE to MT-918 from drums. Qty : 650 kgs
6	Charge DEA from MT-915 to R-916
7	Settle the DEA in the reactor for 15 min
8	Separate the water from bottom and pump it to R-917
9	Charge CPE from MT-918 toR-916
10	Ensure that the jacket is empty and open the steam trap valve of the reactor
11	Heat the contents to 75±5 deg °C
12	Continue heating and attain a temperature of140±5 °C
13	Close the steam supply to the reactor
14	Maintain a temp of 170 ± 5°C for 16 Hrs
15	Transfer the reaction mass from R-916 to R-917 under stirring

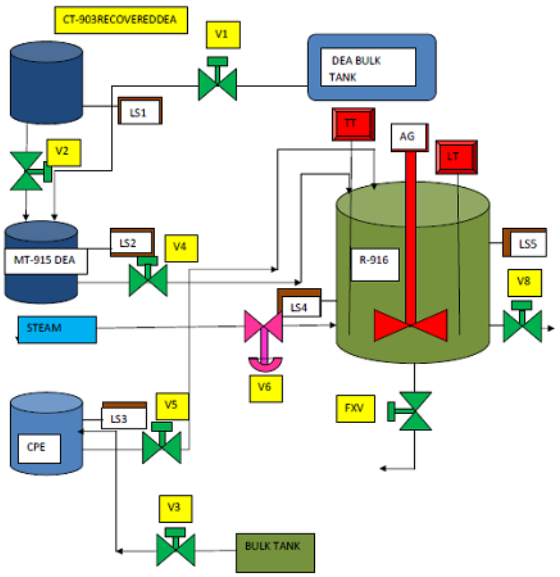

Fig 3.1 Process Flow Diagram of PEDA Formation

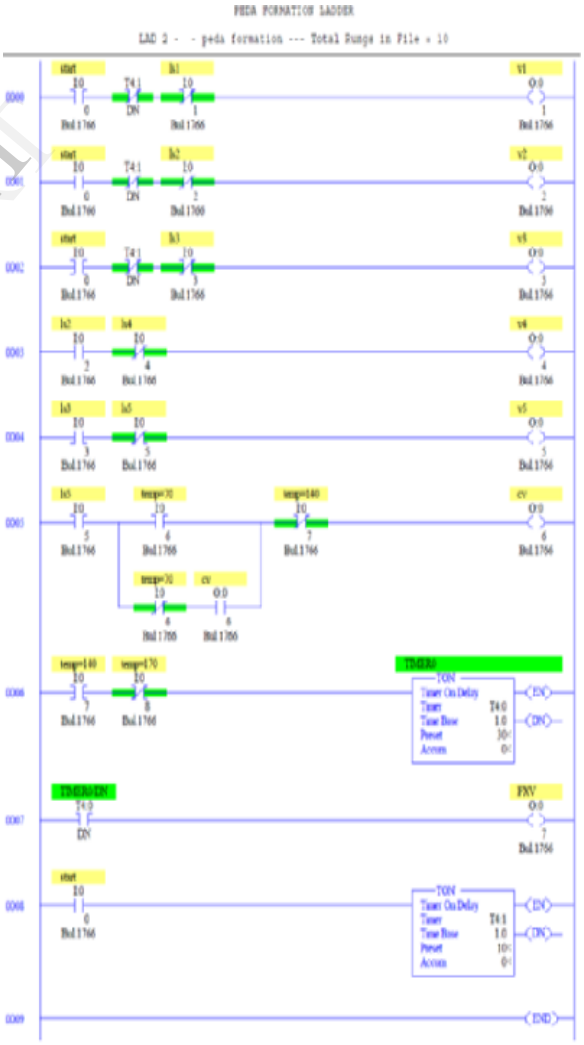

Fig 3.2 Ladder Logic for PEDA Formation

STAGE 2

PEDA Workup is the second process for PRETILACHLOR. In this process water, NaOH and previous reactant mass are using as raw materials. Add the raw materials in the ratio as per the size of the batch i.e volume of the reactor. After addition process start the Agitator to stir the mass and stop agitator and settle the mass for 15 min. Take the pH measuring if result is not ok again add NaOH, if result is ok allow the steam to circulate around the reactor un till reach the temperature 90°C. Now apply cooling water to get temperature to 75°C. And transfer the reactant mass to next reactor for next process.

