Automated Cleaning in Dairy Industry using CIP Method

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Abstract—**Existing cleaning process involves human interactions which is time consuming and is prone to risk. So to overcome drawbacks of human oriented process it is necessary to bring up a automated methodology in the cleaning process especially in dairy industry. This paper gives the basic principles of CIP washing process in the dairy industry. This procedures are automatic or semi-automatic internal cleaning process of production facilities without dismantling the system.**

Keywords—Cleaning In Place (CIP), Dairy plant, Cleaning efficiency, automation

I. INTRODUCTION

In the last 10-15 years techniques and washing of equipment used for food processing have been under observation . In the past, cleaning of the equipment in dairies has been done by workers who had to dismantle the equipment and enter into it to reach the area they needed to clean up. Products were often infected due to inadequately cleaned equipments. The system of circular "cleaning in place" (CIP) has been developed in order to achieve good results in cleaning and sanitation especially adapted in production plant Pumps which make circulation of the fluid also enable automatic circulating, washing and rinsing, a technique called washing in place or CIP. CIP is stated as circular washing, with fluid running through various tubes and machines components and through the various parts of enclosed machines because it is too expensive and difficult to disassemble and assemble frequently Cleaning In Place (CIP) is a method of cleaning the interior surface of vessels, process equipment and associated things without dismantling. Industries like dairy, beverage, brewing, pharmaceuticals, processed foods and cosmetics that require high level of hygiene rely on CIP. The efficiency of cleaning and sanitation of milk contact surfaces are widely influenced by many factors like the character of contamination, micro topography of surfaces etc (Jones et al., 1986).The cleaning process solutions may be used for single or multiple cycle which depends on the processing practice and load of soiling on the various process equipment. For multiple cycle use, cleaning solutions are used to drain out after every several hundred cleaning cycles (Merin et al., 2002). In the dairy industry, reuse and multi use CIP systems operate by chemicals and water combination without taking the equipment apart is practically used. In any CIP mode of operation, cleaning solutions are used for periodic draining when they too polluted (Genevihe et al., 2002). The effectiveness of cleaning is measured by factors like chemical agent, mechanical power, temperature, and time of the procedure(Wirtanen and Salo, 2003).

Cleaning in place in the dairy industry has some specific features. It is equally important to remove the remaining organic contamination, and also milk-water plaque. The sanitation method of CIP is developed to guarantee the elimination of organic and inorganic contaminations, disinfection of the surface from live cells of microorganisms. it helps in elimination of the residues of the sanitation agentsby 99.9 per cent (Vlkovai et al., 2008). Cleaning-In-Place (CIP) involves the jetting or spraying of surfaces or circulation of cleaning agents in the plant under conditions of increased turbulence and flow velocity. It has seen increased demands from customers in terms of CIP verification and validation to provide improvements in hygiene, finished product quality etc(Tamime, 2008). It is important that cleaning procedures ensure that the hygiene in food processing lines is maintained by complete removal of bacteria from surfaces (Gentil et al., 2010). Cleaning-In-Place systems shortens the required time for cleaning, besides using detergents and disinfectants at higher concentrations and temperatures.The automation of these systems also allows for safe and reproducible results and economic optimization of the process (Gracia and Diaz, 2011).

II. CIP WASHING SYSTEMS

There are various types of CIP systems:

a) simple closed systems (washing by circulation) - typical for devices with limited volume, such as filters, chargers or little CIP systems for "lost washing" - for each wash a new cleaning solution is prepared,

b) the automatic CIP system conducts return of the washing solution.

Benefits of CIP procedures for sanitation of equipment which are washed in dairy plants are:

a)greater safety - fewer manual operations, removal of the human factor errors, safety at work

b) higher quality of sanitation -control of the washing is implemented via the control panel and the results are reproducible

c) controlled costs - lower labor costs, the controlled use of resources for sanitation, water and energy.

The transition of fluid over surfaces of various equipments creates the effect of mechanical friction that helps to releases dirt deposits. The dairy industry makes use of a variety of Machines. The design and the volume of the internal surfaces have to be monitored which is difficult to run in circulatory washing so only mechanical cleaning is not sufficient but must be done with specially designed nozzles for washing.

III.   CLEANING SOLUTIONS

In CIP system, cleaning solutions used include various types of detergents, sanitizers or disinfectants (Tamime, 2008).

