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ADVANCEMENT IN DAIRY PROCESSING: EVAPORATION AND DRYING SYSTEMS

This bulletin includes technical and latest development on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information on different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue **Advancement in Dairy Processing: Evaporation and Drying Systems**. It may be understood that the information given here is by no means complete.

In this issue:

INTRODUCTION

Development of new technologies and processes in dairy processing is a regular phenomenon. These developments aim at making processes more efficient and products of higher quality with minimum loss of nutrition. In the present free global and domestic markets, dairy plants essentially need to be competitive both in efficiency and product quality. It is therefore imperative that plant management keeps itself abreast with the advancement in dairy processing, and examines employing it to realize maximum benefits and to remain highly competitive.

This issue of Technews presents some recent developments in milk powder manufacturing systems. More information on advancement in other areas would be provided in forthcoming issues.

EFFICIENT PRE-HEATING SYSTEMS IN EVAPORATION PLANT

The formation of biofilms, that is the adherence, growth, colonization and release of mcro-organisms on stainless steel surfaces, is a proven fact[1]. Increasingly strict limits on thermophilic bacteria and thermophilic spore counts in milk powders have limited the running times between CIP of processing equipment in general and of heat exchangers in particular. The raw milk side of regenerative sections of prehaters, where the temperature is in the critical range is especially susceptible to biofilm formation.

Thermophilic bacteria are bacteria with a growth range of 45-65^{o}C.

Practical experience has shown that after eight hours continuous operation of a plate heat exchanger, vastly increasing thermophilic bacteria counts over and above the level in the raw milk can be detected in the pasteurized milk[2]. The exact time depends on factors such as the level of contamination of the raw milk with thermophilic bacteria, the pasteurization temperature/time combination applied, and also the species of the contaminating thermophilic organisms.

Whatever type of preheater is used the milk is preheated from the supply milk temperature, typically about 6^{o}C in the evaporator balance tank, to about 65-70^{o}C prior to the pasteurization stage. This means that the critical range for growth of thermophilic bacteria is exceeded in the preheaters.

A number of microbiological investigations of industrial evaporator installations have shown that growth of thermophilic organisms in the preheaters will invariably take place after a number of hours.

One example of the development in thermophilic bacteria counts at different locations through an evaporator over time showed that, despite killing a certain fraction of these organisms during the subsequent pasteurization, the growth in the preheaters resulted in increased thermophilic count in the final product after 14 hours of operation.

Niro's new process minimizes or practically eliminates thermophilic growth in the preheating system of evaporator[2]. The process is called the direct contact preheating system (DCP process).

In the process, milk is preheated to 40-43^{o}C in a dead vapour heater or with condensate in a plate heat exchanger. Vapours from the first effect separator are compressed using a thermo-compressor and are used in a direct contact heater to preheat the milk to 67-70^{o}C in one stage.

The advantage of the system is that the critical temperature range for growth of thermophilic organisms is exceeded very quickly and while the milk droplets are airborne. The surface of the DCP heater has a much smaller area than conventional preheaters and will be at the final product temperature, which is above the maximum growth temperature of most thermophilic organisms.

The DCP process virtually eliminates plant surfaces in contact with unpasteurized milk at the optimal temperature range for growth of thermophilic micro-organisms. It also results in significantly lower thermophilic bacteria and spore counts throughout the evaporator and in the final powder, even after 20 hours.

Microbiological results obtained from the industrial installation in Denmark with the low thermophile capability showed that the thermophilic counts remained almost stable over a 20 hour operation period. This was despite the fact that in this particular run, the counts in the feed to the evaporator were quite high and variable. The spore counts also remained stable for 20 hours.

When concentrate heating to 80°C, or even higher, is necessary for certain special products, indirect heating with tubular heat exchangers as the only heating equipment cannot be recommended.

An advantage of the indirect system is that heating does not dilute the concentrate, which happens with direct systems due to condensation of steam in the product. But the residence time in the indirect systems is considerably longer and fouling problems are more pronounced than in direct systems.

Steam infusion heating of concentrate is not used very often, but has occasionally been chosen for high heating/pasteurization of baby food concentrate prior to drying, for instance. The purpose of this application has mainly been to ensure the required microbiological quality of the final powder.

Conventional direct steam injection units have had only very limited use as concentrate heaters due to potential fouling problems. However, the development of the patented lenient system injector (LSI) unit by Niro has changed that situation. In the LSI, the steam is introduced into the milk concentrate by a dynamic mixer. Very minute steam bubbles are created, which instantaneously condense, resulting in extremely fast and even heating, avoiding superheating/denaturation[3]. Therefore, a much higher steam pressure can be used. The LSI unit is often used in combination with a scraped surface heat exchanger for say, instant whole milk powder.

