IDF Symposium on Cheese

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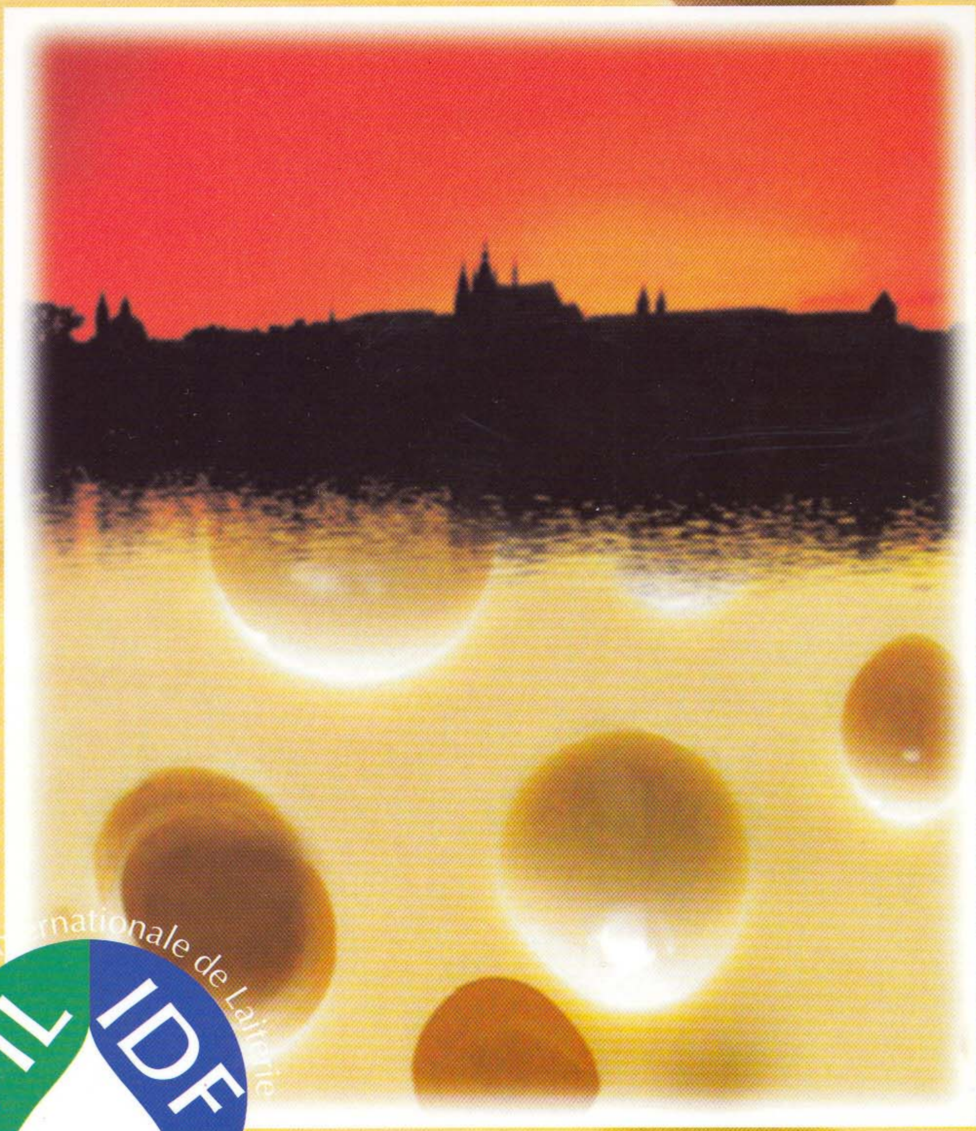

Ripening, Characterization & Technology

Opening Paper:
"Spray Drying in the Cheese Industry"
by J. Písecký, Niro A/S, Denmark

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SPRAY DRYING IN THE CHEESE INDUSTRY

by Jan Písecký

The paper is dealing with the application of spray drying in, and in the relation to the cheese industry. In the introduction the technology of producing the cheese powder is briefly described and also the production of the skim milk powder suitable for later production of cheese. Also the technology of whey processing to various dry products is briefly discussed. The main subject of the paper is the description of a new process, called TIXOTHERM™, developed recently by Niro, for the processing of permeate, produced as a by-product from the ultrafiltration of whey, into a non-hygroscopic powder. After evaporation to 60% TS the permeate concentrate is subjected to a three step process consisting of concentration to 86% in the Rosinaire™ paddle dryer, holding, stabilization and curing in a screw conveyor with two augers, and finally drying and cooling in a combined back-mix/plug-flow fluid bed. In comparison with the traditional processes the TIXOTHERM™ provides great savings of energy (about 30%) and building costs (up to 75%).

