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Milk Powder Production

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6th of May 2021

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Abstract

Milk powder manufacturing is done by the removal of the water from the milk decreasing by that its water activity and increasing its shelf-life. Nutritional properties are manufactured as per demand. The lack of immediate access to adequate refrigeration methods rose the importance to produce powder milk. It is obtained mainly from spray drying and roller-drying methods. It can be used in various applications such as confectionaries, bakeries, infant formulas.

Introduction

Milk powder manufacturing is a simple process which can be carried out on a large scale. It aims on removing water from the milk at the lowest possible cost while conserving its color, flavor, solubility, and nutritional values. Additional vitamins and minerals are added to the process to satisfy the customer end-product demand.

Whole milk contains around 87% water while skimmed milk contains around 91%. This urges the need for concentration by evaporation to reduce water content reaching 30 to 45% prior to drying. It undergoes preheating for bacterial removal. The resulting concentrated milk is than be sprayed into hot air for further reduction in water moisture content resulting with powdered milk as an end-product.

The aim of this report is to produce powdered milk from 50 tons/day of liquid milk and to see the importance of choice when it comes to dryer technologies.

Process description

The milk powder production process is a simple process carried out on a large scale. Raw milk used comes from dairy factories. It is placed in a nearby holder in Centrifugal cream separator. At the point when the separator is turned on, the milk is pivoted (or turned) at an extremely high velocity in its compartment. The outward power follows up on the milk and because of this, the milk isolates into cream and skimmed milk. If WMP is to be fabricated, a part of the cream is added back to the skim milk to deliver a milk with a normalized fat substance (regularly 26- 42% fat in the powder). Sterilization of milk will start by undergoing pasteurization Ordinarily, there are long haul low-temperature and momentary high-temperature treatments for preparing milk. In our case, Low-temperature sterilization is completed under 60℃ inside 30minutes, hence the quality persists. Next, the milk undergoes preheating at a standardized temperature range of 75 to 120C. The holding of this heating is dependent on the nature of the product and its end use. Pretreatment is done via heat exchangers or steam injection into the product.

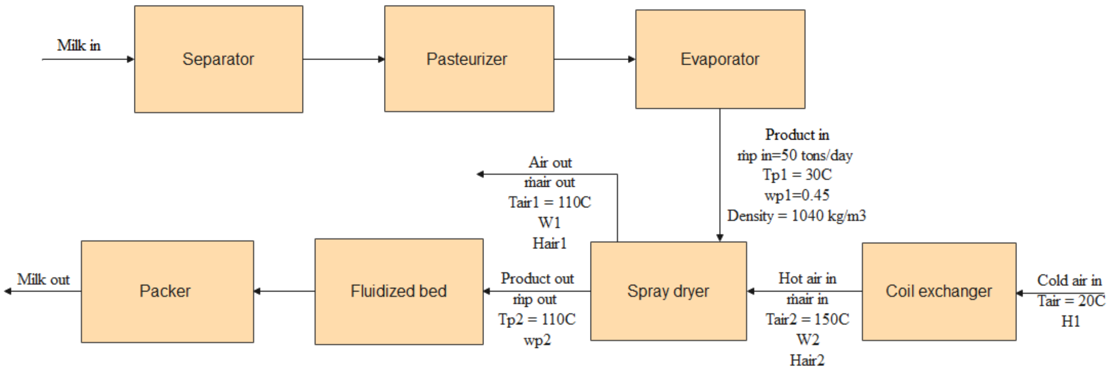
In the evaporator the preheated milk is gathered in stages or "impacts" from around 9.0% complete solids content for skim milk and 13% for entire milk, up to 45-52% absolute solids. This is accomplished by heating up the milk under a vacuum at temperatures beneath. Current plants may have up to seven impacts for most extreme energy productivity. More than 85% of the water in the milk might be eliminated in the evaporator.

During spray drying, the milk droplets from the chamber are cooled by evaporation yet never reach the temperature of the air. To reduce concentrate viscosity and to increase the energy available for drying, heating may be done prior to the atomization in the scraped surface heater. It evaporates a huge percentage of the water content (in this case 85%). This step is considered crucial before entering the drying unit. Homogenization aims to reduce fat oxidation sensitivity and have a more stable cultured milk product. It makes the milk look whiter and more appealing to the eyes as it also preserves the flavors. Remaining water is evaporated is the chamber and the powder exiting consists of approximately 6% moisture content and a particle size of less than 0.1 mm in diameter. A secondary drying takes place to remove -by hot air blown through a layer of fluidized powder- some of the water left, leaving the product with a 2-4% water moisture content.

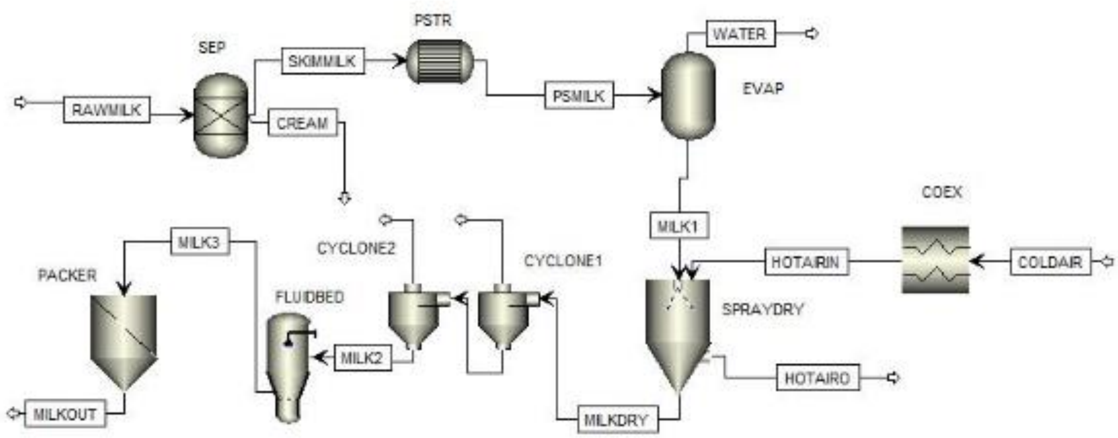
Packaging is finally done as a final stage. It provides the milk powder with a barrier from oxygen, light, and moisture to maintain its quality and shelf-life. They are usually packed under nitrogen gas to protect the product from oxidizing, and it maintains its flavor as well.