Table 3.2 PEDA Workup

S.No	OPERATIONS
1	Check the reactor R-917 and ensure that it is empty, bottom valve is closed and ready for use
2	Charge water from T-901B / MT904 to R-917 Qty : 3000 / 3700 / 4600 liters
3	Charge NaOH from MT-912 to R-917. Qty : 300 / 370 / 465 Liters
4	Keep R-917 under stirring
5	Transfer the reaction mass from R-916 / R-920 / R-923 / R-926 to R-917 under stirring
6	During transferring time take sample of PEDA and send to QC for analysis
7	Stir the mass in R-917 for 15 min
8	Stop agitator
9	Settle the mass for 5 min
10	Take sample from R-917 bottom and check pH
11	If the result is not OK then add NaOH from MT-912.
12	If result is OK then apply steam and heat upto a temp of 90 ± 2 °C.
13	Maintain for 1hr
14	Apply cooling water to jacket
15	Cool the contents to 75 ± 5 °C
16	Transfer the top organic layer to ST-901

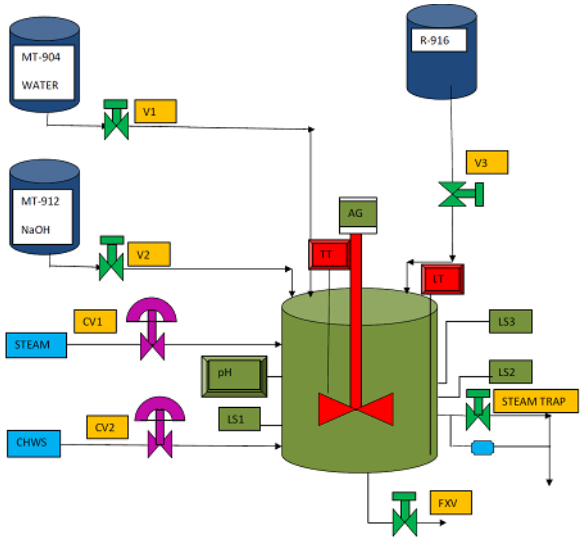

Fig 3.3 Flow Diagram for PEDA Workup

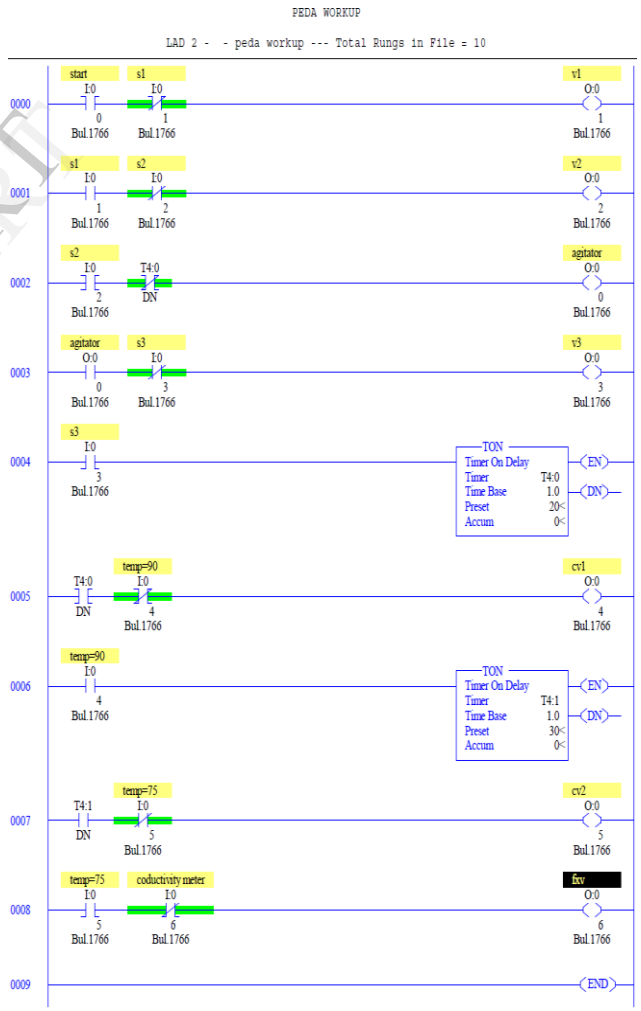

Fig 3.5 Ladder Logic for PEDA Workup

STAGE 3

DEA Recovery is the third process for PRETILACHLOR. In this process previousreactant mass PEDA Organic is using as raw material to undergo the differentreactions like applying vacuum and apply steam to reach the temperature 160°C undervacuum. Now keep the mass under total reflux for 1 hr and take the sample for QC.Stop the heating and breakdown the vacuum with N2 and transfer the reactant mass tonext reactor for next process.

