CLEANING IN PLACE IN PHARMACEUTICAL INDUSTRY USING PLC AND SCADA SOFTWARE

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ABSTRACT

In pharmaceutical industries proper hygiene should be maintained to ensure the proper quality. This paper focuses on the advanced method to clean the pharmaceutical equipments like tanks, filters, pipes, valves, etc. This technique will provide Cleaning of equipment In Place without disassembling the equipments known as CIP. This paper outlines the method of conversion of manual cleaning towards the fully automated cleaning and making the plant environment safer. Automation is done using PLC and SCADA Software. There are three tanks involved in this method filled with cold water, hot water and caustic water respectively having level and temperature sensors and circulated through a circuit of tanks or lines then return to central reservoir allowing reuse of chemical solutions to clean the equipments. The water flow from these tanks is controlled by number of valves. Time, temperature and mechanical forces are manipulated to achieve maximum cleaning.

***Keywords*: Automation, CIP, Pharmaceutical Industry, PLC, SCADA, Sensors.**

I. INTRODUCTION

Industries that require high level of hygiene rely on CIP and they include dairy, beverage, brewing, pharmaceuticals, processed foods and cosmetics**[1]**. CIP Automation is basically a difficult part of the automation process. In many conditions it is more complex to automate the cleaning process than to make the product since the final CIP automation sequence is often defined after process equipment is build and tests are performed. Using CIP is beneficial to industries because cleaning is more faster, also it requires less human power. CIP is more repeatable and focuses on less chemical risk to cleaning operator.

Cleaning in place (CIP) technique provides significant advantages to manufactures as it provides cleaning of equipments in run time at lower costs which improves product quality and plant hygiene. In order to keep less human interference in process here PLC (Programmable Logic Controller) is used. SCADA(Supervisory Control And Data Acquisition) screen is developed in order to control plant and monitor entire system from control room. This minimises errors and faults made by human. The increase of cleaning efficiency in CIP systems is playing a key role in enhanced production. Higher efficiency leads to both, improved hygienic conditions as well as shorter downtimes and therefore to lower production costs**[3]**.

II. DRAWBACK OF CONVENTIONAL SYSTEM

In conventional systems plant equipments are cleaned by disassembling them. Which requires cleaning operator to enter into the plant and also to handle the hazardous chemicals for cleaning which is definitely not safe. Conventional method of cleaning is also time consuming which is not desirable in any industry. This is disadvantage and can reduce product quality. Also there are some systems which are semiautomatic but it still needs an operator.

III. OPERATIONAL PARAMETERS IN CIP

There are four interrelated operational parameters with which overall cleaning process get affected. These factors are needed to be considered very carefully while designing the cleaning process.

Time: The longer a cleaning solution remains in contact with the equipment surface, the greater the amount of contamination that is removed. An increase in time results in reduction of chemical concentration requirements

Temperature: Soils are affected to varying degrees of temperature. In the presence of a cleaning solution most soils become more readily soluble as the temperature is increased.

Chemical Concentrations: Chemical concentrations vary depending upon the chemical itself, type of soil, and the equipment to be cleaned. Concentration normally decreases as time and temperature are increased.

Mechanical Force: Mechanical force can be simple scrubbing with a brush or as complex as turbulent flow and pressure inside a pipeline. Mechanical force aids in soil removal and typically reduces time, temperature and concentration requirements.

IV. BLOCK DIAGRAM OF PROPOSED SYSTEM

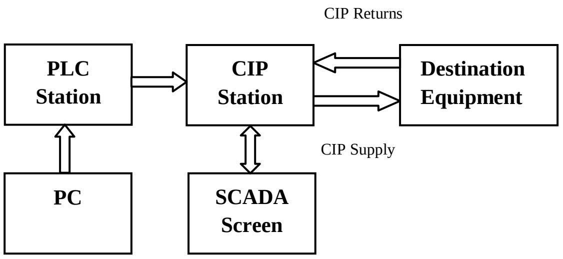

Fig. 1 : Block Diagram of CIP

There are roughly five components in block diagram:

1. PC (Personal Computer): Computer is a device having PLC and SCADA software with which programmer can do programming for specific controller(PLC) and also SCADA screen is designed of CIP. PC is used to download the program into the PLC.

