CLEANING IN PLACE AUTOMATION FOR PROCESS INDUSTRY USING PLC AND SCADA SOFTWARE

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ABSTRACT

In Process Industries, proper hygiene should be maintained to ensure the proper quality of the product. So, the cleaning of Process Equipment's must be done very properly and hygienically. Clean in Place (CIP) Automation is a best way to clean the process equipment's without disassembling. There are various requirements for cleaning equipment as well as many cleaning types. Some process equipment is cleaned with only water while other equipment is cleaned using detergents such as acids or caustic solutions. Also, some plants have taken to recovering the water used for a final rinse and use it as the initial rinse of the next CIP sequence in order to reduce the overall production cost. The following paper gives an approach that makes CIP automation a straight forward task and provides ample modularity and flexibility through the use and application of PLC and SCADA. This paper outlines the method of conversion of manual cleaning towards the fully automated cleaning and making the plant environment safer.

***Keywords*: Automation, CIP, PLC, SCADA.**

I. INTRODUCTION

Cleaning in Place is commonly used in hygiene critical industries, such as Food, Dairy, Beverage and Pharmaceuticals etc., to clean a wide range of Plants. CIP refers to the use of a mix of various chemicals, heat and cold water to clean equipment's, machinery, vessels or pipe work without dismantling or disassembling the plant. The process can be one shot or sequence, in which everything goes to drain or recovery, which recycles most of the liquid. CIP automation can be a very efficient way of cleaning because cleaning process is faster; also it requires less human power. CIP is more repeatable and focuses on less chemical risk to cleaning operator. CIP technique provides significant advantages to manufactures as it provides cleaning of equipment's in run time at lower costs which improves product quality and plant hygiene. In order to keep less human interference in process, PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition) is used. SCADA screen is developed in order to control plant and monitor entire system from control room.

II. DRAWBACK OF CONVENTIONAL SYSTEM

There are many conventional systems available to clean the industrial equipment's and machinery. Those systems are manual or semiautomatic which require human power to dismantle the plant or enter the equipment. The cleaning operator needs to enter into the plant and also to handle the hazardous chemicals for cleaning which is definitely not safe and dangerous. Also, those systems are both time and power consuming which is not desirable in any process industry.

III. BLOCK DIAGRAM OF PROPOSED SYSTEM

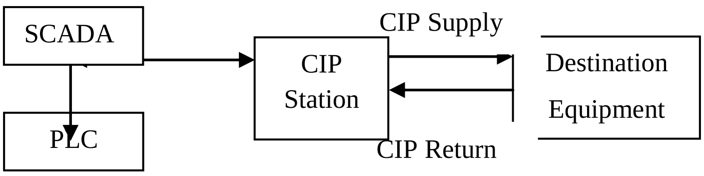

Fig. 1: Block Diagram of CIP System

There are roughly four components in block diagram:

1. PLC (Programmable Logic Controller):PLC is a digital computer used for automation of typically industrial electromechanical process. PLC is a computerised industrial controller that performs discrete or sequential logic in a factory environment. PLCs are used to execute complicated control operations in plant.

2.SCADA (Supervisory Control and Data Acquisition): SCADA is a system operating with coded signals over communication channels so as to provide control of remote equipment. A SCADA system gathers information (such as where a leak on a pipeline has occurred), transfers the information back to a central site, then alerts the home station that the error has occurred, out necessary analysis and control, such as determining if the error is critical, and displaying the information in a logical organized fashion.

3. CIP Station: CIP station is the assembly of all components. It contains tanks, valves, pipes, pumps and other equipment. This station is the platform where all basic preparation is done which is required to clean the destination equipment in place.

4. Destination equipment: It is the process equipment which is to be clean in place. It is usually huge and complex. It can be anywhere and any sized in Industry such as machinery, vessels or pipes, tanks etc.

IV. OPERATIONAL ELEMENTS

4.1 PLC (Programmable Logic Controller)

A Programmable Logic Controller (PLC) is a solid state computerized industrial controller that performs discrete or sequential logic in a factory environment. The Technical Definition of a Programmable Logic Controller is currently defined by the National Electrical Manufactures Association (NEMA) as a “digital electronic device that uses a programmable memory to store instructions and to implemented specific functions like logic, sequence, timing, counting and arithmetic operations to control machines and processes”.

