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Automation of Cleaning-In-Place for Food and Beverage Industry Using PLC and SCADA

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ABSTRACT: In Process Industries, mainly food and beverage industries, proper hygiene should be maintained to ensure the standard quality of the product. So, the cleaning of DestinationEquipment's must be done very properly and hygienically. Cleaning-In-Place (CIP) Automation is the best way to clean the process equipment's without disassembling and without actual human involvement. This project converts manual cleaning into the fully automated one thereby reducing the production time and making the plant environmentally safe. Some process equipment's are cleaned with only water while other equipment'sare cleaned using detergents such as acids or caustic solutions of specific chemical concentration, with some mechanical force, temperature and time parameter. 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. Here automation is done by using the hardware and software tools like PLC and SCADA. We use three tanks filled with cold water, hot water and caustic water simultaneously for cleaning purpose. It consists of three processes namely filling, preparation and CIP process.

KEYWORDS: Automation, CIP, Food and Beverage Industry, PLC, SCADA, temperature, level and conductivity sensors.

I.INTRODUCTION

Industries that require high level of hygiene rely on CIP and they include dairy, beverage, brewing, pharmaceuticals, processed foods and cosmetics 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, valves, machinery, vessels or pipe work without dismantling or disassembling the plant. Cleaning-in-Place is a critical process hygiene aspect that helps to ensure the health and safety of the consumer.The objective of cleaning of destination equipment is to remove ingredients or small food particles and avoids bacteria to grow, and also to kill those bacteria which are present. Cleaning is the complete removal of food ingredients using appropriate detergent chemicals under recommended conditions.Cleaning-in-Place (CIP) is now a very common practice in much process plant replacing manual strip down, cleaning and rebuilding of process systems.Cleaning in place technique provides significant advantages to manufactures as it provides cleaning of equipment's, pipelines valves in run time at lower costs which improves product quality and plant hygiene. To avoid human interference that is to increase automation 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. Totally increase the efficiency of overall plant.

II. DRAWBACK OF CONVENTIONAL SYSTEM

There are various conventional systems or methods available to clean the industrial destination equipment's and machinery. Those systems are manual or semiautomatic which require human to dismantle the plant or enter the equipment. The cleaning operator needs to enter into the plant and also to handle the hazardous concentrated chemicals for cleaning purpose which is definitely not safe and dangerous. Also, those systems are both time and power consuming which is not desirable in any process industry. Conventional system decreases the overall quality of product and ultimately gives effect on plant efficiency. Cost and labour requirement in conventional system is high.

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III. OPERATIONAL PARAMETERS IN CIP

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

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, temperature and mechanical force requirements.

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

Chemical Concentrations: Chemical concentrations vary depending upon the chemical itself, type of contaminants, 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 contaminants removal and typically reduces time, temperature and concentration requirements.

IV. BLOCK DIAGRAM OF CIP SYSTEM.

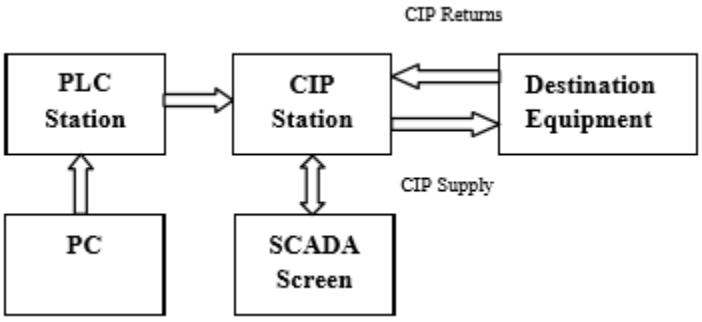

Fig.1 Block diagram of CIP

Fig.1 shows the block diagram of the CIP. It mainly consist of following sections-
1. PLC: Is stands forProgrammable Logic Controller. PLC is a digital computer used for automation of typically industrial 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. PC: It stands for Personal Computer. It is use for day to day application. 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.

3. SCADA: It is a software use in various process industries for control and monitoring purpose and stands for 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.

4. CIP Station: CIP station is the main block in CIP process. Is the assembly of all components use for cleaning purpose. 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.

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5. 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.

V. PLC AND ITS WORKING PRINCIPLE

PLC is digitally operated electronic system, design for use in an industrial environment, which uses a programmable memory for the internal storage of user oriented instructions for implementing specific functions such as logic,Sequencing, timing, counting and arithmetic to control, through digital or analog inputs and outputs, various types of machine or project.
Below figure 2 shows block diagram of programmable logic controller it consist of following blocks.

