Solar Heat In Milk Powder Plant

Ravi Prakash[1], Anu[2], Lavina Dudani[3], sushil jangir[4]

[1]*Assistant Manager (R&D)-B.S.A. India Food Ingredient ltd.,Alwar*

[1]ravidiarytechnologist@gmail.com

[2,3&4]*Assistant professor, Electrical Department, I.E.T.,(RTU)(Alwar)*

[2]*anushreya17@gmail.com*

***Abstract*—India has now become the largest producer of milk and hence, more and more milk are required to be processed and converted into powder, thus needing more energy. With the ever increasing volatility in the crude oil market and the rise of crude oil prices to more than 100$ per barrel, there is a need to decrease our dependence on the Non-renewable energy sources and look for Alternative renewable sources. Solar energy is the best alternative as major part of India receives a good intensity of this energy for almost 10 months per year. This will give an added advantage in reducing CO_2/CO emissions reducing global warming and will save the precious Ozone Layer.**

***Keywords*—Raw milk, solar energy, solar evaporator, solar dryer**

I. INTRODUCTION

Powdered milk or dried milk is a manufactured dairy product made by evaporating milk to dryness. One purpose of drying milk is to preserve it; milk powder has a far longer shelf life than liquid milk and does not need to be refrigerated, due to its low moisture content. Another purpose is to reduce its bulk for economy of transportation.

Approximately 13 kg of whole milk powder (WMP) or 9 kg of skim milk powder (SMP) can be made from 100 L of whole milk. Milk powders may vary in their gross composition (milkfat, protein, lactose), the heat treatment they receive during manufacture, powder particle size and packaging. Special "high heat" or "heat-stable" milk powders are required for the manufacture of certain products such as recombined evaporated milk.

The conventional process for the production of milk powders starts with taking the raw milk received at the dairy factory and pasteurising and separating it into skim milk and cream using a centrifugal cream separator. If WMP is to be manufactured, a portion of the cream is added back to the skim milk to produce a milk with a standardised fat content (typically 26-30% fat in the powder). Surplus cream is used to make butter or anhydrous milkfat. Since drying is an energy intensive process, the energy efficient evaporator and dryers are used for the milk powder plant.

for large scale production of these products, heat exchangers, vaporizers, etc are used which utilize huge amount of conventional energy for working.

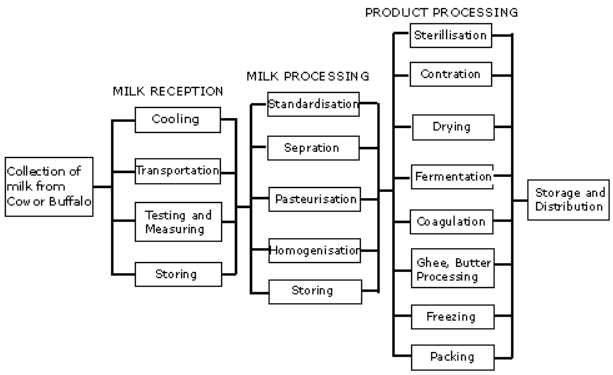

Fig.1- Block diagram of milk processing

At this level major source of energy is electricity, coal or diesel, etc. it is now realized that fossil fuel of non renewable nature are gradually coming to an end by the beginning of the next century. Another concerning problem is air pollutions which is mainly due to fire wood, coal, fuel oil, etc. All above problems can be overcome if solar energy can be used as major source of non conventional energy. Solar energy with its endless origin and free from pollution may be the answer to the energy problems of the coming century. In the present work, a new approach is made to develop method for dehydration of milk by using solar energy (Figure 1) to produce milk powder. Milk powder plant comprise following components:

Solar Energy Efficient Evaporator

Solar Energy Efficient Dryer

II. SOLAR ENERGY EFFICIENT EVAPORATOR

As one of the most energy intensive processes used in the dairy, food and chemical industries, it is essential that evaporation be approached from the viewpoint of economical energy utilization as well as process effectiveness. This can be done only if the equipment manufacturer is able to offer a full selection of evaporation technology and systems developed to accommodate various product characteristics, the percent of concentration required, and regional energy costs.