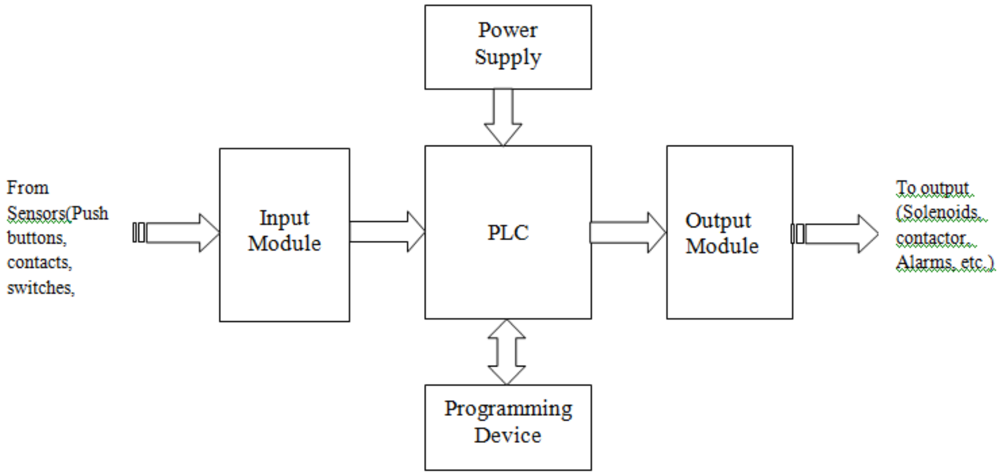

Fig.2 Basic Components of PLC

PLC mainly consists of a CPU, Memory areas, I/O module, and appropriate electronic circuits. PLC works by continuously scanning a program.

PLC Programming languages**:** The IEC standard 1131-3 defines the software model of programmable controller and the languages to program it. The many dialects and proposals from PLC vendors result in a suite of programming languages:

i. Instruction List (IL)
ii. Structured Test (ST)
iii. Ladder Diagram (LD)
iv. Functional Block Diagram (FBD)
v. Sequential Function Chart (SFC)

Ladder Diagram:Ladder logic is a programming language that represents a program by a graphical diagram based on the circuit. LD is a rule based language rather than a procedural language. Ladder logic is widely used to program PLCs, where sequential control of a process is required. Ladder logic is used in simple as well as critical control systems. The name based on observation that programs are similar to the ladders, which has two vertical rails and a series of horizontal rungs between ladders. The flow of logic of ladder diagram is typically from left to right. Each rung consists of combination of input instructions.

4.2 SCADA (Supervisory Control and Data Acquisition)

SCADA is a system operating with coded signals over communication channels so as to provide control of remote equipment. SCADA collects the information, transfer it back to the central site, carry out any necessary analysis and control and then display that information on a number of operator screens or displays.

4.3 Components of SCADA

i. Human Machine Interface (HMI):HMI is an interface which presents process data to human operator and due to this human operator monitors and controls the process.

ii. Supervisory System:It gathers information of the process and commands to the process.

iii. Remote Terminal Units (RTUs):RTUs are used to connect the sensors in the process, and it converts sensor signals to digital data and sending that digital data to the supervisory system.

iv. Communication Infrastructure:It provides connectivity to the supervisory systems to the supervisory systems to the Remote units.

V. CIP PROCEDURE

A typical CIP process consists of many steps which often include (in order):

i. Pre-rinse with WFI (water for injection) or PW (purified water) which is performed to wet the interior surface of the tank and remove residue.
ii. Hot Water Circulation.
iii. Caustic solution single pass flush through the vessel to drain. Caustic is the main cleaning solution.
iv. Acid solution wash – used to remove mineral precipitates and protein residues.
v. Final rinse with WFI or PW – rinses to flush out residual cleaning agents.
vi. Final air blow – used to remove moisture remaining after CIP cycle.

VI. CIP STATION

CIP station contains assembly of three tanks, pipes, valves, pumps, heat exchanger, level and temperature sensors, etc.

What Can the CIP station do?

- Deliver a material from a SOURCE
  - Cold Water, Hot Water, Detergent, Caustic Water**.**
- Control the FLOW RATE
- Control the TEMPERATURE
- Monitor Supply and Return conditions
  - Supply temperature, flow rate, conductivity; return temperature, flow rate, conductivity **[1].**

VII. DESTINATION EQUIPMENT

The destination may include tanks, transfer lines, etc. which is to be clean. Each destination may have multiple options for a supply inlet path as well as return path. For simplicity, only two destination tanks will be used in this example.This methodology is applicable to one or many destinations and paths.

VIII. CIP PROCESS

The CIP process can be divided into three steps as follows,

1. Filling Process.
2. Preparation Process.
3. Cleaning Process.

1. Filling Process:In this process, all the tanks at CIP station are filled with the cold water from the mains supply. Level indicators are used to indicate the filling level of the tanks to avoid the overflow. We can control the flow of water using the inlet valve.

2. Preparation Process: In this process the water is being prepared for cleaning, that is water is heated up to its set point temperature which is typically 80º C. In order to heat, the water from tank2 is passed through "Heat Exchanger (HE)".When temperature sensor indicates that the water is heated up to set point, then it will stop and Tank2 get filled with the hot water. The same process is carried out for filling tank3 with hot water. After heating, caustic soda is added into tank3 with proper concentration and conductivity. Caustic soda is used to remove unwanted soil and rust from container to be cleaned. So, tank2 and tank3 can be label as Hot water tank and Caustic water tank respectively.

3. Cleaning: After the completion of preparation process, the actual cleaning process is started. Initially the cold water is rinse through the destination equipment, which is to be cleaned, to wet the interior surface of the tank and remove residue. After this the hot water is passed and rinsed through the equipment and then taken back to the station in order to save energy. Same procedure is done with Caustic water. Finally after cleaning with caustic water, Cold water is again rinsed through the equipment to flush out residual cleaning agents. After completing all these three process, it can be said that the Destination Equipment is cleaned thoroughly and ready for the manufacturing of the next batch.