Table 3.3 DEA Recovery

S. No	OPERATIONS
1	Check the reactor R-903 and ensure that it is empty, bottom valve is closed and ready for use
2	Apply vacuum to reactor by opening 1 stages of ejector
3	Charge the PEDA organic from ST-901 to R-903. Qty : Approx. 8000 Liters
4	Apply vacuum to reactor by opening 3 stages of ejector slowly
5	Heat the mass up to 160± 5 °C under vacuum
6	Keep the system under total reflux for 1 Hr
7	Collect online sample from reflux line and send it to QC for analysis
8	If the result is OK
9	Stop heating & break vacuum with N_2
10	Transfer the PEDA crude from R-903 to T-903
11	During transferring collect PEDA crude sample and send to QC for analysis
12	Check the reactor R-903 is empty

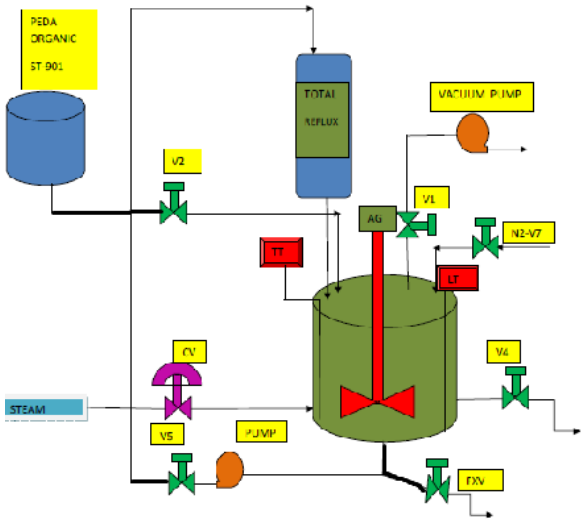

Fig 3.6 Process Flow Diagram of DEA Recovery

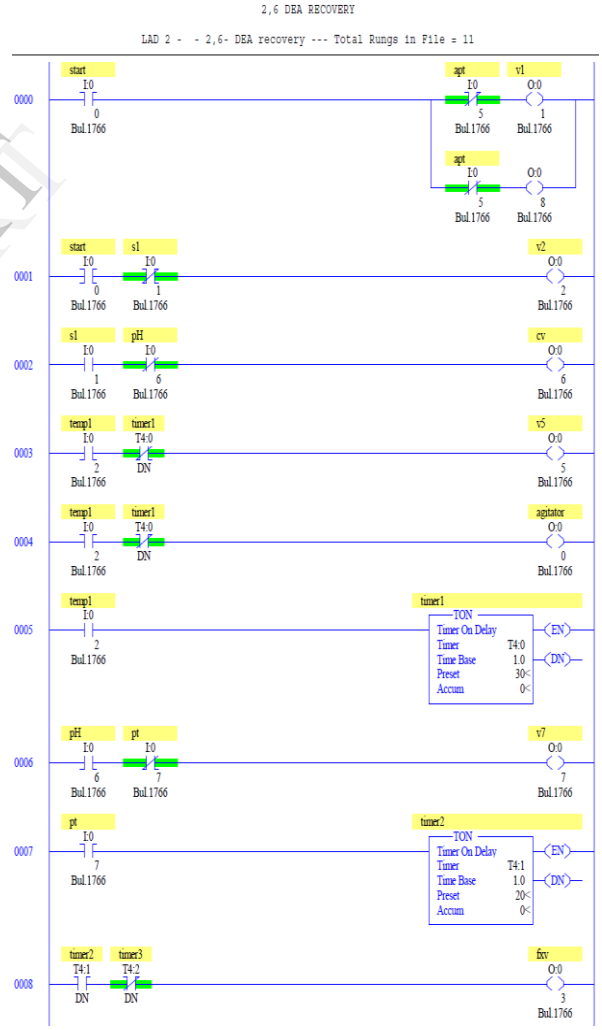

Fig 3.7 Ladder Logic Diagram for DEA Recovery

STAGE 4

PEDA Fractionation is the fourth process for PRETILACHLOR. In this process previous reactant mass PEDA Crude is using as raw material to undergo the different reactions like applying vacuum and start agitator apply steam, hot oil to reach the temperature 175°C under vacuum. Now keep the mass under total reflux for 1 hr and take the sample for QC. Collect the material at precut, intercut, main cut stages for next reaction. Once reaching the temperature 210°C stop last cut and stop heating also. Breakdown the vacuum with N2 and transfer the reactant mass to next reactor for next process.