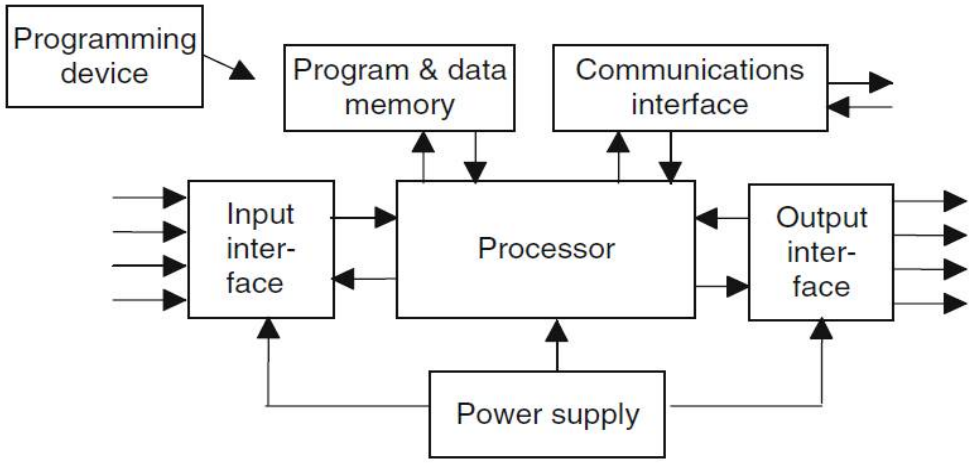

Fig.2. block diagram of PLC.

PLC mainly consists of a Processor; Program and data memory areas, I/O interface, and appropriate electronic circuits. PLC works by continuously scanning a program.PLC mainly consists of a CPU, Memory areas, I/O module, and appropriate electronic circuits. PLC works by continuously scanning a program.Program, Update output status. PLC also has basically three operating modes viz. Run mode, Stop mode, Reset mode.

PLC Programming Language: - As per part 3 of IEC61131 there are mainly five programming languages defines two graphical and two textual.

a. Ladder Diagram (LD)
b. Functional Block Diagram (FBD)
c. Structured Text (ST)
d. Instruction List (IL)
e. Sequential Function Chart (SFC)

Ladder Diagram: - Ladder logic program isexactly similar to electrical ladder diagram. It provides the graphical display of program execution by showing power flowthrough a ladder diagram, thereby making it easier to debug.
This programming is fast. 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. It has two vertical rails and a series of horizontal rungs between ladder and executed rung after rung. 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. So program development environment is user friendly.

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VI. SPECIFICATION

1766-L32BWA Micrologix 1400 modular programmable logic controller (Allen Bradley).

- 1766=Bulletin Number
- L=Base Unit
- 32=I/O Counts (20 inputs and 12 Relay Outputs)
- B=DC Input 24V
- W=Relay Output
- A=AC Power for PLC

VII. SOFTWARE SPECIFICATIOPNS.

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

VIII. HARDWARE SPECIFICATIOPNS.

- PLC configuration.
- PC as programming device.
- CAT-5 LAN Cable.

IX. CIP OPERATION

CIP is the process of cleaning using several cold and hot water and different solutions of water, cleaning chemicals and disinfection agents. In CIP process there is a CIP station which contains assembly of three tanks, pipes, valves, pumps, heat exchanger, temperature sensors, and level switches etc. Initially the three tanks are filled with cold water, this is known as filling process. After that water in the second and third tank is get heated and add cleaning chemical into third tank, called preparation process. At the last this prepared solution passed through the destination equipment termed as CIP process.

Thus we conclude that there is basically three process in CIP operation that are-

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

1. **Filling Process: -** In this process all three tanks are filled with cold water as opening the upper valve .At this time lower valve will be 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: -** It is second process in CIP process. In this process water is prepared for cleaning purpose, for that it heated up to its set points which is typically 80^{o} C. In that water from second tank passed through heat exchanger for heating by opening both upper and lower valve of the tank. Temperature sensor sense the temperature of heating water and when it equal to set point valve will be close. Same procedure takes place for heating the water in the third tank. After heating the water to the set point caustic soda is add into the third tank for proper cleaning of destination equipment.

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3. **CIP Process:** - After preparation process prepared water passed to the destination equipment. Here we apply five steps CIP cleaning process. Firstly, cold water is passed through the equipment and then that destination equipment is rinsed with cold water and then drain out it from destination equipment. After that the hot water from second tank passed through and rinsed in the destination equipment to be cleaned. This hot water is not drain out it take back into second tank. Again destination equipment washes with cold water and drained out it. After that Caustic hot water from third tank circulate in destination equipment and take back into the tank. 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.

