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NITROGEN PLANT AUTOMATION USING PLC & SCADA

ASHA JOHN[1], AKSA ANDREWS[2], ELDHO JOHNSON[3], NIKHIL VINCENT[4] & STEFFI ROSE V. J[5]

[1]Assistant Professor, Jyothi Engineering College, Thrissur, Kerala, India

[2,3,4,5]Student, Jyothi Engineering College, Thrissur, Kerala, India

ABSTRACT

Today most of the industrial processes are controlled by the use of PLC. They are used in industrial like petroleum, gas, chemicals etc. The air, flow, temperature etc in these industries can be controlled, using PLC. SCADA (supervisory control and data acquisition) is a type of industrial control system (ICS). Industrial control systems are computer-controlled systems that monitor and control industrial processes. This project deals with Nitrogen plant automation using PLC and SCADA. A Programmable logic controller (PLC) is a digital computer used or automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement ride, or light fixtures. PLC is designed for multiple inputs and outputs arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact.

Plant has two tanks of similar capacity constituting with different solenoid valves and other associated paraphernalia. Now, oxygen and other impurities absorb by the CMS (Carbon Molecular Sieve) then nitrogen is separated. When first tank works for 40 seconds the nitrogen generated in first tank pass to the storage tank, through appropriate solenoid valves and surge vessel by releasing the impurities. Then the operation repeated in the second tank. Both tanks operate simultaneously one after another with an interval of 10 seconds. So that process is continued and Nitrogen storage tank is filled as required.

KEYWORDS: Nitrogen, Plant, PLC and SCADA

INTRODUCTION

A PLC is a digital computer used or automation of electromechanical process .PLCs are used in many industries and machines. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory.The term SCADA usually refers to centralized systems which monitor and control entire sites, or complexes of systems spread out over large areas. For example, a PLC may control the flow of cooling water through part of an industrial process, but the SCADA system may allow operators to change the set points for the flow, and enable alarm conditions, such as loss of flow and high temperature, to be displayed and recorded.

Plant has two tanks of similar capacity constituting with different solenoid valves and other associated paraphernalia. When the pressure in air receiver tank exceeds 7 kg/cm^2, it admits to first tank through appropriate valves. Now, oxygen and other impurities are adsorbed by the CMS (Carbon Molecular Sieve) and nitrogen is separated. When first tank works for 40 seconds the second one regenerates then within another two seconds both tank equalize the pressure nitrogen generated in first tank pass to the storage tank, through appropriate solenoid valves and surge vessel by releasing the impurities. Then the operation repeated in the second tank. Both tanks operate simultaneously one after another with an interval of 10 seconds. So that process is continued and Nitrogen storage tank is filled as required.

A nitrogen storage tank is installed after nitrogen surge vessel for storage of nitrogen gas at pressure of 5.0 kg/cm^{2}g. And there is an oxygen analyzer and a three way valve in between the nitrogen storage tank and surge vessel. The oxygen analyzer will check the amount of oxygen in the gas. If oxygen content exceeds 0.7% the three way valve will direct that gas to air. Else it is stored in the nitrogen storage tank.

PRINCIPLE OF OPERATION

Nitrogen generates are based on well proven technology using carbon molecule sieves (CMS) developed and supplied by Carbotech- Germany. CMS is an absorbent having infinite number of small pores.

An oxygen molecule having a smaller diameter than a Nitrogen molecule .Therefore, the nitrogen is removed to a higher degree while almost all the oxygen is adsorbed.

Plant has two tanks of similar capacity constituting with different solenoid valves and other associated paraphernalia. When the pressure in air receiver tank exceeds 7 kg/cm^2, it admits to first tank through appropriate valves. Now, oxygen and other impurities are adsorbed by the CMS (Carbon Molecular Sieve) and nitrogen is separated. Both tanks operate simultaneously one after another with an interval of 10 seconds. So that process is continued and Nitrogen storage tank is filled as required.

BLOCK DIAGRAM

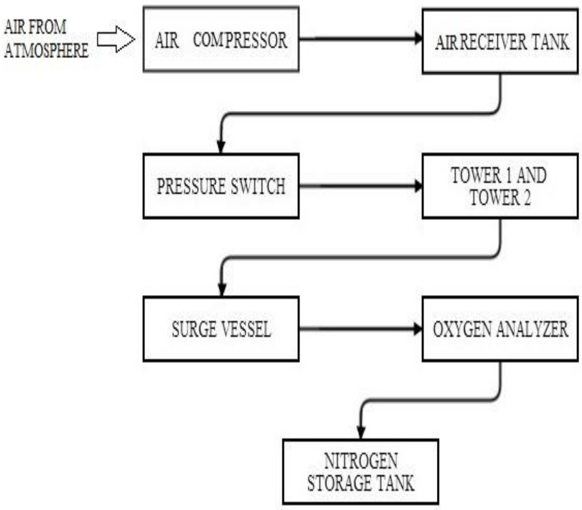

Figure 1: Block Diagram of Nitrogen Plant

Air Compressor: It sucks air from atmosphere to initiate the process the pressure inside the compressor should be between 6-8 kg / cm^2.

