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Efficient Automation of Nitrogen Generator Plant Pressure Swing Adsorption Type Using PLC

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Abstract: **Nitrogen in continuous supply is essential in any chemical plant .It is used to dilute reagent gases, to increase yield of some reactions, to decrease the fire or explosion. It can be generated using technology known as Pressure Swing Adsorption method in which nitrogen can be generated continuously and can be supplied to the plant for its use. This is a continuous process and does not require supervision to operate the process. This paper introduces replacing the old electromechanical controls with the PLC. Firstly it shows the ladder logic that can be implemented to operate the Nitrogen generator plant. Secondly it shows installation of PLC in the plant and factors to be considered for its installation and operation.**

Keywords: **PLC, pressure swing adsorption, nitrogen, generator.**

1. INTRODUCTION

Air is composed of 78% Nitrogen and 21% Oxygen. PSA Nitrogen generation technology works on the principle of air separation by adsorbing Oxygen and separating Nitrogen.

Pressure Swing Adsorption (PSA Nitrogen) process comprises of 2 vessels filled with layer of activated alumina and Carbon Molecular Sieves (CMS).Firstly air is compressed to a pressure of 7 kg/cm2. This compressed air is passed through the heat exchanger to lower its temperature. This Pre-filtered compressed air is passed through one CMS filled tower. At the bottom of the tower, activated alumina is placed which has the tendency of absorbing moisture from the air. After this compressed air will come in contact with bed of Carbonmolecular sieve(CMS) where oxygen,carbon dioxide and moisture are adsorbed. The unadsorbed gas which is mainly nitrogen comes out and goes into the nitrogen surge vessel.Upon saturation of the CMS in the vessel, the process switches nitrogen generation to the other vessel, while allowing the saturated bed to undergo regeneration by depressurization to atmospheric pressure. The waste gas (oxygen, carbon dioxide, etc.) is discharged into atmosphere. The adsorbers keep switching automatically nearly every one minute by a sequence timer and nitrogen with the purity of 99.8 % is continuously produced and goes to the nitrogen surge tank.

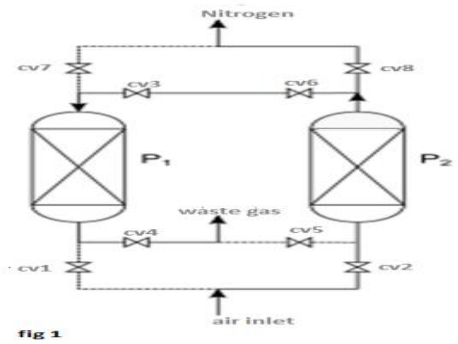

Fig 1. PSA type Nitrogen generator adsorption occurring in P2

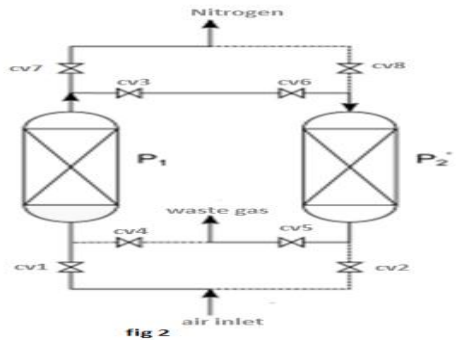

Fig 2. PSA type Nitrogen generator adsorption occurring in P1

The process is occurred by the timely opening and closing of valves simultaneously. As shown in Fig 1 valve 2 is open and air is passed through into chamber 2 containing CMS and simultaneously valve 4 is open so that waste gases from chamber 1 is passed into the atmosphere. Then valve 3 and 6 are open for pressure equalization while simultaneously valve 2 and 4 are closed. Then after that, same process is followed for the second chamber as shown in Fig 2. The cyclical nature of the process between the two vessels ensures continuous production of pure Nitrogen.

