Milk Powder Production System, Equipments and its Drawbacks

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Abstract: It is expected that the milk products shall increase to 49 percent by 2026 worldwide. The consumption of milk powder is also increasing in same pace due to the advantages like long self life, easy packaging and transportation. But the process of converting raw milk to powder milk requires intense energy consumption. This paper emphasizes the milk powder production process and indicates that the equipments utilizes in the process consumes large amount of energy. Few suggestions have been made at the end of the paper to focus upon and ensure the saving of energy while producing powder milk from dairy plant.

***IndexTerms* - Energy Consumption, Powder Milk, Spray Dryer, Atomization**

I. Introduction

Milk is considered as a complete food and most valuable protein contained food. Today, milk is consumed in various forms like ghee, butter, cream, toned milk, double toned milk, skimmed milk etc. Processes and equipments required in converting raw milk into these various forms are also different. For example, Dairy plants collect raw milk from road milk tankers and transfer it to chilling tank at 4ºC for the purpose of pasteurizing. Cream separator separates cream to get skimmed milk and converted to toned milk, double toned milk, skimmed milk or full cream milk as per the requirement and packed in of various capacities.

Milk can be converted to powder form through evaporation and drying process. The liquid milk contain 7.5% to 12% solid while moisture level of power milk varies between 2.5% and 5%. During drying, liquid milk droplets are transformed into solid particles with individual powder surfaces. This conversion not only extends the shelf life of milk but also reduces the weight and volume of product and ultimately lowers the cost of packaging transportation. Powder milk has a high volume in worldwide market since two decades. For example, in France, in 2000, the consumption of milk powder was almost the same as that of fresh skim milk. But the complete conversion of liquid milk to solid is an energy intensive process. It involves heat treatment, evaporation, drying etc and utilities like steam, hot water, chilled water, electricity for driving pumps, fans, conveyors, compressors, compressed air, high temperature hot water and low temperature hot water. Therefore, attention of researchers is required to offers optimum solutions to make this conversion process energy efficient & cost effective.

II. MILK POWDER PRODUCTION AT BANAS DAIRY

Banas Dairy under brand name Amul, founded in 1961 and located at Banaskantha District of Gujarat, India, is a dairy based and is Asia's No.1 milk production house. The Dairy is collecting an average of 50 lakh litres of milk every day. Today, it is producing large number of products like milk (liquid and powder), butter, ghee, dahi, paneer, shrikhand, lassi etc. All products are being marketed by Gujarat Cooperative Milk Marketing Federation, Anand. Total capacity of milk powder plant is 100 TPD (Tonne per Day) and its process flow chart has been shown in Fig. 1.

III. Powder milk production methodology (Process description)

B Raw milk once enter into the diary plant is tested for its temperature, hygiene, antibiotics, water addition and adulteration. Raw milk consists of fat and solid not fat (SNF) content. The ratio of Fat/SNF ratio of milk is considered as 0.340 while total solids (TS) calculation comes out via (Fat+SNF)*Quantity/100. The milk is usually separated into cream through Cream separator to ensure the standardization of the fat content. Results of tests decide the acceptance of milk for further processing. After clearing of tests, the milk is pumped into a silo storage tank held at temperature usually below 5º C. Sugar is added with milk in silo storage tank before transferring to multi effect evaporators through pump at the approximate flow rate of 35000 kg/hr. Evaporation of water takes place under vacuum conditions and at low temperature. Milk enters the evaporators at about 10 % solids and leaves the evaporators at approximately 52 % solids. The output is known as concentrated milk.

During the process, sugar added raw milk is heated by steam which gets condensed and leave the system at 64ºC. As a result the temperature of raw milk increases from 5°C to 50°C. The detail of temperature rising of milk while passing through the evaporator has been show in Fig. 2.

Further, this concentrated milk is atomised and dried to form micron-sized milk powder particles at approximately 96 % solids in the spray dryer and fluidised bed operations. The schematic of this process can be easily understood through Fig. 3.