Milk is concentrated up to 45-48% solid concentration in solar Evaporator. During solar drying gets evaporated easily.

To remove moisture secondary dryer is used which is also working through solar energy. After that we produce milk powder through solar energy without using conventional energy.

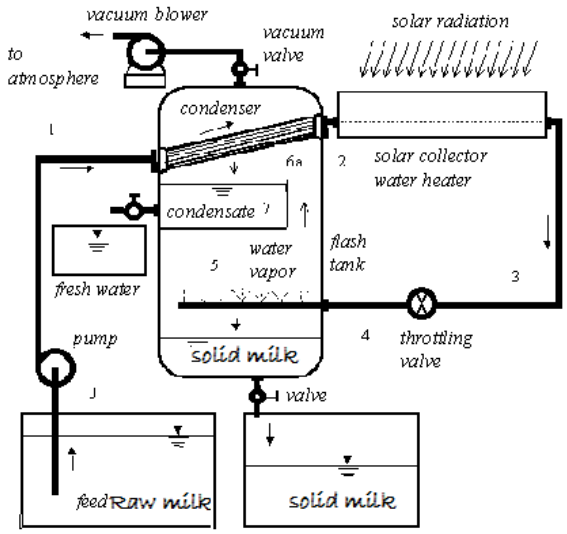

Fig.-2 solar evaporation system

III. Solar Energy Efficient Dryer

Drying involves atomising the milk concentrate from the evaporator into fine droplets. This is done inside a large drying chamber in a flow of hot air (up to 200C) using either a spinning disk atomiser or a series of high pressure nozzles. The milk droplets are cooled by evaporation and they never reach the temperature of the air. The concentrate may be heated prior to atomisation to reduce its viscosity and to increase the energy available for drying. Much of the remaining water is evaporated in the drying chamber, leaving a fine powder of around 6% moisture content with a mean particle size typically of < 0.1 mm diameter. Final or "secondary" drying takes place in a fluid bed, or in a series of such beds, in which hot air is blown through a layer of fluidised powder removing water to give product with a moisturecontent of 2-4%.

This design takes into account the following constraints:

• to achieve concentrated milk from evaporator into fine droplets

• to promote air circulation, by natural convection, avoiding moisture concentration near the concentrated milk, which would counter the occurrence of the desired evaporation.

Such a design implies the need of a storage tank for the effluent of the diary plant, to help the management of a yearly operation cycle.

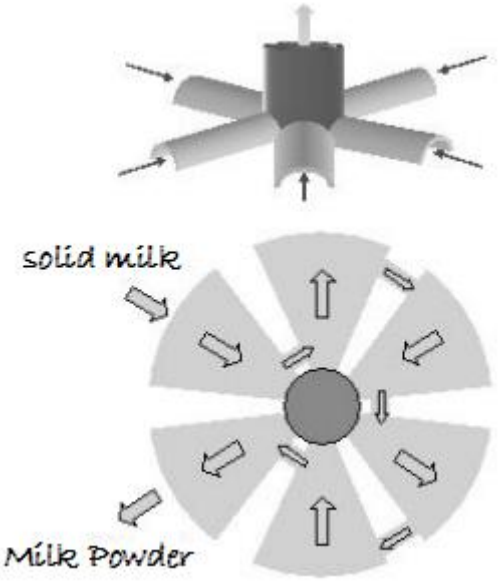

Fig.3 – Advanced Solar Dryer design

New achievement of solar dryer is:

• an increase of the saturated vapour pressure at brine temperature, i.e., heating the brine, which also promotes a decrease of the latent heat of vaporization;

• an increase of the convection coefficient, through higher air flow velocities in the air/brine contact layer;

• a reduction of relative humidity implies a directly proportional increase of the saturated vapour pressure, through the heating of air.