CIP-ABLE BAG FILTERS FOR SPRAY DRYERS

While requirements to environmental protection, energy consumption, noise level, production efficiency and product quality are increasing everyday for the food and dairy industries, powder manufacturers have witnessed a development especially for powder recovery systems. The CIP-able bag filter, SANICIP™, developed by Niro is claimed to meet these requirements [3, 4].

Table 1 compares the performance of different powder separation systems.

SANICIP™ bag filter is of the reverse jet type and made of stainless steel. It consists of a cylindrical bag housing with spiral shaped air inlet, clean air plenum on top, and a conical bottom with fluidized powder discharge. During operation the product collected on the outside of the filter material is removed by a compressed air jet stream from the inside of each bag. The bags are blown clean individually, resulting in a very even discharge of powder and using higher air-to-cloth ratios. The frequency and duration of the cleaning sequence can be adjusted to suit actual running conditions.

Table 1: Comparison of powder separators

	Cyclone	**Cyclone + bag filter**	**Cyclone + wet scrubber**	**SANICIP™**
Emission	20-400 mg/Nm^3	5-20 mg/Nm^3	max. 20 mg/Nm^3	5-20 mg/Nm^3
Pressure loss Exhaust	280 mm WG	340 mm WG	340 mm WG	170 mm WG

system (incl. ducts, etc.)				
Auxiliaries	none	compressed air	liquid circulating system	compressed air
Cleaning	suitable for CIP	difficult	suitable for CIP	Suitable for CIP
Hygroscopic products	insensitive	sensitive	insensitive	insensitive
Use of separated product	first grade	first and second grade	not recommended	first grade
Maintenance	minimal	service of compressed air system and change of bags	minimal	service of compressed air system and change of bags
Sanitary conditions	good	relatively good	less good	good

The bag filter housing is insulated on the cylindrical part below the hole plate and is in a fully welded execution. The supply air system for the fluidizing bottom has a multiple purpose: During production the cone of the bag house is first heated by the warm air, which subsequently is used for fluidizing the powder in the bottom. This ensures an even powder flow out of the bag house. During standstill the air is used for heating of the cone alone and is in a closed loop. Condensation and risk of mould growth is therefore avoided. The filter bags are made from a special 3-layer gradient polyester material, which is heat-treated to give a special dust-releasing surface. Each bag is supported on a stainless steel cage and is easily dismantable.

The CIP of the bag house is divided into the following sequences:

i)Pre-rinse 1, using a minimum of water for initial rinse. Water is not reused. The solid content in the wash water is high, so recovery is possible, and the load on the waste water system is minmized.

ii)Pre-rinse 2, water is recirculated below the hole plate, then to drain.

iii)Caustic wash, using both the internal and external systems. Bags are alternatively washed from the inside and the outside.

iv)Middle rinse.

v)Acid wash, using both the internal and external systems. Bags are alternatively washed from the inside and the outside.

vi)Final rinse, using internal and external systems with clean water.

The CIP is followed by bag drying. It takes around 6 to 10 hours for complete CIP and dry out. Normal acid and caustics are used as CIP agents.
Figure 1 shows spray drying system with SANICIP bag filter.

Advantages of the SANICIP™ filter are:

*Low pressure loss across the bag filter and thus the entire exhaust system, i.e. reduced energy consumption and noise emission.

*Designed for optimum air-to-cloth ratio and powder load (due to one bag being blown at the time).

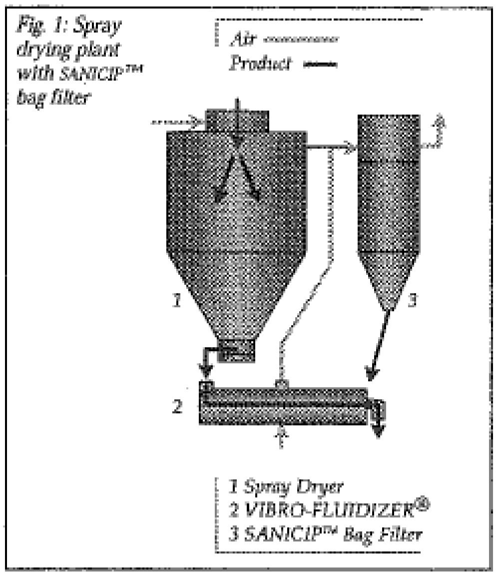
*Higher yield of raw materials due to no second grade products.