The main subject of my paper will be to inform you about a new process for production of permeate powder. However, let me just start with a general survey of the application of spray drying in the cheese industry. You can find spray dryers in almost every cheese factory, however, these dryers are mostly used for the processing of the by-product, i.e. whey and only very few for making cheese powder.

In order to spray dry cheese it is necessary to bring it into a liquid form. This is done by a normal melting process where the cheese rind, if any, is removed, the cheese is disintegrated, and during heating and agitation melting salts such as phosphates and citrates are added together with water.

The aim is to obtain a solids content of about 35% and a temperature of 75°C in order to get a feed which is not too viscous for atomisation. The drying is conducted in a conventional spray dryer with cooling fluid bed (fig.1) with air inlet temperature of 180-190°C. The cooling of the powder is done in a Vibro-Fluidizer supplied with ambient air in the first section and cold dehumidified air in the last section.The integrated belt dryer FMD (fig.2) has proved especially advantageous for cheese powder, which is discharged in an agglomerated form. Further, the cyclone fraction is practically zero and does thus not present any operational problems. Cheese powder is mainly used in dips, dressings, biscuits, chips and direct as flavouring on hot dishes like spaghetti and soups. As a certain amount of aroma is lost during the drying, it is recommended to use aged cheese. In order to avoid problems with the odour from the exhaust air this must be filtered through activated carbon filters.

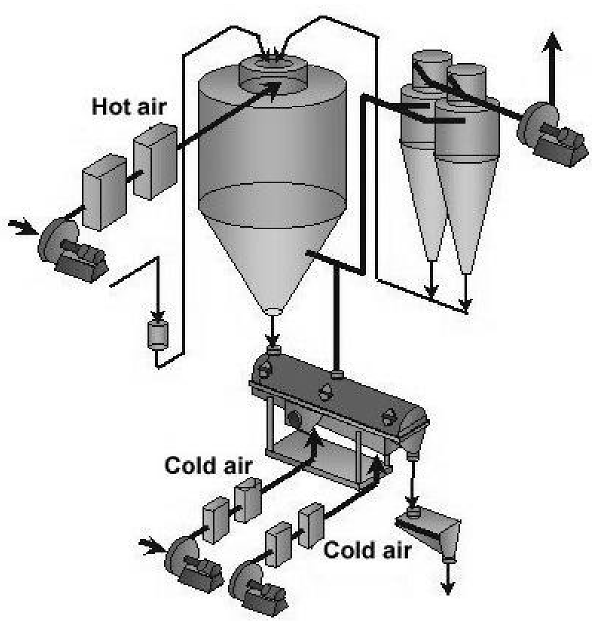

Fig.1 - Single-stage spray dryer with cooling bed.

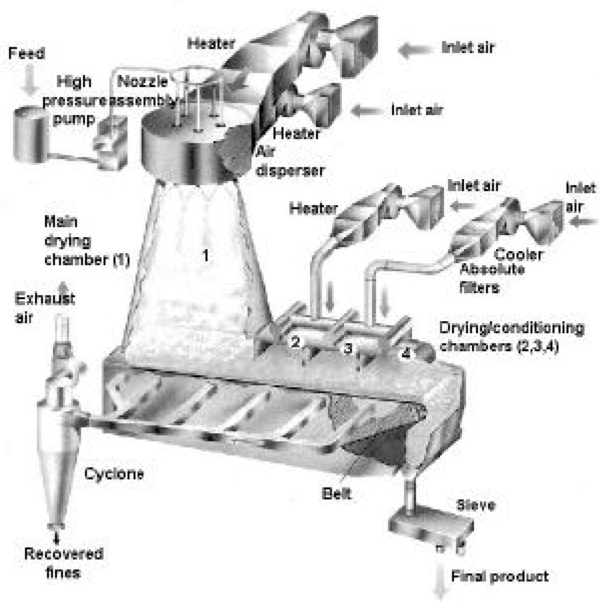

Fig.2 - Integrated belt dryer.

Another interesting application of spray drying, which has a connection to cheese industry, is production of skim milk powder suitable to be reprocessed to cheese. During the last years great efforts have been made to produce skim milk powder for later cheese production. The reason for this is to counteract seasonal variations in supplies of raw milk for cheese production. However, it also opens the possibility of sending powder to countries with no milk production of their own for making special soft cheese with a short shelf-life, or of producing powder for stock, if prices for cheese are low, with a later reconstitution and cheese-making in mind, because the keeping quality of the powder is better compared with that of cheese.

