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DESIGNING A CIP SYSTEM

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Abstract

Safety and quality are the two important keywords in food manufacturing. A lot of efforts are being carried out to achieve them. Modifications and improvements are being made in many aspects in order to stay competitive in the current market. One important factor in achieving these objectives, which unfortunately being overlooked is hygienic design. Safety and product quality are actually built in the design of the plant itself. This paper illustrates an aspect in hygienic plant design - Cleaning In Place (CIP).

Introduction

In conjunction to the development in processing and product technology, todays consumer are getting more particular about quality and at the same time the demands for low cost products still continues. In food processing, quality does not reflect only the physical or chemical properties of the food product but also include sanitary and safety aspects.

For business survival, today many manufacturer are improving their manufacturing scheme to produce safe food product. Consequently, they started to enforce sanitary condition in the manufacturing areas. In addition, the processing equipments and lines are cleaned and sterilized to reduce the bacteriological counts to the acceptable level. But many of these manufacturers still face difficulties in achieving the objectives. Product infections are occurring one after another and this has hit the companies productivity very badly.

The answer to this problem is simple enough but has the tendency to be overlooked. Food safety does not depend on the processing factors alone. It also depends highly on the type and design of the equipments used. No matter how well a food processing plant is operated, its ability to achieve and maintain purity of its content is a function of its detailed process and mechanical design, and consideration standard should begin with the first flowsheets. In other words, food product safety must be designed into a plant or it will not be guaranteed.

What Is CIP ?

One important component of hygienic plant design is the cleaning system set up. Traditionally, equipments and processing lines are dismantled and cleaned manually. Today, Cleaning In Place (CIP) system is more widely used.

CIP is synonymous with cleaning of an equipment or a process line without dismantling. It is based on the idea of circulating water and chemical solutions through the entire process line in the assembled state. It was developed to overcome cleaning problems in complicated processing plants and to reduce labour cost and non-productive cleaning time.

The history of industrial CIP operation started in Oakland, California in 1939 (Harper and Hall, 1976), however the it was not very well accepted until a few years later. In 1953, due to the increase in popularity, works on the automation of CIP operation was started.

The mechanism of CIP consists of two important stages. One is due to the chemical effect in which the acid, alkali and the formulated detergent penetrate into, react with and partly dissolve the impurities. This cleaning mechanism is further enhanced by the turbulence effect which transforms the soil (impurities) deposed on the surface of the equipment into suspended particles in the cleaning solution.

In most cases, the cleaning sequence will include:
1. Initial rinsing with water
2. Cleaning with alkali solution
3. Intermediate rinsing with water
4. Cleaning with acid
5. Final rinse with water

Advantages and Limitations of CIP

CIP is advantageous as it simplifies the cleaning procedure and improve the cleaning efficiency at lower cost as compared to traditional, manual cleaning. It allows the use of stronger chemical solutions at higher temperature, and therefore increases cleaning performance. CIP operation also reduces the risk of infection because it eliminates unreliable manual cleaning and avoids the operators from touching surfaces in contact with the product.

However it cannot be applied to the whole of processing line and has to bypass some of the equipment like filters, positive pumps, open tanks system, and meters. In addition, the design parameter especially the operating conditions are too product specific, hence requiring reformulation of the menu if different type of products are considered.

Designing A CIP System

In designing CIP system, many factors have to be considered. The two governing factors are the soil and water characteristics. Depending on these characteristics, the following CIP parameters which are determined :

1. Type and composition of the chemicals to be used (TITRATION)
2. Duration and frequency of cleaning (TIME)
3. Temperature of cleaning solution (TEMPERATURE)
4. Flow rate of cleaning solution (TURBULENCE)

- Material Selection

Different soil composition will require different composition or even type of chemicals, but principally, detergent raw materials may be outlined as the following :
* alkali - normally Sodium Hydroxide solution is used.
* acid - Either Nitric or Phosphoric acids can be used
* sequestrant, surfactant and Phosphates
* other minor groups including suspending agent and antifoam.

The use of acid and alkali determined the type of materials used in the construction of the equipment and piping system. Due to the high concentration of these chemicals, all pipes and equipments are normally constructed with stainless steel.

For the CIP operation, soft water gives maximum cleaning effect, however this has to be justified by the economic of the treatment. To reduce cost, water from final rinse and part of the intermediate rinse are normally recycled and used in the initial rinsing stage. In some application, usage of reused water in the intermediate rinsing stage is also allowed. In the final rinsing stage, fresh water is required.

- Equipment & Piping System Design

Implementing a CIP system should be considered in the early stage of the plant design itself as modification of existing plants for CIP is always a difficult task. In designing the piping network, great precaution has to be taken to avoid possibility of mixing or contact of the product with the CIP solution, especially during process failure. Safety and diversion valves must be adequate to divert the product stream to proper places.