Table 3.4PEDA Fractionation

Sr. No	OPERATIONS
1	Check the reactor R-902/R-911/R-915 and ensure that it is empty, bottom valve is closed and ready for use
2	Apply vacuum to the reactor
3	Receive PEDA inter cut of previous batch.
4	Transfer the PEDA crude from T-903 to R-902 / R-911 / R-915
5	Start agitator
6	Open the hot oil valves and start hot oil circulation to the reactor
7	Heat the mass up to 170± 5 °C
8	Keep the system under total reflux for 1 Hr
9	Once the mass temperature reaches to 205 – 210 °C stop Last cut collection
10	Close the ejector steam valves.
11	Stop the hot oil circulation to R-902
12	Break vacuum with N_2
13	Drain the residue from R-902 toT-902

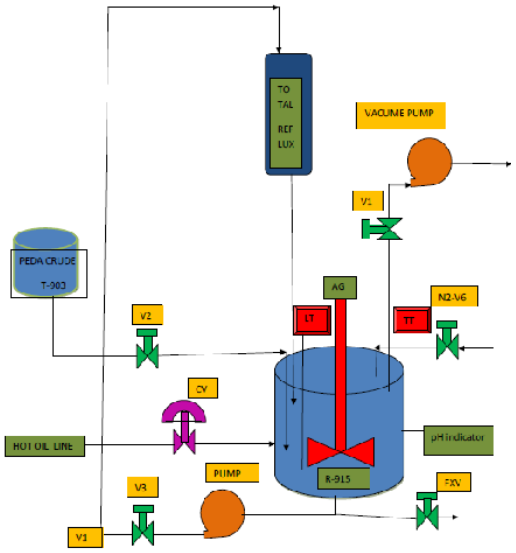

Fig 3.8 Process Flow Diagram of PEDA Fractionation

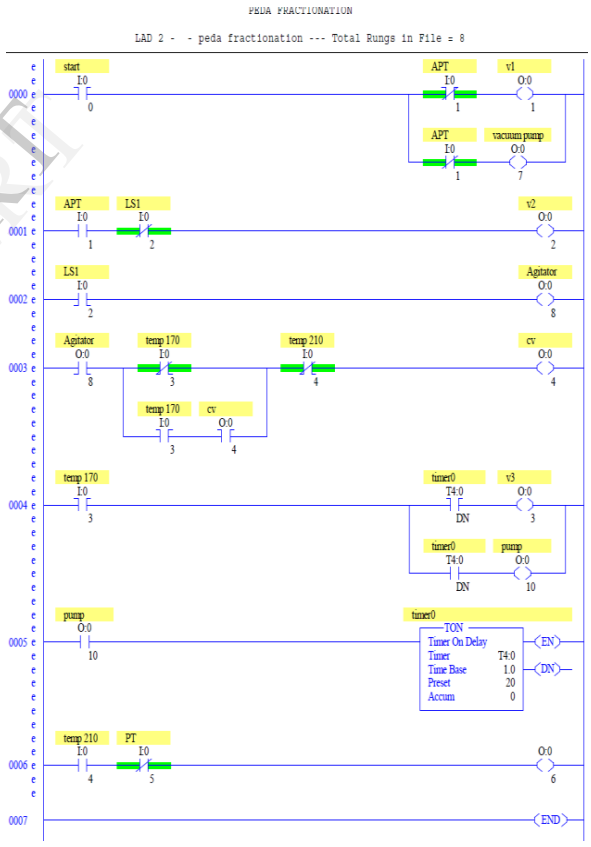

Fig 3.9 Ladder Logic Diagram for PEDA Fractionation

STAGE 5

PTCL Reaction is the fifth process for PRETILACHLOR. In this process CAC, n-Hexane, and previous reactant mass main cut are using as raw materials. Add the raw materials in the ratio as per the size of the batch i.e. volume of the reactor. After addition process start the Agitator to stir the mass and apply child water, slowly add CAC under 55°C. Apply steam to the reactor and keep the mass under total reflux for 3 hrs. Cool the mass to 35°C. And transfer the reactant mass to next reactor for next process.