It is not my intention to go too much into details about the drying technique, but it should be mentioned that unless raw milk of top quality, with respect to hygiene, is available a suitable powder for making cheese of good quality cannot be obtained. Skim milk powder can be classified as follows:

Low heat powder: not less than 6 WPNI mg/g powder
Medium heat powder: above 1.5, but below 6 WPNI mg/g powder
High heat powder: not more than 1.5 WPNI mg/g powder

The main target in this production is to obtain a true low-heat skim milk powder i.e. the powder in which the WPNI (Whey Protein Nitrogen Index) is as high as possible which means to apply low pasteurisation temperature and gentle treatment during the whole process. Single-pass evaporators are recommended, and two-stage drying (fig.3) is to be preferred. It provides a more gentle drying, because the particle temperature is much lower, especially during the critical drying phase from 20 to 10% moisture, which results in a powder with no protein denaturation.

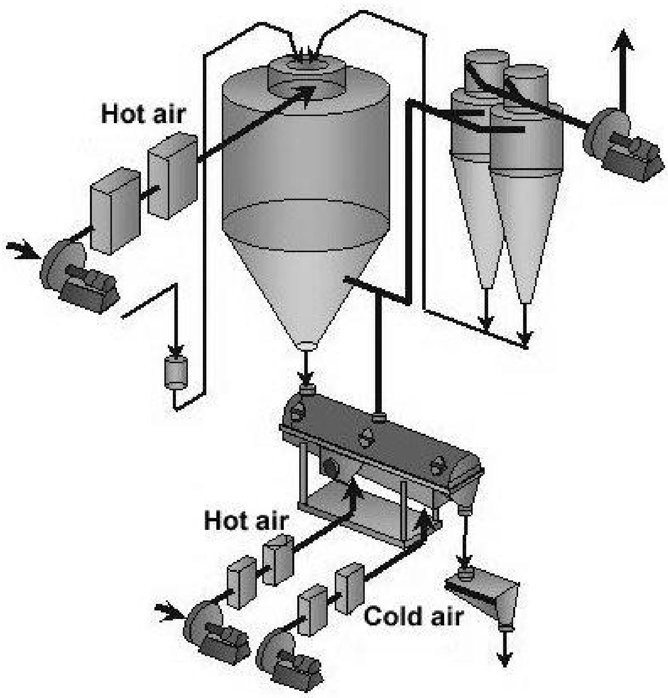

Fig.3 - Two-stage spray dryer with rotary atomizer.

The main application of spray drying in the cheese industry is the further processing of whey. Whey has always been regarded as a troublesome waste product and has been treated accordingly. According to the volume and weight whey is in fact the largest amount of material coming out at the production of cheese. One of the problems the cheese industry is facing is a continuously increasing attention to the pollution problems, which made traditional outlets of whey such as return to the milk suppliers for cattle and pig feeding, dispersing in fields as fertilizer or simply dumping in rivers, practically impossible. It has therefore been necessary to find alternative types of products made from whey which would be more attractive for the consumers, together with alternative low-cost technologies which would be more attractive for the producers.

Whey, considered as a raw material for further processing is requiring the same treatment and care as given to milk. The recommended procedure is cooling down below 10°C just after it is drained from the cheese vats to slow the bacterial activity. It is also strongly recommended to remove the so called cheese dust by clarification and excess of fat by centrifugation, as residues of both will affect further processing. Lack of treatment resulting in developed acidity degrades the quality of final products and causes difficulties during drying. The composition of sweet and acid whey can vary very much, but average values are about 6% total solids, 75-76% lactose in TS and 13-14% whey protein in TS.