Air Receiver Tank: It stores the pressurized gas and also known as air buffer tank. The pressure inside the air receiver tank will be between 6-8 kg / cm^2.

Tower 1 & Tower 2: It is the main part of the system, having similar capacity. Where each tower consists adsorption vessel packed with Carbon Molecular Sieves (CMS). At high pressures, Oxygen and other trace gases are absorbed by the CMS, allowing nitrogen to pass through. Since, oxygen molecules have smaller diameter than nitrogen molecules, they enter into the pores.

Figure 2: Carbon Molecular Sieve

Surge Vessel: It stores the nitrogen generated and also provide better performance.

Oxygen Analyzer: The (dim) purity of the product is being checked continuously.

Nitrogen Storage Tank: It's mainly used for the storage of purified nitrogen.

WORKING

Plant has 2 tanks of similar capacity constitute with different valves and associated paraphernalia. When pressure in the air receiver tank exceeds 7 kg/cm^2 valve V9 will open. It admits air to tanks through valves. Figure 2 shows the complete circuit diagram of nitrogen plant.

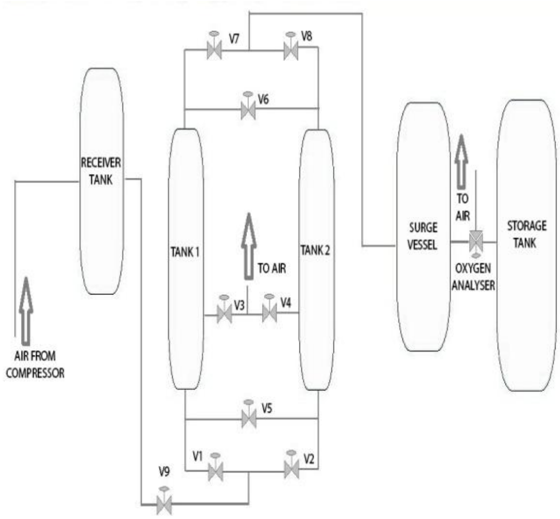

Figure 3: Circuit Diagram of Nitrogen Plant

The PSA [1] process cycle consists of two key mechanisms:

- Pressurization/adsorption
- Depressurization/desorption

In the first cycle tank 1 will be in adsorbing state. Valve V1, V4 and V7 will be open on first cycle. Now oxygen and other impurities are adsorbed by the CMS and Nitrogen is separated. And Nitrogen generated in the first tank passed to the storage tank, through valve V7 and surge vessel. When first tank work for 40 seconds, second one regenerated.

Within another 10 seconds both tank equalize the pressure. The valve V5 and V6 will open. And will equalize the pressure in two tanks. After 10 second equalization second cycle will start. The tank 2 will goes to adsorbing state. And valve V2, V3 and V8 will open. Then operation repeated in the second tank while first tank goes under regeneration where adsorbed gases are desorbed to atmosphere. After that there is an equalization step. It will take 10 seconds. This operation alternatively repeated in both tanks

A nitrogen storage tank is installed after nitrogen surge vessel for storage of nitrogen gas at pressure of 5.0 kg/cm^{2}g. And there is an oxygen analyzer and a three way valve in between the nitrogen storage tank and surge vessel. The oxygen analyzer will check the amount of oxygen in the gas. If oxygen content exceeds 0.7% the three way valve will direct that gas to air. Else it is stored in the nitrogen storage tank.

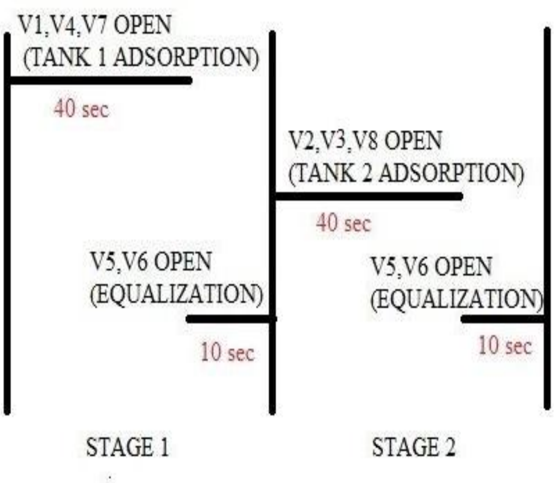

Figure 4: Timing Diagram of Nitrogen Plant

Figure 3 shows the timing diagram of nitrogen plant [3]. There are 2 stages for a complete cycle of the plant. It needs 100 seconds for one complete cycle. Each tank will tank 40 seconds for adsorption. For equalization it will take 10 seconds. After every adsorption step there will be an equalization step.

