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# INSTRUMENTATION & PROCESS CONTROL OF AIR SEPARATION UNIT

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**ABSTRACT**: In Air Separation Unit, the process control and interlocking systems are implemented by using analog signal processing cards (M/s BELLS make) and relay logics. Advancement in the field of digital signal processing opens many other features for optimized process control. These digital systems are highly reliable and it takes low down time for maintenance or trouble shooting. There are two layers of signal processing and control in this automation. Layer one is to have interface with the field and signal processing at lower level. Layer two will have graphical tools and database tools mixed with communication protocols. In this Paper an attempt is made to adapt PLC's for the automation of Air Separation Unit.

**Key Words:** Air Seperation Unit, Instrumentation, PLC's, SCADA System, Data Acquisition

## I. INTRODUCTION

Steel is manufactured upon blowing pure form of oxygen gas at a very high pressure (at 9 kg/cm$^2$) on to hot metal (liquid iron) being heated at 1400°C.An Air Seperation Plant (ASP) is set up to seperate Oxygen from the composition of Air. The plant adapts the convention process involving liquefaction and rectification of air at cryogenic temperatures to produce various products like $O_2$, $N_2$ and Argon. The pure form of $O_2$ that is separated by the ASP is 99.5% pure.

## II. AIR SEPERATION UNIT (ASU)

**2.1 Main Process in ASU:** Air Compressing Process, Pre Cooling Process, Air Drying Process, Air Drying and Distillation Process.

**2.2 General Description of Process:** The general overview of ASU is shown in "Fig 1". Feed Air is taken from atmosphere through self-cleaned air filter. The air is compressed to 6.0 Kg/Cm$^2$. This huge quantity air passing through requires a heavy motor (11 MW for 500 TPD ASP) and heavy Impeller. This requires proper condition monitoring and other process controls. Air is then cooled down to10°C in the tower E10. The water tower E10 uses water coming from the general circuit and cooled down in the Nitrogen water tower E11 by means of refrigeration contained in the waste Nitrogen coming from the cold box. A refrigeration unit X01 on this water circuit brings additional refrigeration make-up, so that the temperature of the water is brought down to 5 °C, before the water enters the air water tower E10. At the outlet of this cooling system, the air passes through a drying and carbon dioxide removal unit, composed of, two bottles R01 and R02 filled with alumina in the bottom and moleculartwo sieves at the top, the air flow going from bottom to top. Moisture is adsorbed by aluminareactivated by waste Nitrogen coming from the cold box. The total cycle is 10 hrs (5 hrs adsorption + 5 hrs regeneration) with10 °C at the inlet of bottles. Then, the compressed air, dry and carbon dioxide free, is filtered to eliminate dust particles it may carry by post filters F11 or F12, and then enters the cold box. It is cooled

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by exchange in counter current with the gaseous products of separation (oxygen and nitrogen) in the main Exchanger E01-E02. A part of the air is taken at an intermediate point of the exchangers and sent to a centrifugal expansion turbine D01/ D02 equipped with a brake generator to provide the necessary refrigeration to make-up for thethermal losses of cold box.