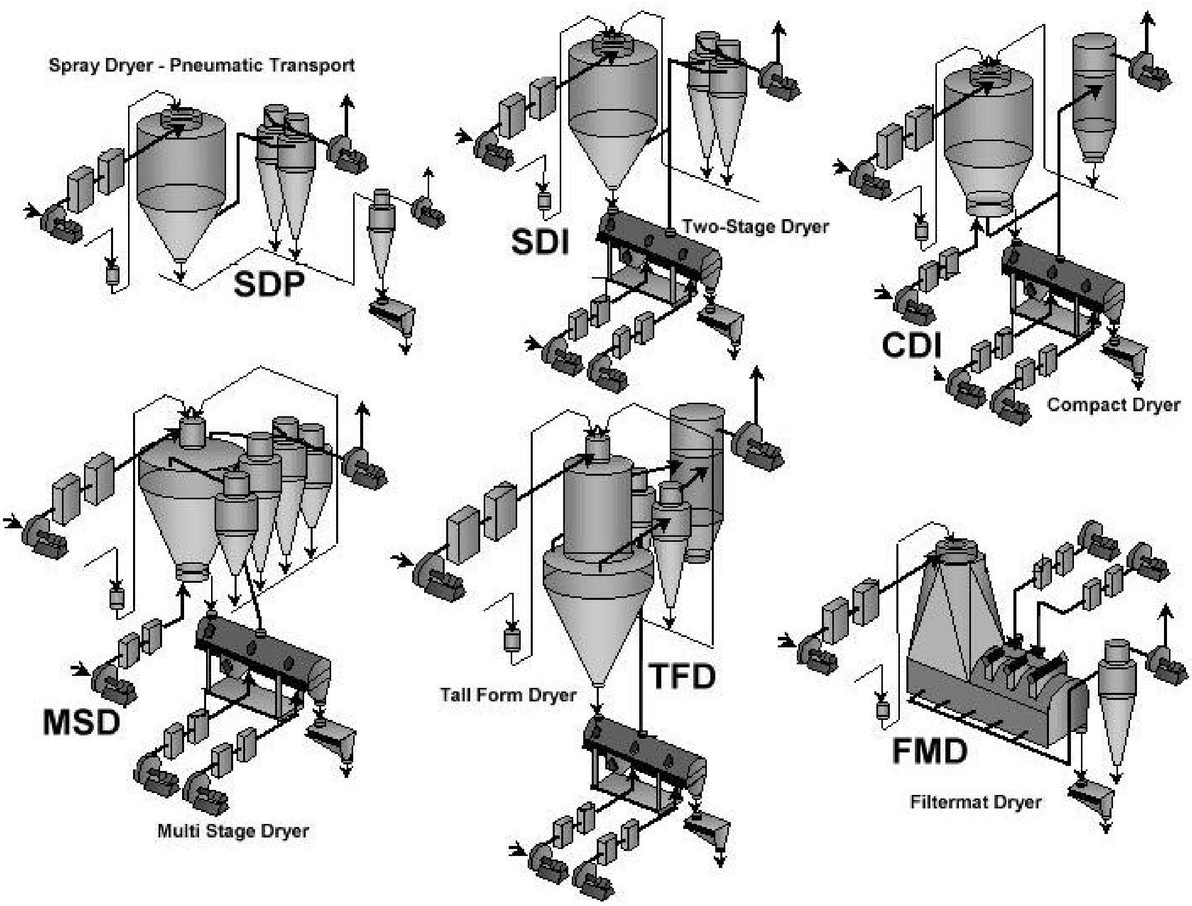

Fig.4 - Various types of spray dryers used for drying of whey products.

Whey, both sweet and acid, can be dehydrated as such and also used as a raw material for a number of products. Modern processes such as demineralization, ultrafiltration and enzyme hydrolyzation have further expanded the product spectrum to modified whey powders, i.e. demineralized and hydrolyzed products, whey protein powders and dried permeate. Furthermore whey can be used as a carrier for fat during the production of fat filled whey powders. Most of these products are difficult to dry requiring special technologies and special equipment. Various types of spray dryers used for drying of whey products are shown on fig.4. from the most simple single-stage dryer (SDP) to two-stage and possibly three-stage drying systems (SDI, CDI, MSD, TFD) and finally to FMD. The decision which type of dryer to apply for a given product depends on product difficulty and final product quality requirement. In other words the more difficult product and the higher quality requirement the more sophisticated dryer must be used.

The main lines for processing of whey are:

- concentration and spray drying for producing whey powder, the quality of which could be, according to the type of process and equipment, everything between dusty hygroscopic powder and granulated non-caking powder. Alternatively the fat-enriched whey powder can be produced or demineralized whey powder whereby, as drying is concerned, similar technology and equipment is used.

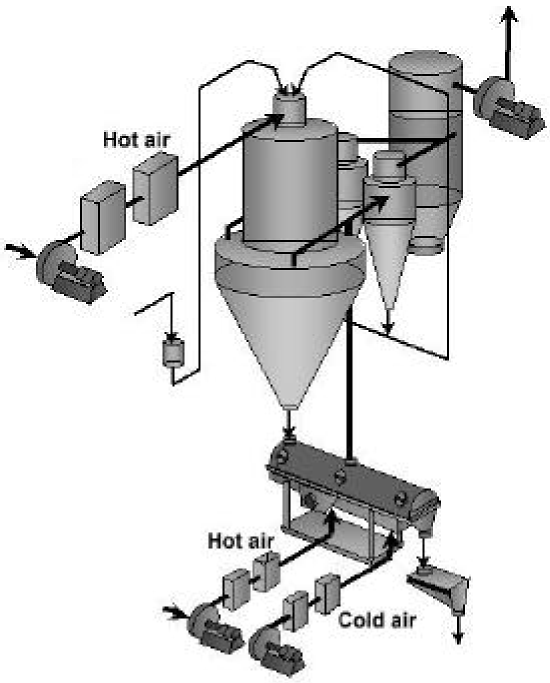

Fig.5 - Tall-form dryer for protein concentrates.