X. FLOW CHART OF CIP

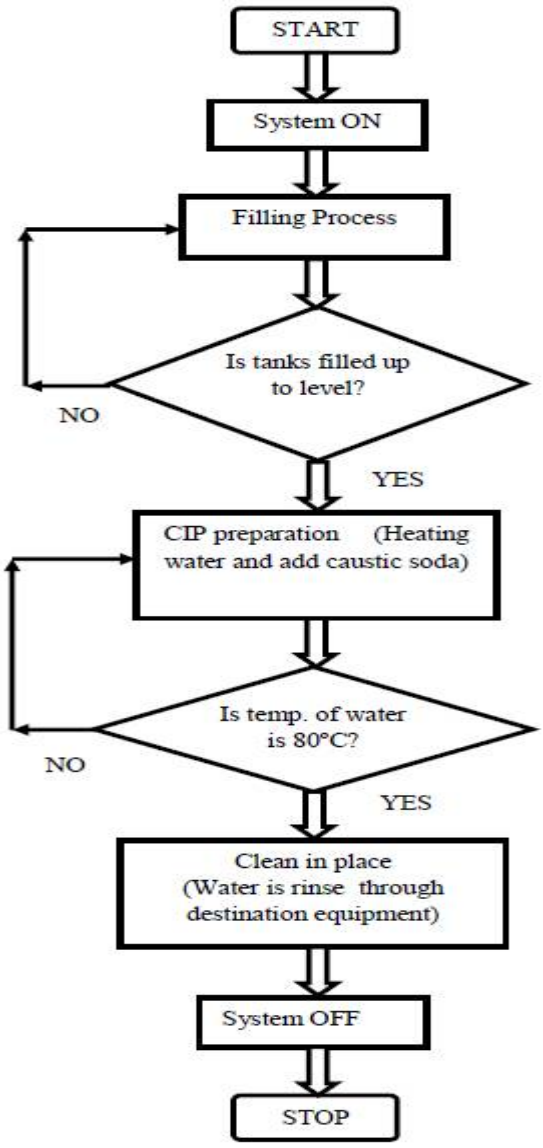

Fig.3. Flow chart of CIP process

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The flow chart of CIP shows the procedure ofCIP sequentially. By starting the system, process become on, carry the three processes which are filling process, preparation process and CIP process simultaneously with checking corresponding conditions.

XI. CIP ADVANTAGES

A Cleaning in Place system has many benefits to the end userand due to its automation it becomes more profitable in the various process industries and there main advantages are:

- It is safer as operators are not required to enter plant to clean it.
- Increase throughout predictability of quality.
- Hazardous cleaning materials or chemicals do not need to be handled by cleaning operators.
- Reduce operation time effectively.
- Use of cleaning materials is more effectively controlled using a CIP system.
- Cleaning costs can be reduced substantially by recycling cleaning solutions.
- Increased consistency of output.
- Increased consistency of output.

XII. RESULT

Figure shows the response of the hot water temperature for the preparation process with respect to time. As mentioned earlier the set point temperature is 80^0 C shown by green line. The blue colour represents hot water temperature. When the temperature of the process variable is above the set point the controller output indicated by red colour becomes high and water circulates in the heat exchanger will stop.