2. EXISTING CONVENTIONAL TECHNIQUE

This process is completely automated and no personnel is required to operate the plant. The valves are operated automatically by using timers and contactors logic. But this electromechanical control causes many problems.

a. There was wear and tear in the contactors causing it to regularly change the control which causes to break in the process.
b. There were complex hardware wirings
c. There were regular contact failures which resulted continuously shutting down of the plant.
d. There were delays in switching of contacts.
e. Troubleshooting was difficult in these type of controls as one has to check every relay to check for the problem.

3. PROPOSED WORK

Continuous supply of nitrogen is required in a chemical plant. So a system is required that does not require continuous maintenance and replacements of timers and controls which can be done by using programmable logic controller.PLC is a specialized computing system used for control of industrial machines and processes.They are equipped with special input/output interfaces.

The benefits of using a PLC are:

a. There are no wear and tear
b. Reduces hardware wirings
c. Contact failure rate is very less.
d. Speed of operation is very high.
e. System can be made compact
f. Reduces maintenance cost
g. Easier way of making logics
h. Troubleshooting is much easier the electromechanical controls as it points out to the problem.

Ladder Logic

Design a ladder logic and download it to the PLC controller .The proposed ladder logic that can be used to operate the valves is shown in the following figure.

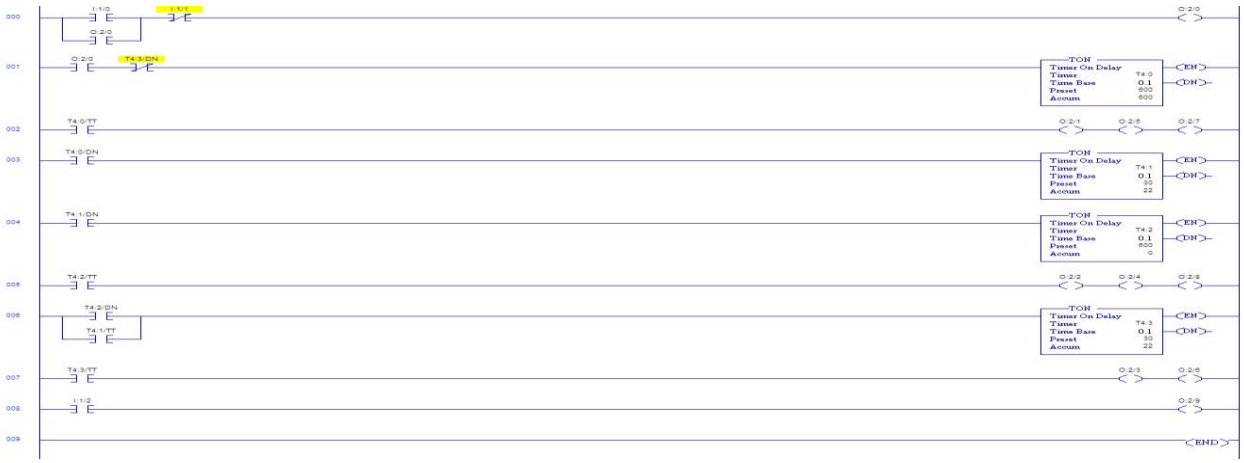

Fig. 3

In the figure 3,

- there is 3 input and 8 outputs.
- 2 input switches(I:1/0, I:1/1) are used to start and stop the process.
- 1 input switch(I:1/2) is connected to oxygen analyser.
- 1 output bulb(O:2/0) to show whether the process is on or off.
- 8 output (O:2/1 – O:2/8) that are connected to the solenoid valves which operate the valves(CV1- CV8) accordingly.Span of the process is nearly 2 minutes and fig 4 shows span of opening and closing of the valves.
- 1 output switch(O:2/9) to operate the final vent valve(3 way control valve).