A. Detergents
The detergents used in CIP system may be alkali or acid . Very commonly used alkali detergents are Sodium Hydroxide, Potassium Hydroxide, sodium Carbonate etc The acid detergents include Hydrochloric Acid, Nitric Acid, Phosphoric Acid, Citric acid etc
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▪ *Alkali detergents*

Alkaline cleaners or detergents have a pH higher than 7. They are commonly used in the dairy industry because they change fat and convert it into soap which can be removed with water. These are usually consist of sodium hydroxide (caustic soda) potassium hydroxide (caustic potash), sodium carbonate (soda ash), and sodium silicates.

Typically 0.5 – 2 per cent caustic soda has been used at temperatures of up to 85₀C. For highly fouled surfaces, up to 4 per cent caustic soda can be applied (Mosteller and Bishop, 1993). The best cleaning effect for surfaces with the burned milk soil was achieved with a two phase cleaning procedure using chelator based sodium hydroxide (Wirtanen and Salo, 2003).

Caustic soda is a very strong alkali, and is a commonly used material in formulating detergents for use in CIP ant other cleaning process because of its low cost. It helps in excellent removal of proteinaceous soils and fatty oils by changing fats into soap (Tamime, 2008).

• *Acid detergents*

Acid circulation in CIP method for pasteurization is used to remove encrusted protein and salts from the surfaces of equipment.The flow rate must be greater than 1.5 m/sec to achieve the mechanical force(Wirtanen and Salo, 2003). The most common acids found in dairy cleaning are the inorganic acids like phosphoric acid and nitric acid, and the organic acids, such as citric acid.Various other mineral acids that may be used are hydrochloric acid and sulphuric acid. Organic acids like hydroxyacetic acid and gluconic acid are also used (Tamime, 2008).After an alkaline wash,acidic detergent wash is applied in order to remove any traces of alkaline product from equipment surfaces. It enhances draining and provide bacteriostatic conditions that delay the growth of organisms that may be found in the water supply.

The most common acid detergent is nitric acid, which is generally used at a concentration of 0.5–1.0 per cent under either ambient or heated conditions (55–80₀C) for 5 to 20 minutes (Bremer and Seale, 2010).

B. Sanitizers

Disinfectants used in the diary industry include oxidizing agents such as hypochlorite, hydrogen peroxide etc. Also denaturing agents which can be alcoholic products, non-oxidizing enzyme based products are also used (Troller, 1993).

Sanitizers based on per oxygen can eliminate spores but they are corrosive at high temperature and highly concentrated (Russel and Chopra, 1996). Wirtanen and Salo (2003) suggested that the sanitizers must be used at either high concentration or at high temperature to be able to eliminate spores. But it is actually not suitable for disinfection due to corrosion and toxicity. The process includes both cleaning off organic and inorganic matters mixed with microorganisms which may be the primary cause of the formation of the plaques (Vlkovai et al., 2008). Sodium hypochlorite based sanitizers are widely used as they have many features which make them desirable for CIP applications in diary industry.

IV. CIP PROGRAMS

CIP programs in dairy industry differ according to circuits included in system for cleaning of the heating surfaces or not. So on the above basis programs are divided into following:

a) CIP programs for circulatory washing which include pasteurizers and other equipment of heating surfaces(UHT, etc.).
b) CIP programs for circulatory washing which have tanks for the reception of pasteurized milk. The main difference between the two programs is that the acid circulation is always included in the first type to remove deposits of proteins and salts from heating surfaces. CIP circulatory washing is one into which pasteurizers and other. Equipment of heating surface are grouped and termed as "hot components" In dairy industry, once washed with water, CIP system is programmed to start rinsing the system equipments with acidic cleaning solutions, so as to first remove salt deposits and break up the layer of dirt. Therefore enabling the breakdown of the proteins by alkaline detergents. Accordingly, the cleaning process has to begin with alkaline cleaning solution and end up with acidic detergent, after which it is finally rinsed with water, and the equipment is cleaned. The equipment should be rinsed with weak alkaline solution to neutralize acid before disinfecting by chlorine chemicals.