- production of lactose whereby there remains a problem of the mother liquor which is the by-product and which needs also further processing to the powder.

- treating the whey by ultrafiltration for the production of whey proteins and transforming them into whey protein concentrate powder whereby there follows a by-product which is the permeate. Production of whey protein powder is a good alternative to processing whey since the product is much sought and has high value on the market. It is used mainly as a component for babyfood and also as a protein fortification in various food-formulae. Standard products on the market contain 35, 60 and 80% protein. 80% is the most used and valuable product, which originates from an ultrafiltration plant as an approximately 20-25% total solids concentrate which can be further concentrated in the evaporator up to almost 40%.

Due to the high protein content the powder tends to be very light and fluffy with a high content of occluded air. To minimize this, pressure nozzle atomization is preferred. The most recommendable plant is a two-stage tall-form dryer (fig.5). Two stage drying is used to protect the proteins against denaturation. A TFD plant has the advantage of a low cyclone fraction giving acceptable powder stack loss levels even without a bag filter. Other dryer types such as SDI and CDI operating with pressure nozzles can be used as well but for these plants a bag filter is necessary.

Each of these possibilities can, depending on local conditions and volume of available whey and considering at the same time the outlet possibilities for the products and production costs, be justified. It is not the intention of this paper to describe the technologies of all these processes. These are very well known.

Considering the value of the product and its utilization possibilities it will probably be the whey protein powder which is most attractive. The other product from ultrafiltration, which is permeate usually contains about 4.5% lactose. Traditionally it can be further converted to powder by means of the so called Straight-through process and Wet process.

The straight-through process applies in sequence the processes evaporation, precrystallization, spray drying and finally fluid bed drying. The evaporation is done in multiple effect TVR or MVR evaporators, whereby the permeate is concentrated to 50-60% total solids. Special attention must

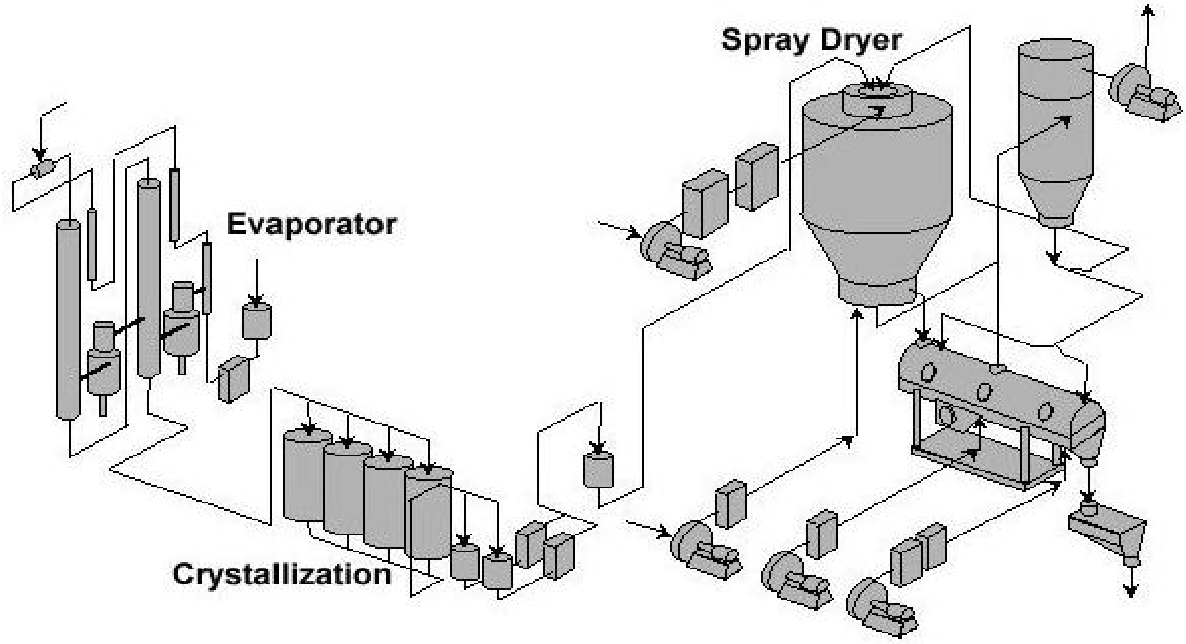

Fig.6 - Straight-through spray dryer with MVR-evaporator, crystallizers and vibrating fluid bed for permeate powder.