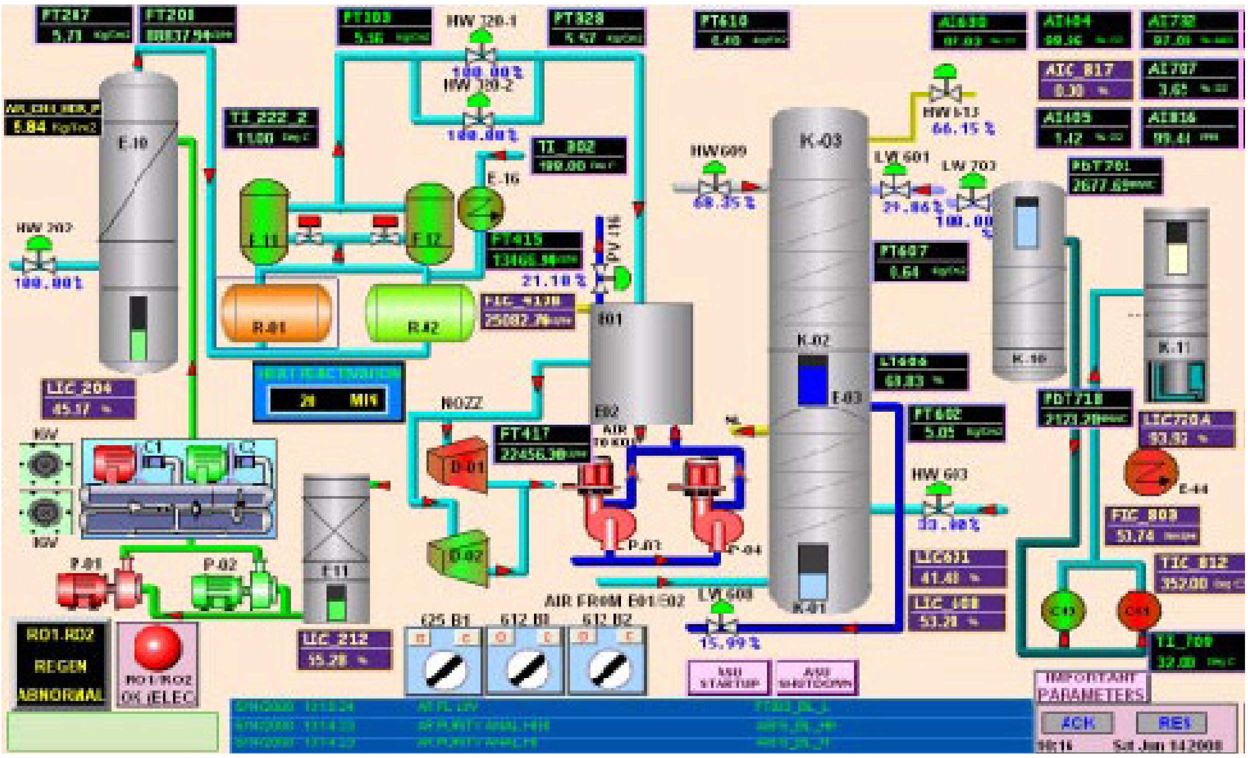


***Fig 1: general overview of ASU***

**Pure liquid nitrogen:** Poor liquid with low oxygen content used as reflux on the top of the low pressure column K02 after passing through sub cooler E05 and Expansion in a valve HIC 613. Rich liquid at the bottom, a liquid containing about 40% oxygen sent to the low pressure column K02, after passing through exchanger E04 and Expansion in a valve LIC601. The up flowing gas in the low pressureand carbon dioxide by molecular sieves. One of the vessels is in operation while the other isthermal loses of the cold box. The adiabatic expansion in D01/D02 down to an approximately atmospheric pressure provides the main part of the refrigeration required by the plant. The other part is cooled in E01/E02, and sent to the bottom of the medium pressure column K01 to perform the first separation. In the column K01, the up flowing gas becomes enriched with nitrogen by contact with the down coming liquid. This liquid result from the nitrogen condensation in the vaporizer/ condenser E03 located at the top of the column. From top to bottom, the medium pressure column K01 gives the following products:column K02 is the gas vaporized in the vaporizer/ condenser E03 located at the bottom of this column. This exchanger vaporizes liquid Oxygen at low pressure by condensation of medium pressure Nitrogen in K01. The rich liquid sub cooler E04 makes it possible for the liquid oxygen to flow through filter R03/R04 by a thermo Siphon effect.