CIP systems comprises of four reservoirs: with cold water, an acid, a base and the so steamy water reservoirs. There are systems with added hot water tank or reservoirs.
The operator is given the option of choosing the washing program wherein complete wash or particular washing step can be selected. There are sensors for measuring levels of temperature and concentration of the fluids in each tanks. All

signals from the from system equipments are forwarded to the central computer. All the relevant data for the system is seen at the terminal , and it is possible to select washing program cycle, steps, etc.

V. THE DESIGN OF CIP SYSTEM

CIP is termed as a method that is used for automated or semi-automated washing and cleaning purpose of technological system elements without disassembling them. Practically, there are no restrictions in processing individual requests for the size and complexity of the CIP system. CIP station in a dairy consists of the equipment required for the storage, tracking and distribution of cleaning liquid solutions to the various CIP circuits. A centralized CIP system has found its place in many dairy industries, but in large dairies with a large processing capacity, the distance between the central CIP systems and peripheral circuits becomes long. The residual water dilutes detergent solution, which means that large amounts of the concentrated detergent must be added in order to maintain the required concentration. The greater the distance, the higher the cost.

VI. CLEANING PROCEDURES

As per the Dairy Practice Council (1993), the recommended cleaning procedure involves

Step 1: Pre-mixing the required amount of a well-balanced alkaline circulation cleaning solutions with cold water to provide a concentration of 0.7 to 1.0 per cent.

Step 2: Add the pre-dissolved cleaner directly into the surge tank.

Step 3:Circulate this alkaline cleaning solution for 30 to 45 minutes, maintaining temperature at 1750F.

A procedure given by Tamime and Robinson (1999) explains the rinsing of the system with clean cold water for 5 to 20 minutes ensuring washing out the remains of the processed milk. Cleaning with an alkaline solution of concentration 1.0–1.5per cent at 75– 800C for 6–45 minutes aims to remove the organic deposits like oil, proteins, polysaccharides from the surface and rinsing with warm water Cleaning with an acid agent having a concentration of 0.5–2 per cent for about 5–45 minutes between 600C and 900C eliminates the inorganic sediments and then finally rinse with cold water for 5 to 20 min.

To specify the correct processing timings of every step of cleaning methods is at most important. If cleaning process proceeds given timings will cause fouling on the surface of processing equipment especially in heating equipments which result in growth of harmful bacteria (Wirtanen and Salo, 2003). Wirtanen and Salo (2003) carried out less environmentally harmful cleaning procedures based on ozonated water and enzyme based gent in CIP and obtained promising results. Eidie et al. (2003) used four CIP methods for dairies compared using life cycle assessment (LCA). The methods included alkaline/acid cleaning with hot water disinfection, alkaline cleaning with acid chemical disinfection, enzyme based cleaning with acidic chemical disinfectant and last with disinfection by cold nitric acid at pH 2.

Cleaning process has a series of discrete stages as follows firstly removal of gross debris, pre rinse, detergent circulation, intermediate rinse, second detergent circulation, intermediate rinse disinfection and final rinse (Tamime, 2008).

A. Security analysis

Since the CIP process is automative the drawback of human intervention in process of cleaning the dairy every time gets reduced or say completely eliminated, the workload of human workers gets reduced as in this process the human workers need not enter into the equipment to clean it. The safety levels gets increased as the whole process is operated automatically the only operation to be performed by human is to select whether they want complete wash or just the part of the process.

VII. EXPERIMENT AND RESULT

The CIP methods with small volumes and low temperatures, such as enzyme-based cleaning and one-phase alkaline cleaning turned out to be the best alternatives for human based cleaning process for the impact categories like energy use, global warming etc.CIP also controls all important parameters like time, flow, concentration. Easy for operation and independent on operator skills with reliable components.

VIII. CONCLUSION

Modern technology implemented in food processing methods have led to reduced likelihood of diseases that are associated with food. On the other hand, modern methods of food production and processing also rely on secured technologies for washing and sanitation of the equipments used. It also aims to simultaneously provide and maintain product safety. Preventing human diseases due to food, reducing the failure of finished products and improving their quality are achieved by this method. Cleaning In Place system in a Dairy industry make use of types cleaning solutions like disinfectants or detergents which can be stored and reused.System with CIP methods will economize the cleaning process. The disadvantage of the system can be that repeating the use can lead to building up of organisms in the equipments subsequently in to the pasteurized milk. So it is necessary that timely checking of the cleaning strategies should be carried out to achieve good product quality results
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