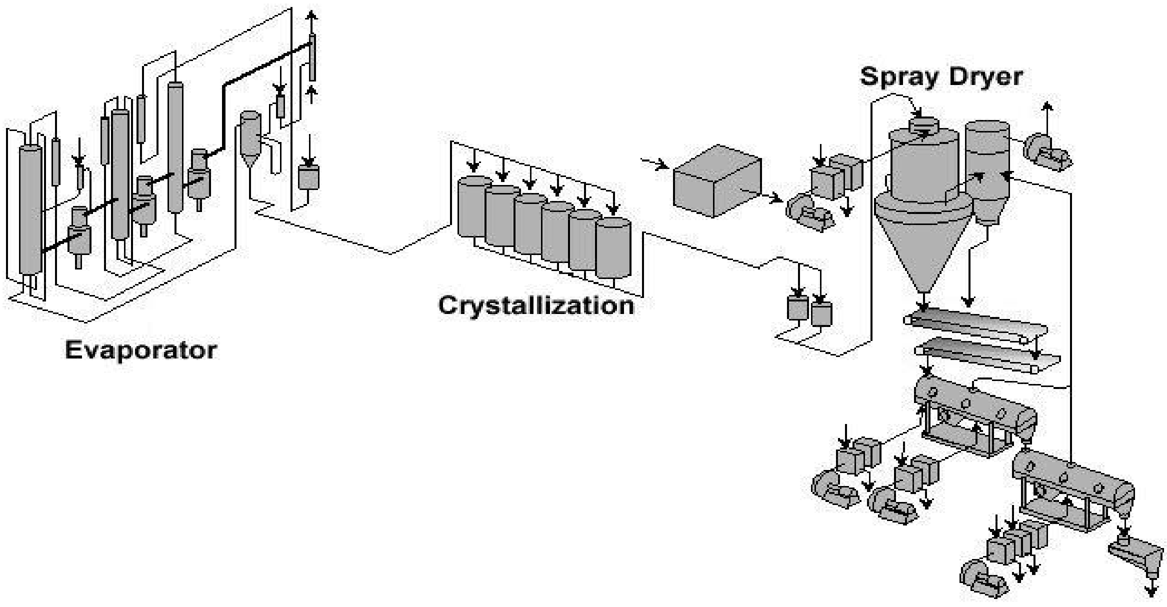

Fig.7 - Wet-process for drying permeate with MVR-evaporator, crystallizers, tall-form dryer with after-crystallization belt and vibrating fluid bed.

be paid to $Ca_3(PO_4)_2$ complex, as this may precipitate on the tubes during evaporation jeopardizing continuous operation. This problem is possible to overcome by ion-exchange or heat-precipitation. The concentrate can be dried directly, but it will be very hygroscopic and therefore a precrystallization is recommended. The concentrate is flash-cooled to about 30°C and transferred to crystallization tanks. Depending on the requirements to the product quality this precrystallization takes 6 to 24 hours - the longer precrystallization the less hygroscopic is the product. Many types of drying chambers can be used for spray drying, but nowadays the most convenient type is the Compact dryer with integrated annular shaped fluid bed. The atomization in this dryer is conducted by atomizer wheel. The water removing process is then finalized in vibrating fluid bed.

The wet-process is consisting of more or less the same operation steps and same equipment with these differences: for spray drying the most convenient type is the tall-form dryer in which the atomization is conducted by pressure nozzles. The outlet air temperature in this dryer is much lower than in the straight-through process thus the powder discharged from the chamber has higher residual moisture content. This powder is than treated on after-crystallization belt to obtain higher crystallization and finally dried in vibrating fluid bed as in the previous process to the final moisture content.

So far we have been talking about spray drying. Transforming liquid milk and milk derivates into dry powder requires removal of almost all the water, the amount of which exceeds by many times that of the final product. During this water removal process, significant changes of the properties, physical structure and appearance take place. Milk is a sensitive product and its quality can be seriously affected especially by the influence of heat or bacterial activity. Spray drying, in combination with vacuum evaporation and fluid bed drying, has been found as the superior way of removing water from milk without affecting its valuable properties.

Milk is a valuable product and thus we have to accept that this process is relatively expensive as to investment, building requirements and operation costs. Also whey protein concentrates, obtained from the ultrafiltration of whey are valuable products and therefore application of spray drying technology for dehydration is fully justified. On the other hand, the permeate coming as a by-product from the ultrafiltration of whey is a material of low value and from the point of view of the manufacturer, the most convenient way to dispose of it with the least losses was, until not too long ago, the dumping. This is not allowed any more, and therefore also for the permeate the spray drying process has so far been applied in spite of the fact that it is a luxury way of processing.