**The low pressure column K02 gives:** At the bottom, liquid oxygen at a purity of 99.5% part of this liquid oxygen is sent directly at the outlet of the cold box for storage. The other part is vaporized in the air liquefier E06 and then heated in the main exchangers line E02-E01. At the top, waste nitrogen which is heated in the main exchangers line E02-E01. The pure nitrogen column K03 is located above the low

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pressure column K02, and gives at its top pure gaseous nitrogen at 99.9% purity, which is also heated in the main exchangers line E02-E01. For recovery of Argon, a gaseous flow is picked up from the low pressure column K02 at a point where argon content is about the maximum possible. These fractions are taken to the bottom of the crude argon column K10 and then send to column K11. The crude Argon undergoes the process of Vaporization and then is passed through Driers, Catalytic Reactor, Water coolers, Refrigeration unit, Expander, Compressor and finally the pure liquid argon boiling at the bottom of the column K11 is drawn.

## III. INSTRUMENTATION

The plant operation is supervised from the Central Control Room. Each ASU is provided with a central control desk for monitoring and operation of the respective units. Each AIR, OXYGEN AND NITROGEN compressor is provided with a central control desk containing sequential startup and monitoring instruments. Also, all these compressors are provided with local panels near the respective machines for monitoring and operations. Each expansion turbine, Refrigeration Unit, mixture Argon Compressor and other auxiliary equipment's are provided with only local control panels for startup and monitoring. Liquid storage tanks and the distribution system for Oxygen and Nitrogen are also provided with respective central control desk. All utilities and common facilities are grouped together in one control desk. This central control desk contains all Indicators, Controllers, Manual Loaders and Recorders grouped for easy identification and operation. On the desk portions mimic is provided with indication lamps and push buttons for machinery and ON-OFF control valves.All the Control Valves are Pneumatic Valves under operationare controlled by the supply of air as input for the valve opening and closing. The Valve is under Automatic control by an equivalent signal of 0-10 Volts or 4-20 mA. All the Valves employ PID Controls.

**PID Valves:** **"**Fig 2" shows the Control Valves that are being operated. The outputs of HIC 410B (Nitrogen Flow Indicating Control), PIC 416(Oxygen Pressure Indicating Control) and FIC 803 (Argon Flow Indicating Control) are shown in Results.

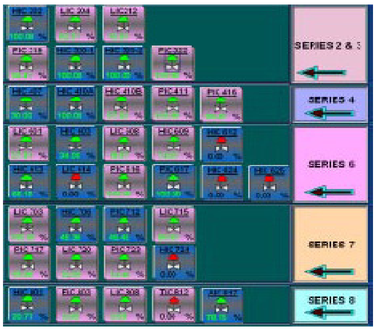

Fig 2: Control Valves

## IV. PROGRAMMALE LOGIC CONTROLLERS (PLC):

**4.1 Features:** "Fig 3" shows the interfacing of PLC with PC and Field. A PLC or programmable controller is a digital computerused for automation of industrial processes, such as control of machinery on factory assemblylines.

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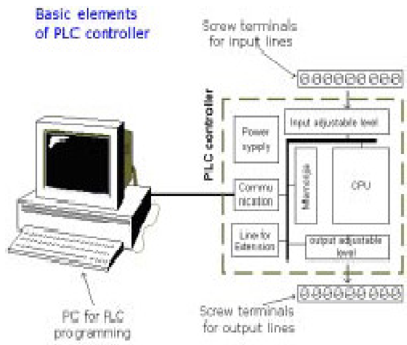


Fig 3: Interfacing of PLC

Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges,immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

**4.2 PLC Compared With Other Control Systems:** PLCs are well-adapted to a range of automation tasks. These are typically industrial processes in manufacturing where the cost of developing and maintaining the automation system is high relative to the total cost of the automation, and which changes to the system would be expected during its operational life. PLCs contain input and output devices compatible with industrial pilot devices and controls; little electrical design is required, and the design problem centers on expressing the desired sequence of operations in ladder logic (or function chart) notation. PLC applications are typically highly customized systems so the cost of a packaged PLC is low compared to the cost of a specific custom-built controller design.

**4.3 Programming a PLC:** The PLCs were programmed in “ladder logic”, which strongly resembles a schematic diagram of relay logic. Modern PLCs can be programmed in a variety of ways, from ladder logic to more traditional programming languages such as BASIC and C. Other methods are Functional Block Diagram, Instruction and Statement list. PLC controller can be reprogrammed through a computer (usual way), but also through manual programmers (consoles). This practically means that each PLC controller can be programmed through a computer if you have the software needed for programming.