Unit	Role
Separator	Separates the cream from the skimmed milk.
Pasteurizer	Milk pasteurizer machine can take out pathogenic microscopic organisms destructive to our wellbeing, and safeguard milk quality.
Preheater	destroys unwanted bacteria, inactivate enzymes, and generate natural antioxidants.
Evaporator	It evaporates a huge percentage of the water content (in this case 85%). This step is considered crucial before entering the drying unit.
Scrapped surface heater	It is a heat exchanger made from scratching components that will add

	additional turbulence in the food product. Hence increasing the heat transfer area.
Homogenizer	Homogenization of milk under high tension through a minuscule opening, which brings about a decline in the normal diameter and an increment in number and surface region, of the fat globules.
Atomizer	Which will convert the milk into small droplets. Due to increased surface, rate of evaporation of water becomes more at room temperature
Spray drying	Atomizing the milk concentrate from the evaporator into fine droplets in a large drying chamber where hot air circulates (considered as a first drying step).
Fluidized Bed	A piece of equipment used for drying or cooling milk powder. Air is blown through the powder from below, causing the powder particles to separate and behave rather like a fluid. (secondary drying step)
Packer	Packaging of powdered milk for quality preservation and storage.



Process Flow diagram



Spray Drying

Assumptions

Air is entering the coil exchanger at ambient temperature T_a =25°C and a relative humidity of 60%.

The drying process is considered adiabatic.

The reference temperature is taken to be 0°C.

Mass balance

$\dot{m}_a * W_2 + \dot{m}_p * w_{p1} = \dot{m}_a * W_1 + \dot{m}_p * w_{p2}$ (1)

Energy balance

$\dot{m}_a*H_{a2}+\dot{m}_p*H_{p1}= \dot{m}_a*H_{a1}+\dot{m}_p*H_{p2} +Q$ (2)

Where $H_a= c_s*(T_a-T_0)+W*H_L$; $c_s=1.005+1.88W$

And $H_p= c_{p,milk}*(T_p-T_0)+w_p*c_{p,water}*(T_p-T_0)$

$\Delta H=H_{a2}-H_1 = c_{p,milk}*(T_{a2}-T_a)$ (3)

Results

Air entering the coil exchanger had a relative humidity of 60% at T=20°C, using psychometric charts W is found to be 0.0088 kg water/kg Dry Air. Since heater conserves the absolute humidity air entering the drying will have W_2=0.0088 kg water/kg DA at T=150°C. Using equation (3), H_{a2}=174.84 KJ/ kg DA. Air exiting the dryer at T=110°C, will have the same enthalpy as the one entering it (H_{a2}). Hence using the psychometric charts W_1= 0.0215 Kg water/Kg DA.

The feed inlet rate (F) is given at wet basis, yet it must be used at dry basis in the equilibrium equations thus $\dot{m}_p=w_{p1}*F$ = 22.5 tons Dry milk/day.

Using Solver on Excel: set an objective of mass balance verified and under the constraint of energy balance conserved, w_{p2} was obtained to be 0.06 leading to $\dot{m}_a$=690.73 tons Dry Air/day.

ma (kg DA/day)	690732.7162
mp (kg DS/day)	22500
Ta in Celsius	150
Ta out	110
Tp in	30
Tp out	110
wprod in	0.45
wprod out	0.060119756
W air in	0.0088
Wair out	0.0215
HL in (Kj/kg)	2113.7
HL out (Kj/kg)	2229.7

Cp product (Kj/kgK)	3.77
Cp w 30	4.18
Cp w 110	4.23
Cs in	1.021544
Cs out	1.04542
Ha in	171.83216
Ha out	162.93475
Hp in	169.53
Hp out	442.6737224

Discussion

Absolute humidity of air increased as it went through the dryer, this is due to its absorption of water previously found in the product. This humidity increase was of about 172.73% which proves the high efficiency of the spray dryer. This efficiency is verified by producing powdered milk with 6% water content which is within the range in the literature studies (3 to 6%).

The heat required around the dryer is obtain from $Q=\dot{m}_{milk}*c_{p,milk}*\Delta T$. Taking the dry content of the inlet feed at 45%, the heat required was determined to be 1885 KWh which costs around 175 $/day. However, skipping the concentration by evaporation step and going directly to the drying with a feed at 80% dry basis reached Q=3351 KWh which costs around 312$/day (taking 1 day as a basis for spray drying operation). A good increase in electricity for the spray dryer was observed.

Lethality for pasteurization process is for holding time only which is done at a temperature of 60°C for a duration of 30min. This combination was optimized to mitigate any undesired non-enzymatic reactions such as browning or what is known as Maillard reaction. This will conserve the exterior and interior attribute for the milk powder while destroying unwanted bacteria and inactivating undesired enzymes. This temperature preserves the crystalline structure of lactose, being the most sugar source in milk.

Conclusion

Efforts are still on their way to develop more efficient and optimized models for milk powder production, however each unit presented in this report were proven to be essential. Hence, focus in the studies remains in the optimization and heat integration to produce better integrating products at lower costs.

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