*Design with 4 or 6m bags to suit specific building requirements.

*Reduced space requirements for new installations.

*Easy replacement of cyclones for retrofits without major building changes.

The following products have been produced on dryers with CIP'able bag filters:
- skimmed milk;
- whole milk;
- non-crystallized whey;
- pre-crystallized whey;
- mother liquor;
- demineralized mother liquor;
- WPC 35%;
- 50% fat-filled whey; and
- permeate.



NEW COMPACT SPRAY DRYERS

Traditional dryers can be both inefficient and unnecessarily large. Equipment supplier Niro claims that its new dryer is smaller, quieter, uses less energy and produces better quality powder than any of its previous spray dryers[5]. The company's Integrated Filter Dryer (IFD) simplifies spray drying by combining the dryer, fluid bed and flag filter within the confines of the drying chamber (Fig.2). It produces free flowing agglomerated powder with low dust content, and is particularly effective for products that are difficult to produce on other spray dryers.

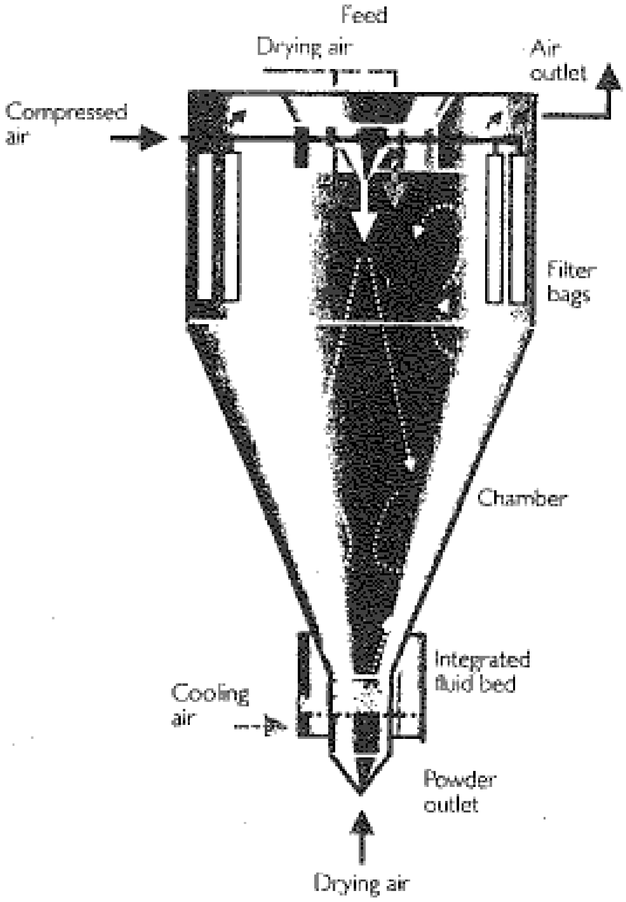


Fig 2 Integrated filter dryer

With a traditional dryer, exhaust air filters are placed on the outside of the drying chamber, but with the IFD they are on the inside. This eliminates the need for external cyclones, bag filters and fines recycling. This in turn reduces the space requirement and improves product containment. Reduced pressure drop over the particulate air filters (and no cyclones) means that energy consumption is reduced and the dryer is quieter.

By locating the filters inside the plant, the IFD can provide better control over particle formation and, as a result, over the dried product's quality specification. It also incorporates a fluid bed within the spray dryer. This allows users to achieve precise product properties required, thus improving he powder quality.

Niro claims that the IFD also reduces product losses as all products are retained within the dryer. This is particularly useful when drying high value powders. Product loss is further reduced because the compact design means that less equipment comes into contact with the dried product. A further advantage of this is that, using Niro's SANICIP filter system, it is much easier to clean than some other dryers, making it easier to switch products as often as required.

The filters can be cleaned in place, which helps to reduce water and chemical consumption. A purge air system means that the entire clean air assembly can be cleaned in place. Spray dryers using internal filters use less energy, run quieter, have better control of extremely fine particles, produce a higher yield (up to 99.9%) and have lower exhaust emissions. Reduced cross contamination is also important in the dairy industry to avoid microbiological problems and flavour contamination issues. The IFD can be supplied with co-current, two-fluid nozzles or pressure nozzles as required.

Results have shown that the IFD is suitable for long-run batch production for producing milk powder or baby food.

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