## V. SUPERVISORY CONTROL AND DATA AQUISATION SYSTEM (SCADA):

**5.1 Introduction to SCADA:** SCADA systems are typically used to perform data collection and control at the supervisory level. The supervisory control system is a system that is placed on top of a real-time control system to control a process that is external to the SCADA system This implies that the system is not critical to control the process in real-time, as there is a separate orintegrated real-time automated control system that can respond quickly enough to compensate for process changes within the “Fig 3” Interfacing of PLC time-constants of the process. The process can be industrial, infrastructure or facility based as per necessity and requirement.

**5.2 Systems concepts:** “Fig 4” shows the block diagram of how the SCADA with PLC, controlling and maintaining the process in the system. A SCADA system includes input/output signal hardware, Controllers, HMI, networks, communication, database and software. It mainly comes in the branch of Instrumentation Engineering. The term SCADA usually refers to a central system that monitors and controls a complete site or a system spread out over a long distance (kilometers/miles). The bulk of the site control is actually performed automatically by a Remote Terminal Unit (RTU) or by a PLC. Host control functions are almost always restricted to basic site over-ride or supervisory level capability. For example, a PLC may control the flow of cooling water through part of an industrial process, but the SCADA system may allow an operator to change the control set point for the flow, and will allow any alarm conditions such as loss of flow or high temperature to be recorded and displayed. The feedback control loop is closed through the RTU or PLC; the SCADA system monitors the overall performance of that loop.

Data acquisitionbegins at the RTU or PLC level and includes meter readings and equipment statuses that are communicated to SCADA as required. Data is then compiled and formatted in such a way that a control room operator usingthe HMI can make appropriate supervisory decisions that may be required to adjust or over-ride normal RTU (PLC) controls. SCADA systems typically implement a distributed database, commonly referred to as a tag database, which contains data elements called tags or points.

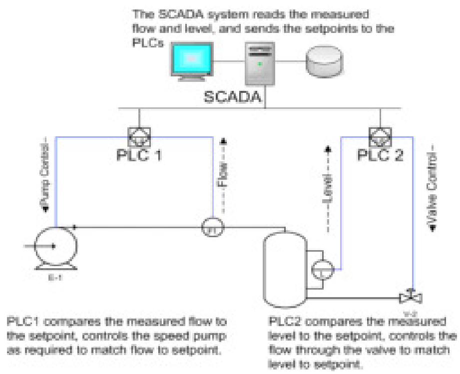


**Fig 4: SCADA Communication System**

## VI. RESULTS:

**6.1 AO_FIC_410B:** The set value is 24922.50 NM3/Hr and process value is 24873.29 NM3/Hr of the Nitrogen Flow is shown in “Fig 5”. To maintain the respective values of sp and PV the maintained value will make the valve to open at 57.1% Control showing the values of Set Point, Process valve and Maintained value.

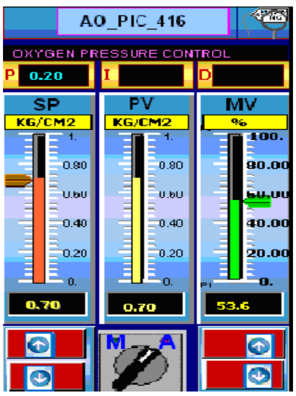


**Fig 5: Bar Graph of Nitrogen Flow**

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**6.2 AO_FIC_803:** “Fig 6” shows Argon Flow Control displaying the values of Set Point, Process valve and Maintained value

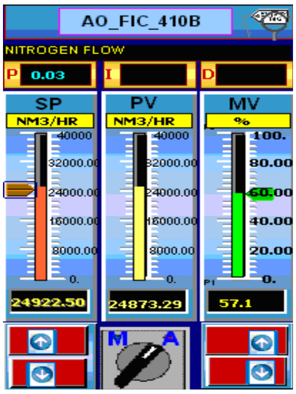


**Fig 6: Bar Graph of Nitrogen Flow**

**6.3 AO_PIC_416:** “Fig 7” shows Oxygen Pressure Control displaying the values of Set Point, Process valve and Maintained value. “Fig 8” shows the trends of PV, MV and air supply which is controlling the status of the valve opening and closing. As shown in the diagram the air supply is varying continuously with time subjected to the variations in process values.