Table 3.5 PTCL Reaction

S.No	OPERATIONS
1	Receiving the RM for PTC
2	Charge CAC from drums to MT-910 Qty : 1000 kgs
3	Pump recovered / fresh n-hexane from T-922 / CT-909A / bulk tank to MT-919
4	Pump batch quantity PEDA main cut from CT-902A / CT-911A / CT-915 to MT-917 Qty : 2055 kgs
5	Check the reactor R-910 and ensure that it is empty, bottom valve is closed and ready for use
6	Check that chilled water circulation is on to primary and secondary condenser
7	Charge n-hexane from MT-919 to R-910 Qty : 3000 Liters
8	Settle it for 15 min
9	Separate the bottom water layer and pump to R-919
10	Charge PEDA main cut from MT-917 to R-910
11	Start the agitator
12	Apply chilled water circulation to reactor jacket
13	Slowly add CAC from MT-910 to R-910 from room temperature to 55 ±5 °C
14	After addition drain the reactor jacket
15	Apply steam to reactor
16	Reflux mass at 55±5°C for 3 hrs
17	Take reaction sample from R-910 and offer to QC
18	Apply cooling water circulation to jacket
19	Cool the mass to 35 ±5 °C
20	Transfer the reaction mass from R-910 to R-919 by pumping

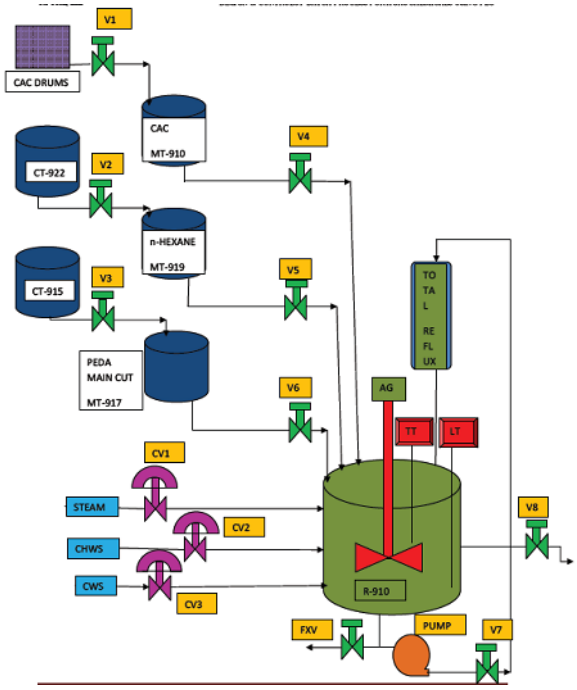

Fig 3.10 Process Flow Diagram for PTCL Reaction

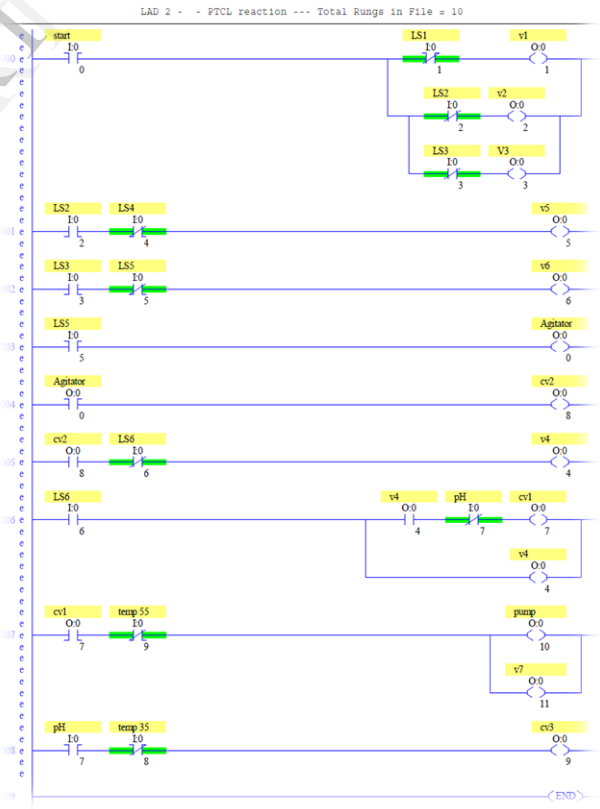

Fig 3.11Ladder Logic Diagram for PTCL Reaction

STAGE 6

PTCL Workup is the sixth process for PRETILACHLOR. In this process water, Na2Co3 and previous reactant mass are using as raw materials. Add the raw materials in the ratio as per the size of the batch i.e. volume of the reactor. After addition process start the Agitator to stir the mass and remove the aqueous layer and transfer the reactant mass to next reactor for next process