FLOW CHART

When pressure in the air receiver tank exceeds 7kg/cm^2 the valve V9 opens and it starts operation. The PSA [5] process cycle consists of 2 key mechanisms:

- Adsorption
- Desorption

When first tank 1 works for 40 seconds the second one regenerates. At this time adsorption take place for tank 1 and valves V1, V4 and V7 were open. Nitrogen generated in first tank pass to the storage tank, through these valves and surge vessel by releasing the impurities. Within another 10s both tank equalize the pressure and valves V5 and V6 were open. Next 40s adsorption take place for tank2 and at this time first tank regenerated. Nitrogen generated in tank 2 reaches the storage tank through valves V2, V3and V8.Next 10s both tank equalize the pressure. This operation alternatively repeated in both tanks. When the amount of oxygen is less than 0.7%, it reaches the storage tank. Otherwise it is vented to air.

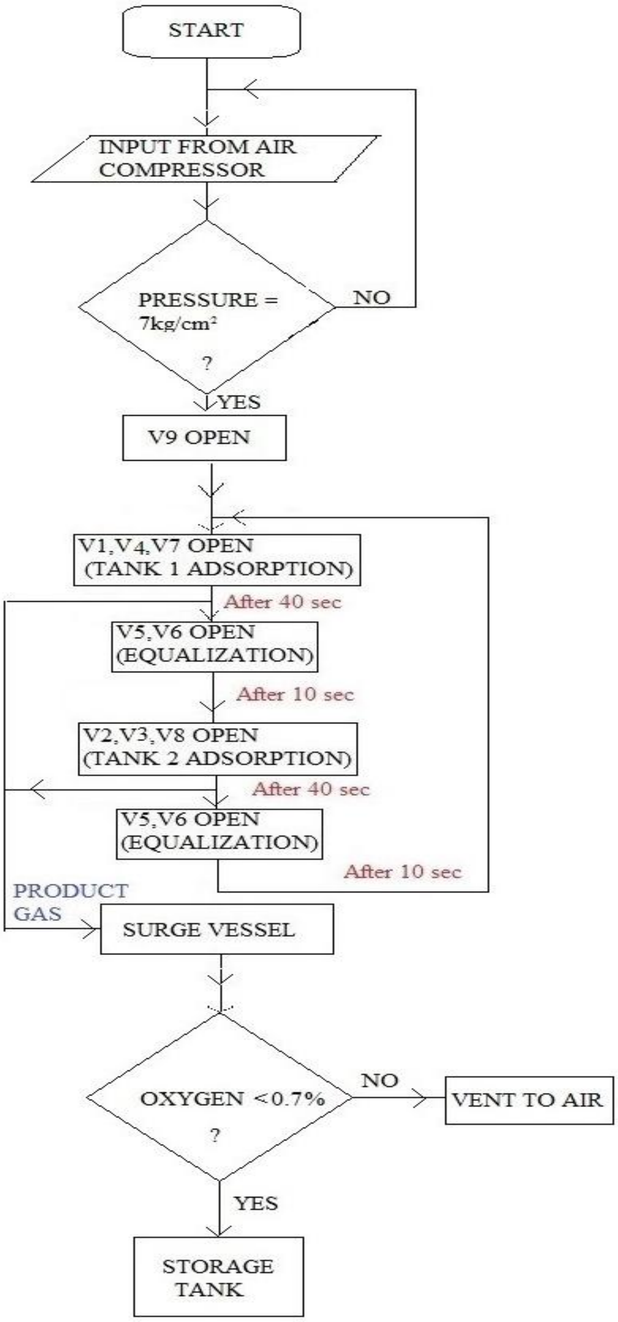

Figure 5: Flow Chart of Nitrogen Plant

CONCLUSIONS

The process of manufacture and control of Nitrogen were done using PLC and SCADA with the automation process in the industry and verified the result.

FUTURE WORKS

Increased power efficiency in PSA nitrogen generators is being driven both by process improvements and enhanced adsorption materials. A large range of flow and purity combination can be met by adjusting the size of the air compressor and adsorption vessels containing the CMS. The plant flow rate can be reduced by inserting an "idle" step in the cycle thus saving plant power.

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