Spray drying technique converts concentrated form into powder product in a single step. This drying technique has been widely adopted to dry many other products due to its quick drying and ability to obtain a powder form product [1]. Spray drying milk powder involves atomizing concentrated milk into a hot air stream (180 – 220 C) through pressure nozzle. All moisture of concentrated milk can be evaporated by varying air temperature and flow rate. Finally, size of droplet can be controlled while exposing solid at low temperature. Fig. 4 explains the flow of air and product in detail. Spray drying technique converts concentrated form into powder product in a single step. This drying technique has been widely adopted to dry many other products due to its quick drying and ability to obtain a powder form product [1]. Spray drying milk powder involves atomizing concentrated milk into a hot air stream (180 – 220 C) through pressure nozzle. All moisture of concentrated milk can be evaporated by varying air temperature and flow rate. Finally, size of droplet can be controlled while exposing solid at low temperature. Fig. 4 explains the flow of air and product in detail.

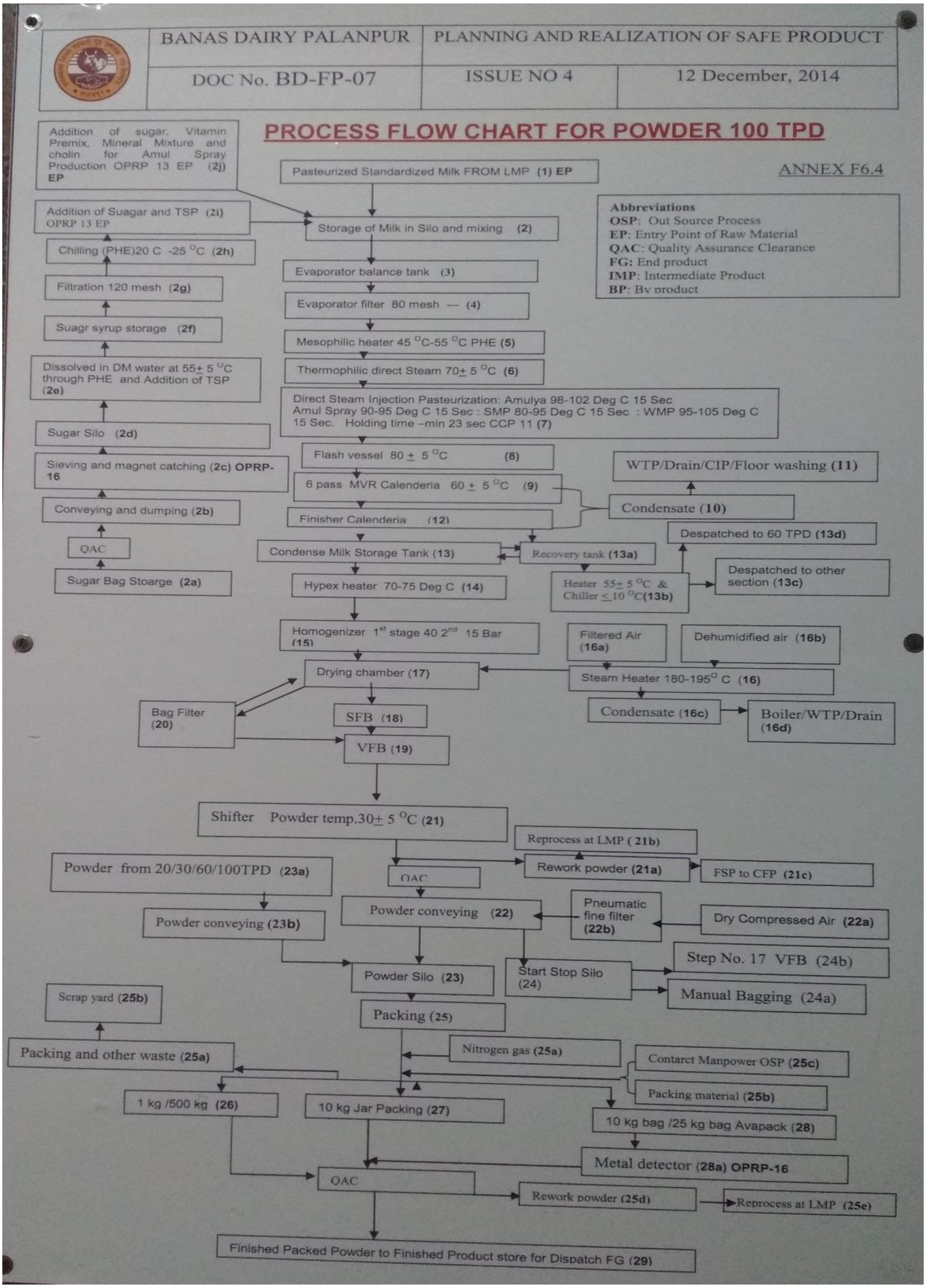

Fig.1 Process flow chart for 100 TPD of BANAS DAIRY

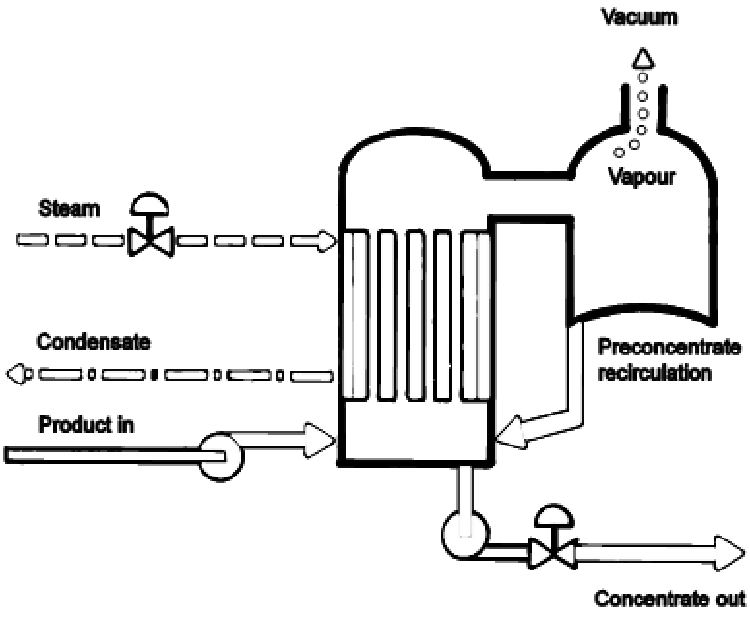

Fig.2 Treatment of raw milk in evaporator

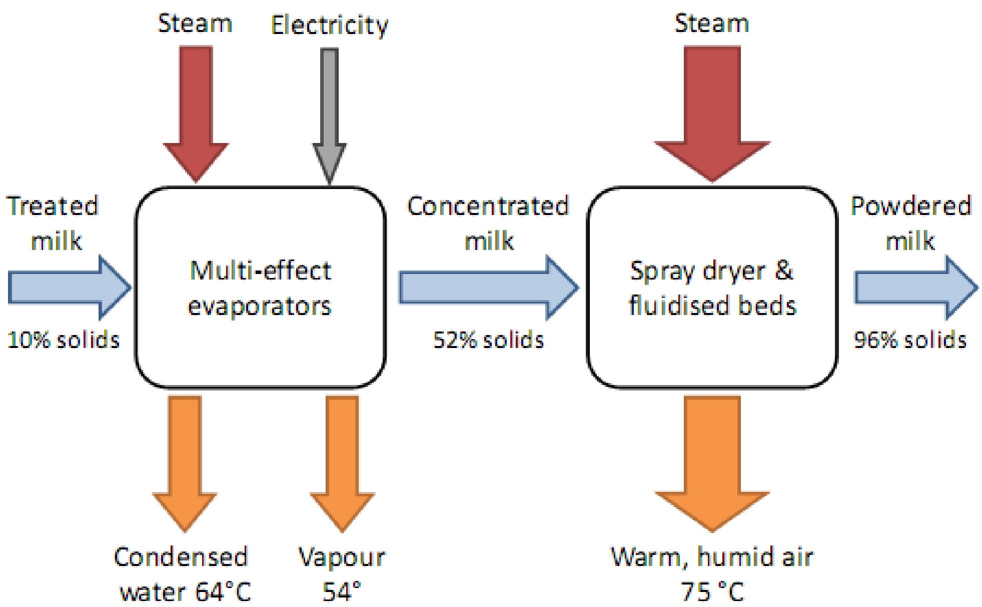

Fig. 3 Schematic Representation of Powder Milk Conversion.