2. PLC (Programmable Logic Controller): PLC is a digital computer used for automation of typically industrial electromechanical process. It is a solid state device**[6]**. 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.

3. SCADA: SCADA (Supervisory Control And Data Acquisition) 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**[8]**.

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.

4. 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.

5. Destination equipment: It is the equipment which is to be clean in place. It is usually hug and complex.

V. PLC AND ITS WORKING PRINCIPLE

Technically the PLC can be defined as "Digital Electronic device that uses a programmable memory to store instruction and to implemented specific function such as counting, arithmetic, timing, sequence, and logic operations to control machines and processes". PLC is used as industrial computer as heart of industrial automation. Basic PLC components are shown in fig below.

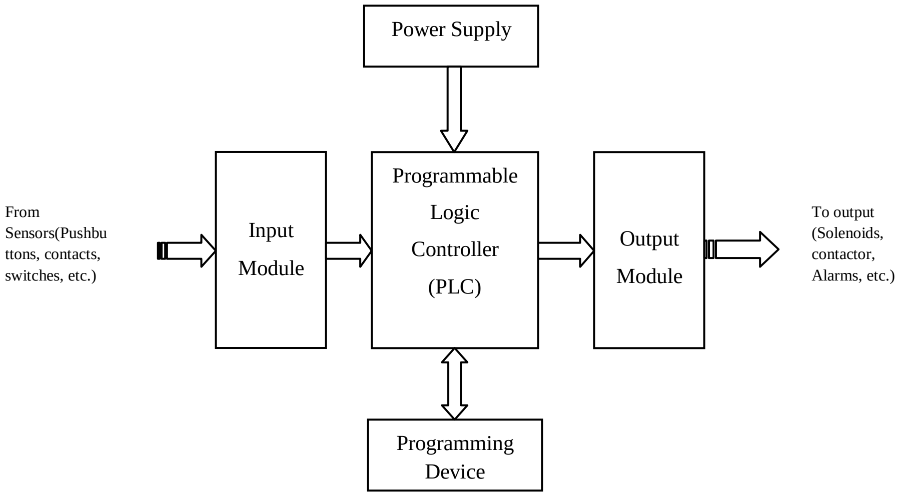

Fig. 2 Basic Components of PLC

PLC mainly consist of a CPU, Memory areas, I/O module, and appropriate electronic circuits. PLC works by continuously scanning a program. There are typically three steps of working of PLC-Check input status, Execute

Program, Update output status**[5]**. PLC also has basically three operating modes viz. Run mode, Stop mode, Reset mode.

Design of any CIP system must consider cleaning ability of the system itself and attention should be given to elimination of crevices and stagnant areas, drainage, minimization of internals, arrangement of valves and pumps, piping welds, sanitary coupling, instrumentation and instrumentation ports**[2]**.

5.1 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)

5.2 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 ladder and executed rung after rung**[7]**. The flow of logic of ladder diagram is typically from left to right. Each rung consists of combination of input instructions. These instructions lead to only one output instruction which is a result of many input instruction in ladder.

SPECIFICATION:

1766-L32BWA MicroLogix 1400 Small Programmable Logic Controller.

1766-L32BWA is a Catalogue number.

- 1766 = Bulletin Number
- L = Base Unit
- 32 = I/O Count (20 inputs and 12 relays outputs)
- B = DC input 24V
- W = Relay Output
- A = AC power for PLC

SOFTWARE SPECIFICATION:

- RSLogix 500 (Rockwell automation software uses for programming in Ladder diagram).
- RSLinx classic (for establishing communication between PLC and PC).
- Factory Talkview (SCADA Software).
- RSLinx Enterprise (for communication between SCADA and PLC).

HARDWARE SPECIFICATION:

- PLC configuration.
- PC as a Programming device.
- CAT-5 LAN Cable.