It is important to ensure that all surfaces to be exposed to product are completely wet by the cleaning solution. Spray balls or nozzles must be installed at the right location. Furthermore, to have sufficient cleaning effect by turbulence, dead end in piping must be less than 3 times the pipe diameter (see figure 1).

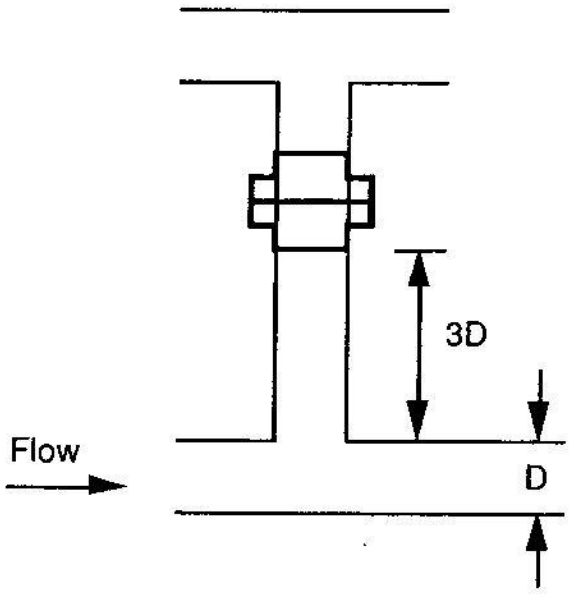

Figure 1 : Dead End Must Be Less Than 3 Times Pipe Diameter

- Design of CIP Station

There are two type of CIP station - single-use and multi-use system. In a single-use system, the cleaning solutions are used only once. It operates with small volume of solution at lowest possible chemical concentration. Single-use system is advantageous for its small size, simple design, low initial investment and flexibility of operation. In addition, the system occupies small space and easy to move about in the plant.

However, this configuration will incur high operating cost due to extensive chemicals and water usage, and safety risks due to frequent handling of concentrated chemicals. As a consequence, its application is normally restricted to small networks and specialised cases such as in heavily soiled circuit in which the returning chemicals are heavily polluted and would contaminate the whole storage tanks if recycled.

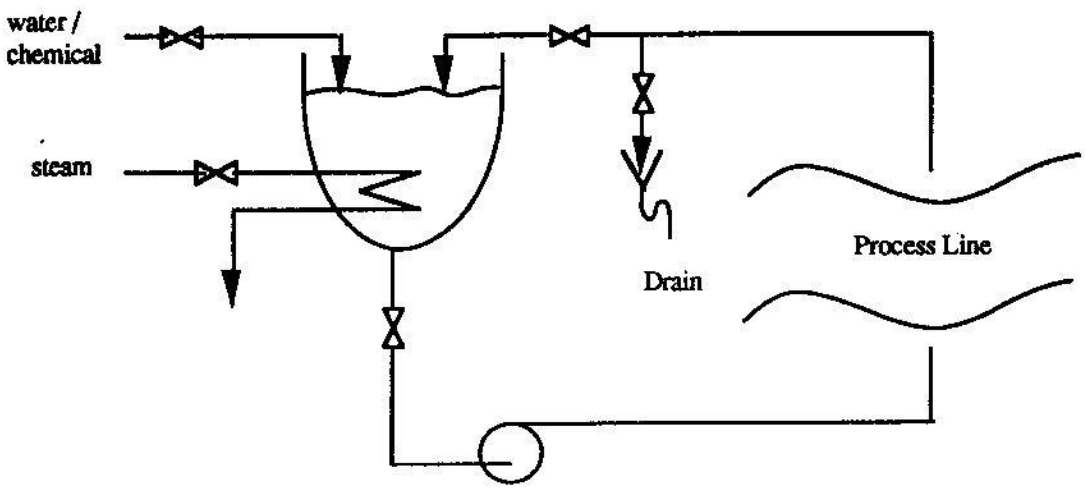

Figure 2 : Single Use CIP Station

In multi-use CIP station, cleaning solution is utilised as many times as possible. The configuration is similar to the single station but several centralised tanks are used to store chemicals. In this configuration chemicals are recirculated for maximisation of their usage and replacement with fresh chemicals is made periodically..

Concluding Remarks

Public demands are moving steadily in the direction of natural foods with no artificial additives and the pressure is now firmly on the food manufacturer to remove preservatives from their products. At the same time the race continues for flavour improvement and minimum of processing to preserve the natural quality of the food. Safety and quality awareness of the public has also initiated the government to impose rules and regulation on the production of food products.

It is true that many alternatives can be taken to improve safety margin of the product, however if the plant is not properly designed and important features like CIP is not emphasised, food product safety can never be guaranteed. This is an example of an arca where chemical engineer can contribute to the manufacturing industry. Studies must be made to overcome process limitation.

References

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