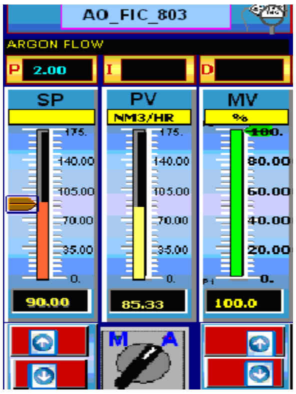


**Fig 7: bar Graph of Oxygen Pressure**

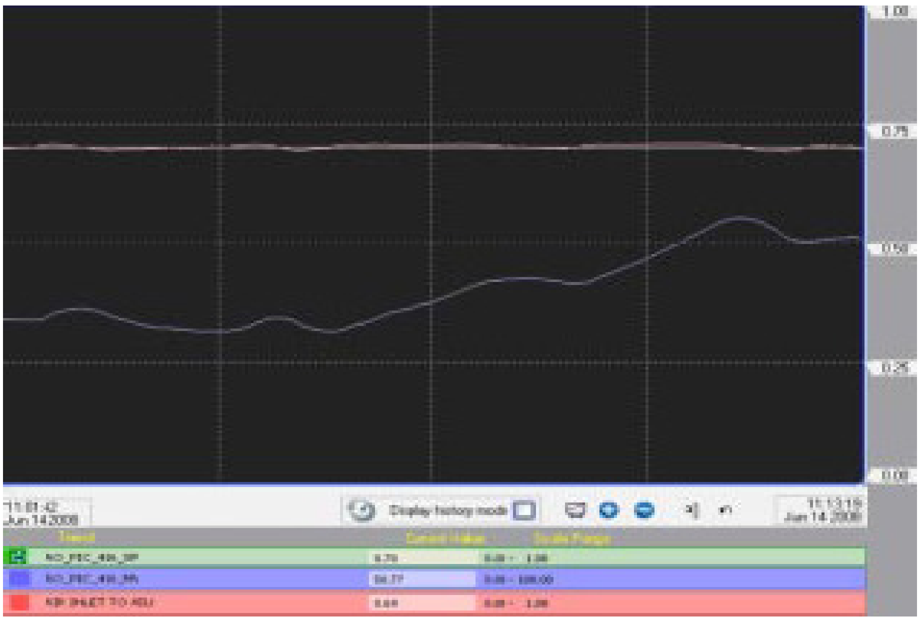


**Fig 8: Trends of Oxygen Pressure Valve**

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## CONCLUSIONS

1. The automation of air separation unit leads to best productivity, less breakdowns, less indenting cost
2. It offers less maintenance costs, less manpower and provides expanding facilities, easy diagnostics, any voltage operation and any control.
3. PLC system will help in integrating information by establishing common bus bar.
4. Fault finding is easy, total information is available at all places due to common network. So, we can assess it at any point and also trends can be generated for varying periods of time.
5. By adopting PLC systems problems in the process are less due to elimination of relays and also problems which remained unnoticed have also come to light with the implementation of the PLC system which enables timely correction reaction.
6. Hence, it is observed that PLC with SCADA is best suited for automation of industry.

## FUTURE SCOPE:

The existing system of PLC with SCADA is Level 1 Control System. Adopting Level 2 Control System results in Optimization of Power and Energy and Ammunition. Level 2 Control System could be designed with suitable Digital Model Emulator,which determines different Process Set Values of Distillation Unit. The aim of this system will be to minimize the Energy loss and to meet the variable demands of Oxygen to be produced.

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