VI. CIP OPERATION

CIP are characterized by automatic cleaning mostly ladder programs based on a succession of several cold and hot water and different solutions of water, cleaning chemicals and disinfection agents. These chemicals are discharged into sewer systems together with large amounts of water necessary to rinse out residual chemicals from the container in system**[4]**. In CIP process there is a CIP station which contains assembly of three tanks, pipes, valves, pumps, heat exchanger, level and temperature sensors, etc. Initially the three tanks are filled with cold water, this is called filling process. Then the water in second and third tank is get heated, this is called preparation. And finally CIP procedure takes place in which this hot water is passed through the destination equipment.

So, here we can conclude that there are basically three steps in cleaning an equipment -

1. Filling Process.
2. Preparation Process.
3. CIP Process.

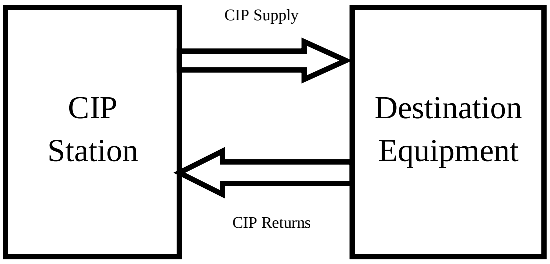

Fig. 3 CIP Basic Overview

1. Filling Process: The first step in filling process is to ON the system valve. In this process all the three tanks are filled with cold water. As soon as system valve is on the first tank is get filled by opening its upper valve, at the same time lower valve is closed. When level sensor sends the signal then it indicates the tank is filled. Then the filling valve of the first tank is closed and the second and third tank starts filling by the same process one after another.

2. Preparation Process: In this second process the water is prepared for cleaning, that is water is heated up to its set point temperature which is typically 80º C. In this process the water from second tank is passed through "Heat Exchanger (HE)" for heating purpose. During this both valves of second tank are open for water circulation from HE to tank. When temperature sensor indicates that the water is heated up to set point, then it will stop and both valves will be closed. This same process takes place for heating the water in third tank. After this caustic soda is added to hot water in third tank with proper concentration and conductivity. Caustic soda is used to remove unwanted soil and rust from container to be cleaned. This process includes pumps for suction of water.

3. Cleaning in place: After preparation process the water is passed to the destination equipment with the help of output valve. Firstly, cold water is passed through the equipment and then that destination equipment is rinsed with the cold water. And then the cold water is drain from equipment. After this the hot water from second container is passed and rinsed in the equipment to be cleaned. But this hot water is not drain, it is taken back after rinse operation, as in any industry energy is not wasted. Same procedure is done for third tank in CIP station. Finally after rinsing the destination equipment with caustic soda water it is again washed and rinse with cold water.

After completing all these three process, it can be said that the Destination Equipment is cleaned and ready for the manufacturing of the next batch.

VIII. CLEANING SOLUTIONS: Cleaning solutions may include different types of Sanitizers, detergents or disinfectants. The detergents used in CIP system are alkali or acid detergents. The alkali detergents includes Sodium Hydroxide, sodium Carbonate, Potassium Hydroxide, etc and the acid detergents are Hydrochloric Acid, Citric acid, Nitric Acid, Phosphoric Acid, etc**[1]**.