Advanced Solar Dryer's thermal parameters	
Solar collector properties	
greenhouse - $F'\tau\alpha$	0.52
greenhouse - $F'U_L$ [W/m^2°C]	15.2
solar chimney - $F'\tau\alpha$	0.62
solar chimney - $F'U_L$ [W/m^2°C]	7.8
Radiation	
Cover transmissivity	0.85
Brine absorptivity	0.94
Brine emissivity	0.9
Conduction	
concrete thermal conductivity [W/m°C]	1
concrete thickness [m]	0.2
insulation thermal conductivity [W/m°C]	0.004
insulation thickness [m]	0.003
soil thermal conductivity [W/m°C]	1.2
soil thickness [m]	2
Total thermal conductivity [W/m°C]	0.842
Total thickness [m]	2.203

Table 1- Solar dryer parameters

IV. Application of Milk Powder

Milk powder is the dried form of fresh milk that comes in a can or box and does not require refrigeration. Although it does not have quite the same taste as fresh milk when it is

reconstituted with water, you can substitute milk powder for fresh milk in recipes without noticing a difference in taste. Milk powders of various types are used in a wide range of products including the following:

Baked goods, snacks and soups

Cheese milk extension (powder is added to local fresh milk to increase the yield of cheese)

Chocolates and confectionery (e.g. milk chocolate)

Dairy desserts

Direct consumer use (home reconstitution)

Ice cream

Infant formulae

Nutritional products for invalids, athletes, hospital use etc.

Recombined "fresh", UHT, evaporated and sweetened condensed milks

Recombined cheeses, mainly "soft" or "fresh"

Recombined coffee and whipping creams

Recombined yoghurts and other fermented products

V. RESULTS AND DISCUSSION

The process of milk powder involves the gentle removal of water at the lowest possible cost under stringent hygiene conditions while retaining all the desirable natural properties of the milk - colour, flavour, solubility, nutritional value. Whole (full cream) milk contains, typically, about 87% water and skim milk contains about 91% water. During milk powder manufacture, this water is removed by boiling the milk under reduced pressure at low temperature in a process known as evaporation. The resulting concentrated milk is then sprayed in a fine mist into hot air to remove further moisture and so give a powder. Approximately 13 kg of whole milk powder (WMP) or 9 kg of skim milk powder (SMP) can be made from 100 L of whole milk.Preparation of milk powder by solar as well as traditional method is approximately same by sensory evaluation shown in Table 1.

S/no	Method	Flavor (9)	Body and texture (9)	Color and appearance (9)	Overall acceptability (9)
1	Solar	8.1±0.81	8.0±1.25	8.4±0.21	8.2±0.33
2	Traditional	7.8±0.46	8.1±0.28	8.3±0.42	8.1±0.57

Mean values ± Standard deviation are based on 3 trials.

Table: 2 sensory evaluation of milk powder

Heat requirement to evaporate 1 k.g. water from miik :

Evaporation: 1200 kcal/kg

Dryer: 980 kcal/kg

Moisture dryer: 850 kcal/kg

By conventional method there have lots of energy waste in this process. To save fassil fuel and reduce CO_2 emission use of solar energy is one of the best ideas in dairy.

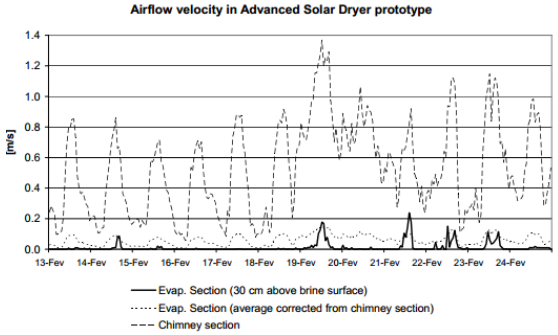

Fig. 4- Approximate Airflow velocity in Solar Dryer section

VI. CONCLUSIONS

The following conclusions are made from the present investigation

1. More amount of moisture from the milk can be removed in conventional method than the solar method of dehydration.
2. Labor cost can be saved.
3. A high and uniform quality product in respect of color flavor, body and texture, color and appearance and overall acceptability can be obtained by solar method.
4. Atmospheric pollution can be minimized by using solar dehydration of milk.

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