Realizing that the price for permeate powder is low, many attempts have been made to develop a process involving low investment, low energy consumption and reduced space requirements.

The TIXOTHERM™ process, developed by Niro (patent pending) offers these advantages. When applying TIXOTHERM™ for processing of the permeate, the process is starting again by evaporation to about 60% in which TVR multi-effect or MVR solutions can be chosen. To ensure 20 h production a decalcification process should be included. After evaporation you can forget everything about flash-cooling, precrystallization, tremendous building sizes and high energy consumption, i.e. the features necessary for traditional processes.

The process is a simple three-step process consisting of the following operations:

- concentration
- curing
- final drying and cooling

Fig.8 - Rosinaire™ Paddle-Processor

The concentration is conducted in the Rosinaire™ Paddle-Processor, manufactured by Barr-Rosin and conducting following operations:
· receives the uncrystallized feed of 60% TS from the evaporator,
· concentrates it as a thin film on the heated side walls to 86% solids, whereby
· high shear-rates utilize the thixotropic nature of permeate and thus
· it is achieved almost instantaneous crystallization by optimizing moisture and temperature of the paste,
· evaporated moisture is removed by the air drawing counter-currently through the annular space,
· this saturated air is cleansed in the scrubber and exhausted to the atmosphere.

The Rosinaire™ paddle dryer consisting of a double jacketed horizontal tube heated by means of steam is shown on fig.8. A shaft in the centre with paddles is moving the concentrate slowly forward, while the evaporation takes place. To remove the vapour a counter-current air stream is established, which is passed through a wet scrubber for cleaning, and together with the evaporation itself this keeps the temperature of the product low, so that discolouring is avoided. As the lactose will be super-saturated, a spontaneous crystallization will occur.

A viscosity increase will take place partly due to the crystallization and increase in the solids content, but due to the thixotropic nature of the product the vigorous mechanical treatment in the Rosinaire™ will keep the product fluent. When the product is discharged at ca 86%TS it is like a paste.

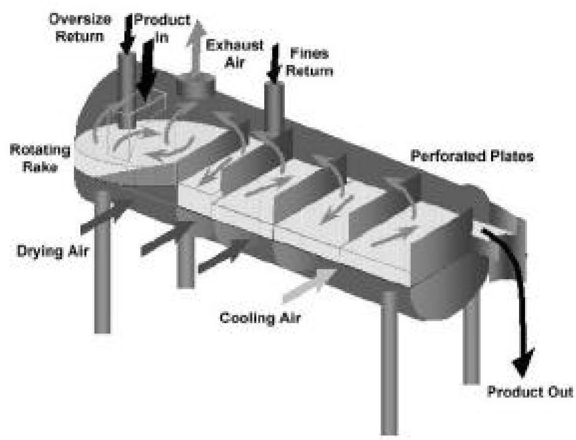

Fig.9 - Combined back-mix and plug-flow fluid bed showing product flow and air flow.

The next processing step which is a holding, curing and stabilization step conducted in a screw conveyor with two augers. The screw conveyor is double jacketed and chilled water is circulated to cool the product. This is done for the following reasons:
· the lactose becomes super-saturated again so that further crystallization is obtained and due to long enough holding time it is obtained almost 100% crystallization,
· browning of the product is avoided,
· viscosity is increasing, facilitating thereby the disintegration in the fluid bed.

At the discharge from the screw conveyor the product exhibits a texture suitable for fluid bed drying. The product is therefore further processed on a combined back-mix /plug-flow fluid bed (fig.9), similar to the lactose fluid bed, operating with a powder depth of about 1m. This type of fluid bed is very well known in the chemical industry, it is non-vibrating and thereby with reduced maintenance costs and is compact in comparison with vibrating systems. It is provided with an agitator as shown on the next picture. This is the final operation step, but milling of the final product is recommended. The outlet air from the fluid bed is cleaned in a SANICIP™ bag filter. This filter is fully CIP'able and provides effective powder removal from the exhaust air.

The described TIXOTHERM™ process (fig.10) brings many advantages in comparison with the traditional processes. Let's look for example at the building requirements for the Wet Process in comparison with the TIXOTHERM™ process, which requires only 25% of building space in comparison with the Wet Process.