Table 3.6 PTCL Workup

Sr. No	OPERATIONS
1	Check the reactor R-919 and ensure that it is empty, clean & bottom valve is closed
2	Apply cooling water circulation to reactor jacket
3	Transfer the reaction mass from R-910 to R-919 by pump
4	Start the agitator
5	Charge 10% Na_2CO_3 solutionfrom MT-905 to R-919
6	Stir it for 20 min
7	Stop the agitator
8	Settle it for 10 min
9	Take aqueous layer sample and offer to QC for pH
10	If the result doesn't complies then add excess 20% Na_2CO_3 solution from MT-905 to R-919
11	If result compliesAllow to settle again 20 min
12	Separate the bottom aqueous layer to T-919A
13	Charge water from MT-904 / T-924 to R-919 Qty : 1000 Liters
14	Start the agitator
15	Stir it for 20 min
16	Stop the agitator
17	Settle it for 20 min
18	Separate the bottom aqueous layer to T-919A
19	Charge water from MT-904 / T-924 to R-919 Qty : 1500 Liters
20	Start the agitator
21	Stir it for 20 min
22	Stop the agitator
23	Settle it for 30 min
24	Transfer the PTC organic from R-919 to R-918 through sparkler filter by pump

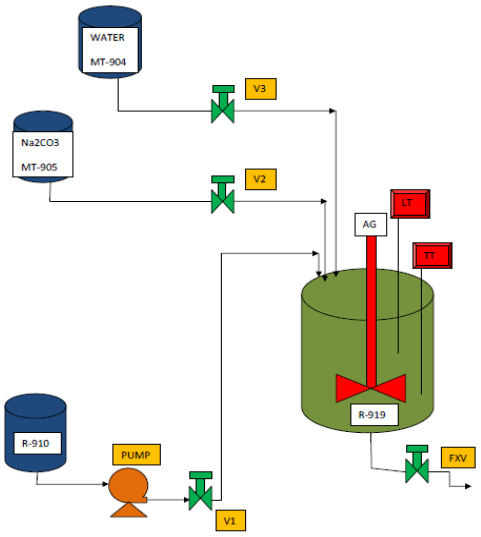

Fig 3.12 Process Flow Diagram of PTCL Workup

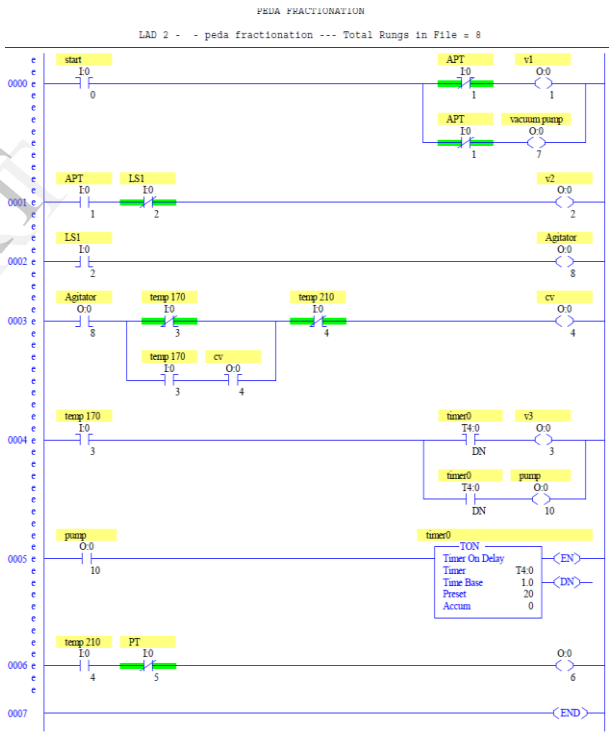

Fig 3.13 Ladder Logic Diagram for PTCL Workshop

STAGE 7

PTCL Final concentration is the last process for PRETILACHLOR. In this process previous reactant mass are using as raw materials. Add the raw materials in the ratio as per the size of the batch i.e volume of the reactor. After addition process start the Agitator to stir the mass and apply steam to reach the temperature 80°C and apply cool water to reduce the temperature to 60°C and move the mass to next reactor and apply vacuum. Apply steam to raise the temperature to 80°C and again apply cool water reduce the temperature to 45°C. Break the vacuum with N2. And transfer the final product for end users