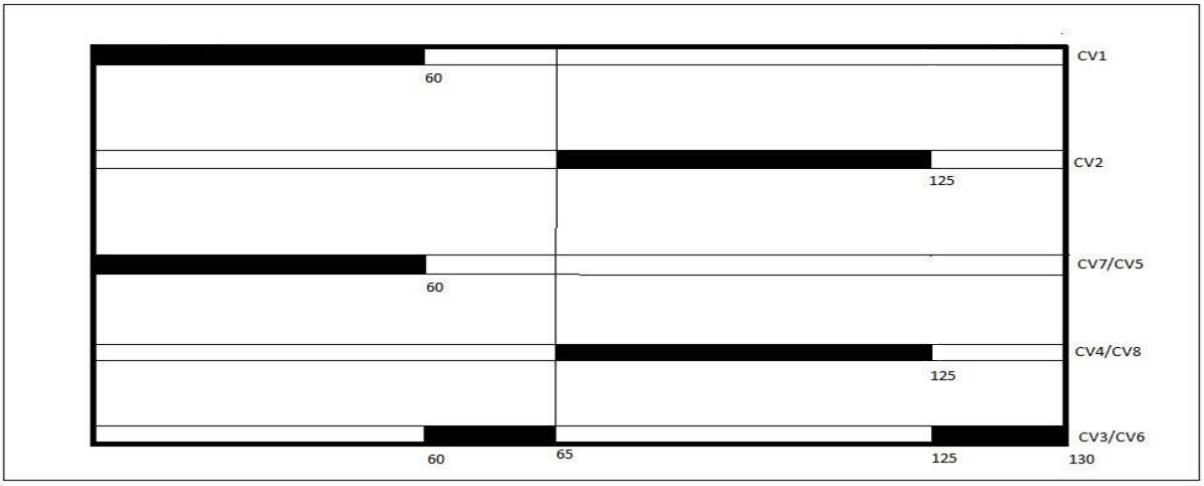

Fig. 4

The shaded portion in the figure 4 shows the time of opening of the respective valves.

Hardware Required

Basic components that are required for the installation of PLC at the site of the nitrogen generator plant are:

- Controller
- Memory
- Power supply
- Input module
- Output module

Digital output cards can also be used here. It is basically type of binary codes which will trigger the on- off switch. It can be used for operating the solenoid valve which further will operate the actuator of the valves we want to operate.

Input module monitors field devices such as switches and sensors.it is used to start or stop the process .Most plc controllers work either at 24VDC or 220VAC. The power supply provides internal DC current to operate logic circuitry and input/output assemblies.

Memory is provided for permanent storage for the operating system the fixed data used by the controller. The programming device is used to enter the required program into the memory of the processor.

There are various considerations for the site of the PLC installations.The temperature inside the enclosure should not exceed 60 degrees. See the proper power considerations.

Check that all protective devices are set to their appropriate trip settings.Check that all the cable connections between plc and the plant are complete, safe and to the required specification and meeting local standards.

Other components that can be required for the installation are 8 solenoid valves which are connected to the actuators of the valves which are operating in the plant. The controller will switch on/off the valve which will in turn open/ close the valve, Air distribution panel (ADP) to supply pressure to the solenoid valves , Pneumatic tubes, Pneumatic fittings, Cable glands, Pressure switch, 3 way control valve.

For the efficient operating of the Nitrogen generator plant are-:

Oxygen analyser is connected to the nitrogen surge tank. It is basically use to check the purity of the nitrogen.If the oxygen content in nitrogen is more than 0.4 then the final vent valve (3 way valve) automatically opens until the oxygen content is in the limit.

Pressure switch are connected at the inlet of the PSA towers. Basically air has to be at a certain pressure before entering the towers. If air is below that pressure than the plant will automatically trips.

4. CONCLUSION

The focus of this paper is to replacing existing traditional methods of using relay logic with the PLC logic for the nitrogen generator plant . Pressure Swing Adsorption method is favourable for the production of nitrogen because this process does not require any supervision and nitrogen can be generated continuously. Efficient automation of the plant is necessary as electromechanical controls can create many problems which can cause disturbance in the continuous production of nitrogen. There is wear and tear in the relays which causes its replacements after some time. Further there are complex hardware wirings thus causing difficulty in troubleshooting and there are delays in switching of contacts. Thus plc can be used to replace electromechanical controls.

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