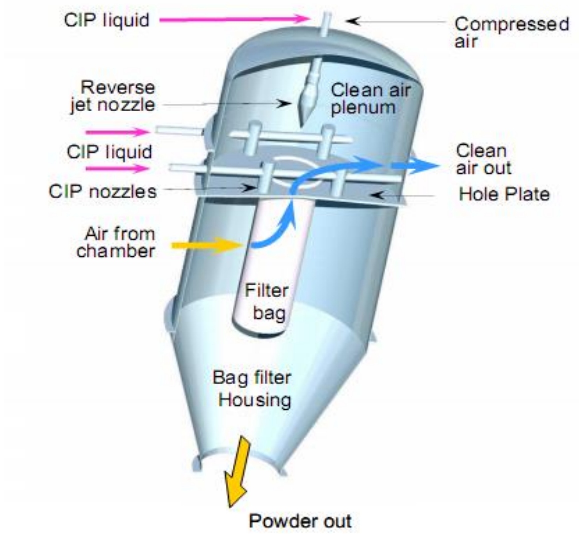

Fig. 4 Atomization of concentrated milk through nozzle

The concentrated milk is atomized into droplets of 1–200μm by a high pressure spray nozzle, located at the top of the spray chamber. The droplets fall into the spray chamber in a concurrent flow with a hot filtered air; the moisture in the emulsion droplets is removed by hot air. Spray drying chambers can be of vertical type [2] or horizontal type [3,4]. Vertical vessels with a cylindrical cross-section and a conical bottom are more in operation while horizontal layout are still not popular and its performance characteristics are not well under so far. The size of vertical depends on the application. During drying in spray dryer, the excess water present in free form between the particles of the dry solids gets evaporated easily. The droplets of milk shrink in size due to the evaporation of water from its surface. Finally, the droplets lose most of their moisture and become particles with a solid crust. In the single-stage spray drying process, a pneumatic conveying system is always needed to remove the final fraction of moisture from the nominally dried powder and to cool it prior to storage.

This process requires more energy as water contained in pores and capillaries of the solid particles need to be evaporated. Vibro Fluid Bed Dryer requires less energy for removal of balance moisture.

The combination of multiple effect evaporators, spray dryer with fines recirculation system and use of a 'Vibro Fluid Bed Dryer', produces instant quality powder. Few researchers [5, 6] used commercial code to simulate spray dryer using superheated steam as the drying medium. Fundamental understanding on spray dryer is still lacking. In the 1980s, a three-stage drying system was developed for milk drying [7] to enhance the overall performance to a higher level as the production capacity requirements increased. Although spray drying is used in many industries, fundamental understanding is still lacking. Powder leaves the dryer and enters a system of cyclones that simultaneously cools it. Spray dryers can also have bag filters to reduce environmental emissions and also to increase yield and ensure that there are no powder particles emitted to attract birds and rodents and also act as a medium for microbial growth which can then be carried back into the plant.

IV. CONCLUSION AND SUGGESTIONS

- ✓ Since the conversion of raw milk into powdered milk is energy intensive due to the high energy content it is important to incorporate a three-stage drying in the process. Researchers [8] have reported that three stage drying process can save 20% of energy consumption compared to the single-stage spray drying system.
- ✓ As seen in Fig.4, the drying air is exhausted from the middle of the drying chamber. The cyclones can be omitted if a suitable bag filter is installed in the middle of the chamber.
- ✓ By adoption of conveying belt drying system wet particles can be continuously dried on the belt in a lower temperature environment.
- ✓ New energy efficient spray drying methods need to be evolved to reduce the energy consumption in the system. One example is the Pulse combustion spray drying [9] which is not yet developed.
- ✓ The exhaust steam can be utilized elsewhere in the plant.
- ✓ There has been limited success with heat recovery from milk spray dryer exhausts with heat exchangers or recuperators. As a result typical milk powder spray dryers are not integrated. A coupled loop heat exchanger between the dryer exhaust and inlet air can recover heat.

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