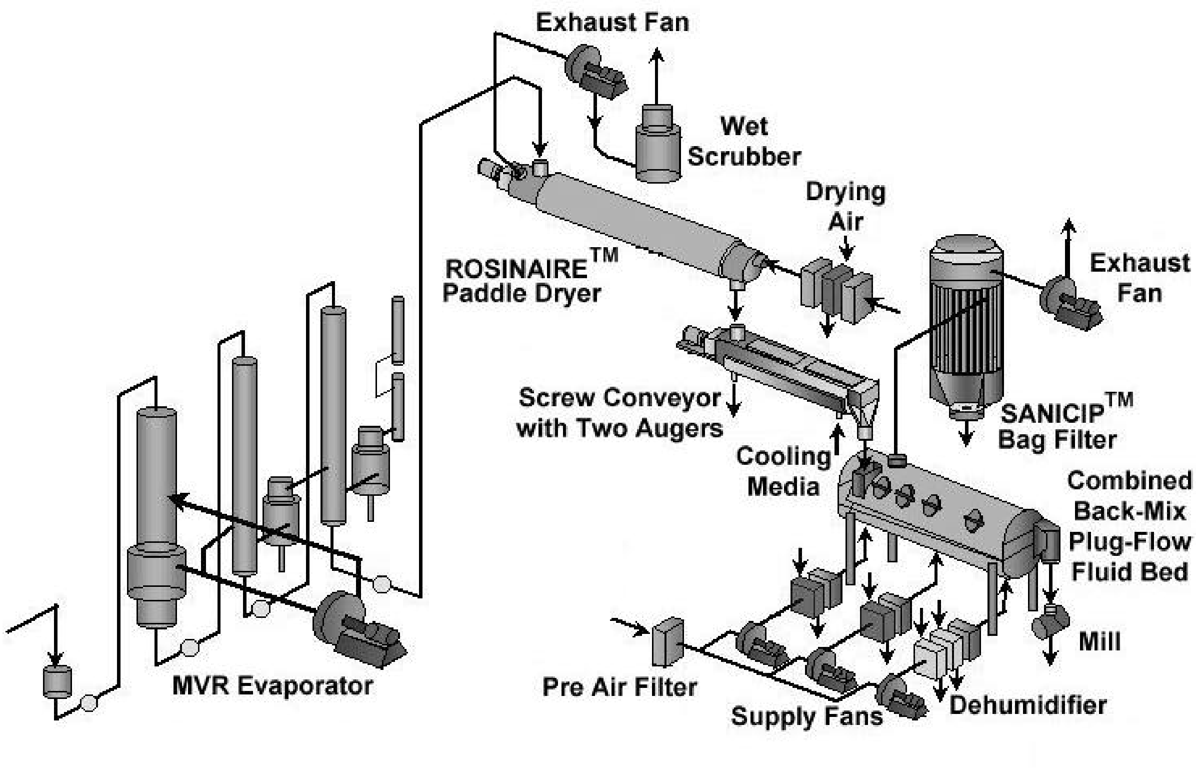

Fig.10 - The Niro's TIXOTHERM™ process for dehydrating the permeate.

Also in consumption of energy the TIXOTHERM™ is superior, as can be seen from the table on the next page.

The TIXOTHERM™ process is saving about 30% energy and up to 75% building requirements in comparison with the alternative processes. To summarise all the advantages:

- no pre-crystallization tanks are needed,
- the high-concentration step takes place at atmospheric pressure,
- spray drying is not necessary,
- great savings of building costs,
- great savings of energy,
- attractive investment costs.

Design	Steam Consumption per Hour			
Wet Process	Main Air Heater	7594 lb/h	3444 kg/h	2495 kW
	VF 1 Ambient	206 lb/h	93 kg/h	67 kW
	VF 1 Heating	1124 lb/h	610 kg/h	370 kW
	VF 1 Reheat	313 lb/h	142 kg/h	103 kW
	Extraction Fan 1	191 lb/h	87 kg/h	63 kW
	Extraction Fan 2	191 lb/h	87 kg/h	63 kW
	Nozzle Cooling	118 lb/h	53 kg/h	38 kW
	Nozzle Heating	812 lb/h	368 kg/h	267 kW
	Total	10540 lb/h	4705 kg/h	
TIXOTHERM Process	Rosinaire Jacket	2756 lb/h	1250 kg/h	906 kW
	Drying Section 1	1151 lb/h	522 kg/h	378 kW
	Drying Section 2	845 lb/h	383 kg/h	278 kW
	Backhouse Cone	32 lb/h	15 kg/h	11 kW
	Total	4785 lb/h	2170 kg/h	

The above consumption is based on the production of 2.5 metric ton powder production rate.

The TIXOTHERM™ process has been tested only in a pilot plant, but industrial size plant has already been designed.

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