Table 3.7 Pretilachlor Concentration

S. No	OPERATIONS
1	Check the reactor R-918 and ensure that it is empty, bottom valve is closed and ready for use
2	Transfer the PTC organic from R-919 to R-918 by pump
3	Start the agitator
4	Apply steam to reactor R-918
5	Raise the mass temp slowly up to 80 deg °C
6	If temp reaches 80 ± 2°C close the steam supply
7	Apply the cooling water circulation to jacket
8	Cool the mass to 60 ± 2 °C
9	Check the reactor R-909 / R-922 and ensure that it is empty and ready for use
10	Transfer the pre concentrated PTC mass to R-909 / R-922 by pumping
11	Apply vacuum to R-909 / R-922 by ejector
12	Apply steam to reactor R-909 / R-922
13	Distill out n-hexane slowly into CT-909A / CT-922 under vacuum
14	Raise the temp up to 80 ± 2 °C
15	Ensure maximum n-hexane collected in CT-909A / CT-922
16	Close the steam trap valve
17	Apply cooling water circulation to jacket
18	Cool the mass to 45 ± 2 °C and get final product.

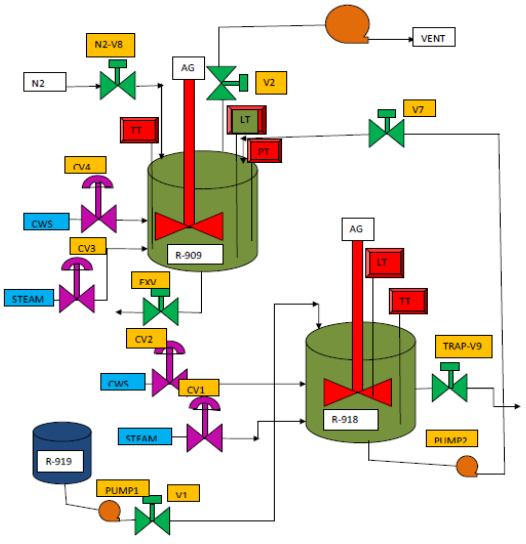

Fig 3.14 Process Flow Diagram Pretilachlor Concentration

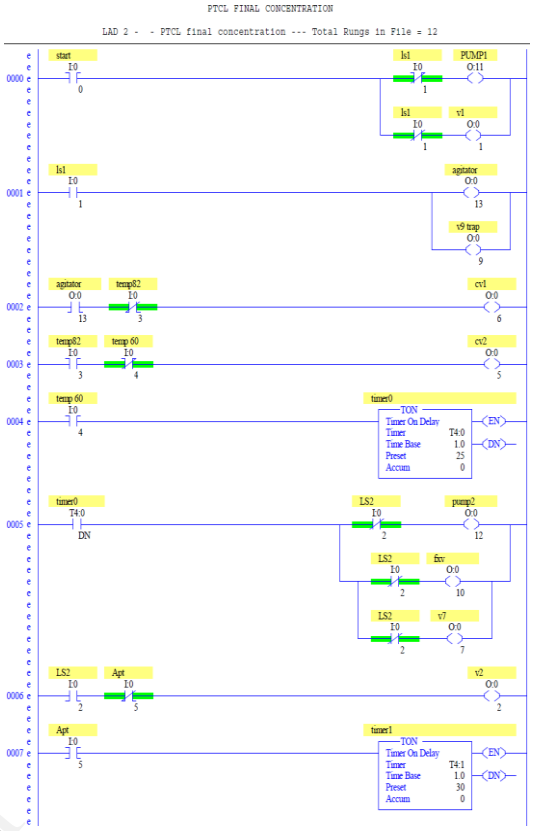

Fig 3.15 Ladder Logic Diagram for Pretilachlor Concentration

IV. CONCLUSION

The batch process of PTCL is implemented using PLC. By using PLC the online problem rectification will be easy. Programming for PLC is easy compared to DCS. Batch process is easier than Continuous process to rectify the troubles occurring in the process. With the help of batch process high quality of end product can be maintained. By using automation for processes the quality of the product, quantity of the product, reduction of process time, reduction of man power, low maintenance can be achieved

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