IX. FLOWCHART OF CIP AUTOMATION

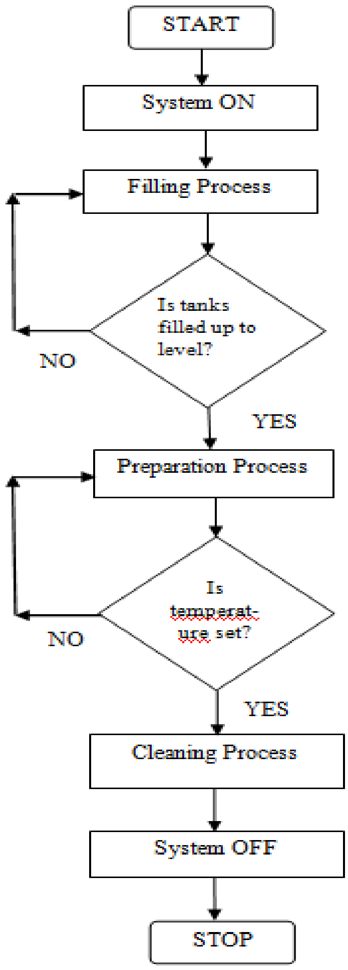

Fig. 3 Flowchart of CIP Process

X. ADVANTAGES OF CIP AUTOMATION

A Cleaning in Place system has many benefits to the end user, the main reasons for implementing Cleaning In Place are:

- Increased throughput or productivity.
- Improves the quality or increases predictability of quality.
- It improves robustness of processes.
- Increased consistency of output.
- Less operation time and work handling time significantly.
- Safety operators are not required to enter plant to clean it.
- Production down time between product runs is minimized.
- Cleaning costs can be reduced substantially by recycling cleaning solutions.
- Water consumption is reduced as cleaning cycles are designed to use the optimum quantity of water.
- The cleaning system can be fully automated therefore reducing labor requirements.
- Hazardous cleaning materials or chemicals do not need to be handled by cleaning operators.
- Use of cleaning materials is more effectively controlled using a CIP system.

XI. RESULT AND DISCUSSION

The result of this project can be observed as the destination equipment which is to be cleaned is cleaned and hygienic after CIP process is done without dismantling the plant. CIP process is nothing but the ladder program which is downloaded into the PLC. The SCADA screen to operate the CIP process is developed, shown below.

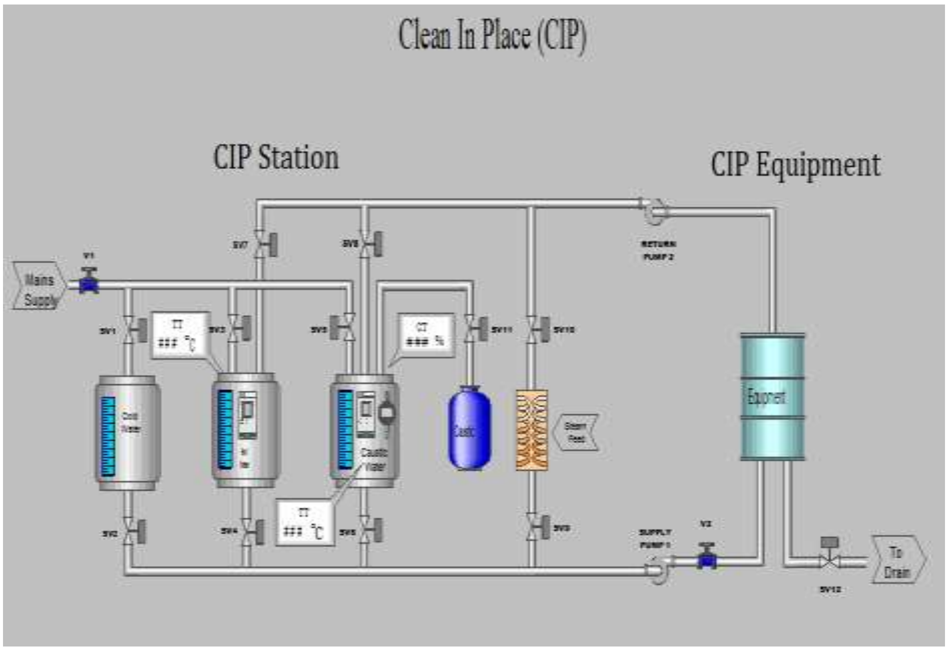

Fig.4 SCADA Screen of CIP

XII. CONCLUSION

Using PLC and SCADA automation, we have developed a modular and flexible CIP process with significant advantages:

- The automation team is not needed to know how to CIP the equipment.
- It gives a modular and straight forward design and implementation approach.
- There is no need to change the code to create new or change the CIP procedure.
- Create reusable operations to meet standard CIP operating procedures.

This advanced methodology results in reduced costs in engineering and implementation time, also a flexible solution that can be implemented across a facility with limited re-work of code.

XIII. ACKNOWLEDGEMENT

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