VIII. FLOWCHART OF CIP

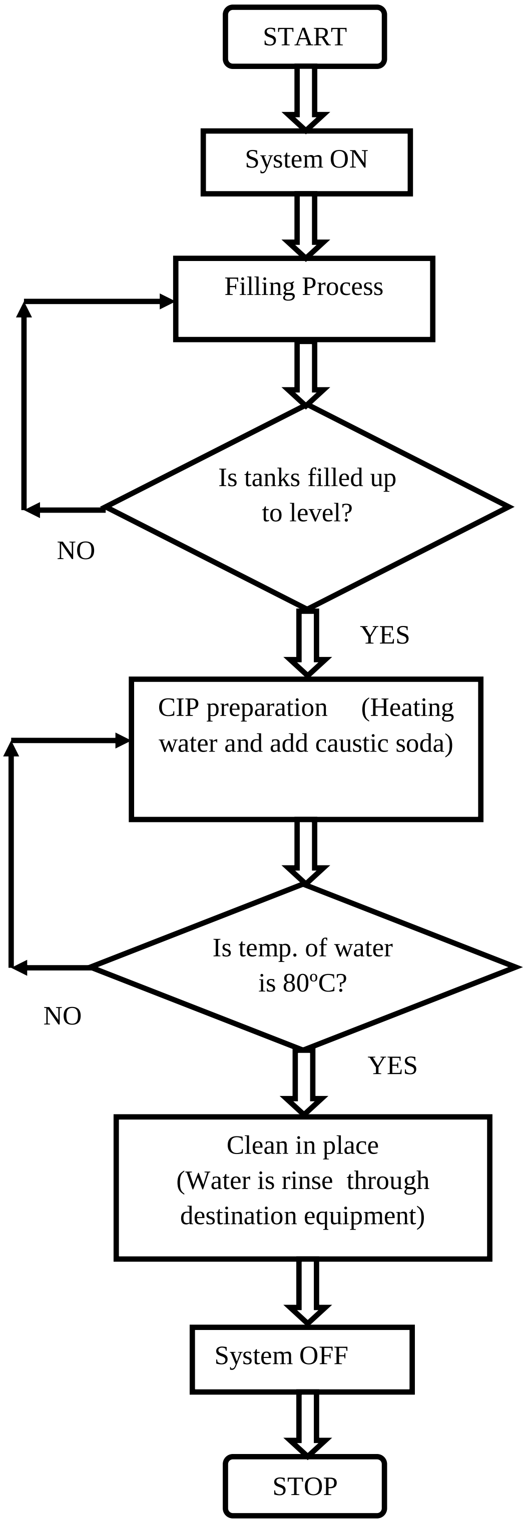

Fig. 4 Flowchart of CIP Process

IX. ADVANTAGES OF CIP

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.
- CIP improves the quality or increases predictability of quality.
- It improves robustness of processes.
- Increased consistency of output.
- Reduces operation time and work handling time significantly.
- Safety operators are not required to enter plant to clean it.
- Difficult to access areas can be cleaned.
- 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.

X. 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. CIP process is nothing but the ladder program which is downloaded into the PLC.

XI. CONCLUSION

From this project it is concluded that using CIP technique for cleaning and hygiene is advantageous. This CIP process can be efficiently used in pharmaceutical industry using automation tools like PLC and SCADA. This is concluded that this system is better than the conventional present system. This system gives accuracy and guarantee in cleaning automation.

XII. SCADA SCREEN

The SCADA screen for monitoring and controlling the process from remote place the SCADA screen is developed.

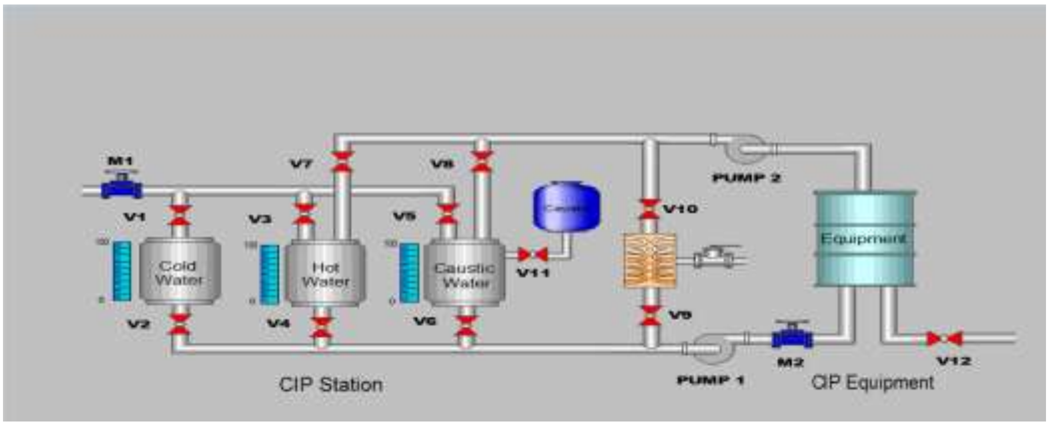

Fig. 5 SCADA Screen of CIP Station and Destination Equipment

XIII. ACNOWLEDGEMENT

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