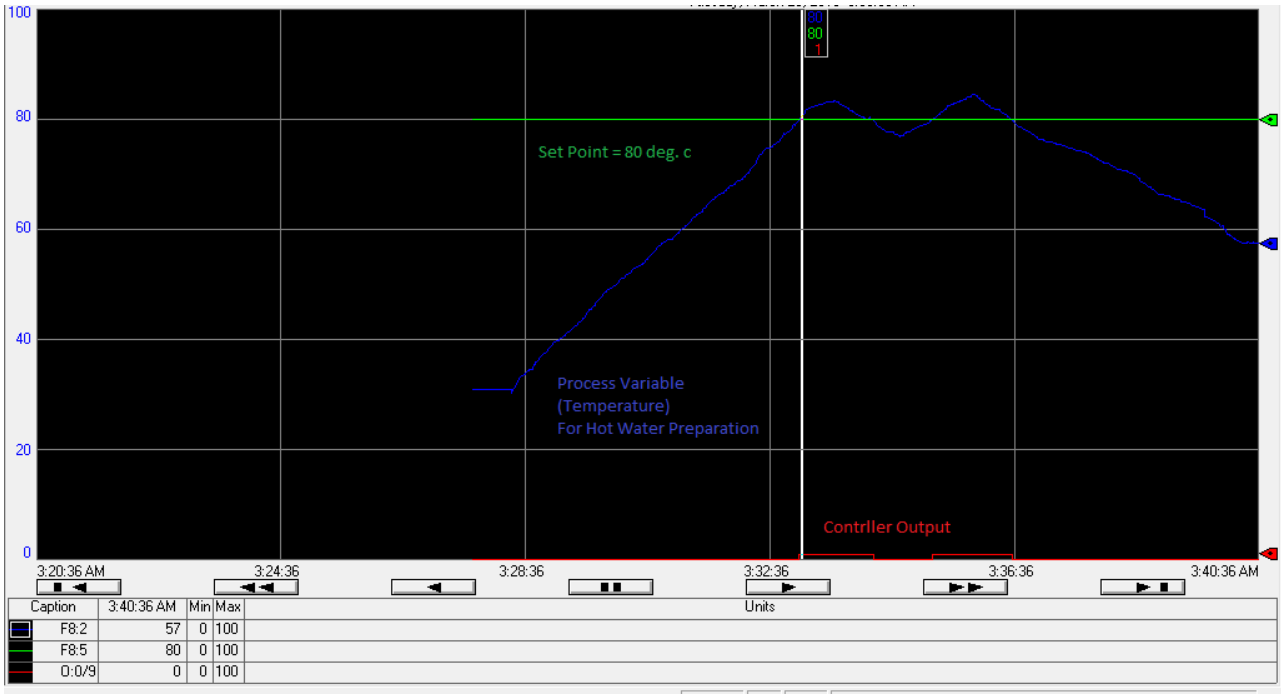

Fig.4. Time vs. Hot water temperature.

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. Here we use the five step CIP process. CIP process is nothing but the ladder program which is downloaded into the PLC.

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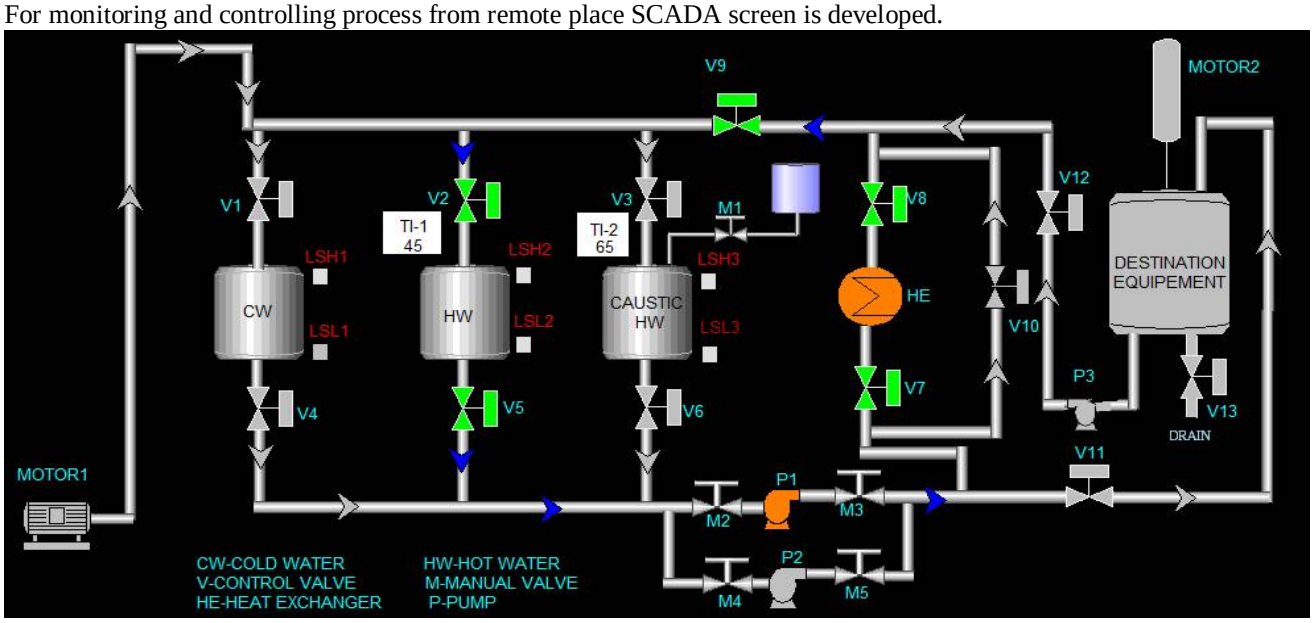
XIII. CONCLUSION.

From this project it is concluded that using CIP technique for cleaning and hygiene is advantageous. This CIP process can be efficiently used in food and beverage 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. This CIP technique is safer and increase predictability of quality.

XIV. SCADA SCREEN.

For monitoring and controlling process from remote place SCADA screen is developed.



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REFERENCES

1. Siddhesh Dhonde, Bhaskar Nadigatla,"cleaning in place automation for processindustry using plc and scada software." IJEEE, Vol. 07, Issue 01,pp. 1-7, 2015
2. Amitha Thomas, C. T. Sathian, "Cleaning-In-Place (CIP) System in Dairy Plant-Review",IOSR-JESTET, Vol.8, Issue 6, pp.41-44, 2014.
3. Nurgin Memisia, Slavica Veskovic Moracaninb , Milan Milijasevic b ,Jelena Babic b , ''CIP cleaning processes in the dairy industry**"**, International 58th Meat Industry Conference, Procedia Food Science 5,pp.1-3, 2015.