Technews

National Dairy Development Board

For Efficient Dairy Plant Operation

January - February 1997 No.6

POWER PLANT - FIRE HAZARDS

This bulletin includes technical information, latest developments on products, systems, techniques etc. reported in journals, companies' leaflets and books, and based on experience. The technical information would be on different areas of plant operation in different issues. It is hoped that the information contained herein, if employed in the factory, will help in making dairy plant operations more efficient.

Your contributions and suggestions will make this bi-monthly bulletin more useful, and are welcomed.

The theme of information in this issue is ***Powder Plant - Fire Hazards*** *in dairy plants.*

It may be understood that the information given here is by no means complete.

In this issue

1. SOME INCIDENTS OF FIRE IN MILK SPRAY DRYERS

a. A fire broke out in a spray dryer manufacturing tea whitener. The dryer employed nozzles for spray. The dryer chamber was seriously damaged. Subsequent study led to the conclusion that a combination of reasons - backdraught of air carrying powder into the air disperser when the dryer was restarted after a short power failure, heavy deposits of powder on the wall, choked nozzle decreasing the feed spray - caused the fire. The fire spread to the cyclones. Although all the controls worked water spray did not take place as the main manual water valve was closed !

b. In another case, the atomizer wheel in the spray dryer was given too much lubricating oil. The powder deposited on the underside of the dryer roof soaked the oil, and during subsequent operation the oil-soaked powder spontaneously ignited. The burning material fell to the bottom of the dryer. One full batch of the product had to be discarded.

c. A spray dryer producing skim milk powder suffered an explosion. Investigation revealed that a deposit around the fines return pipe had ignited and had resulted in the explosion. The pipe itself was at about 40' C. It was assumed that the air surrounding it was at 200' C, and under these circumstances the critical thickness of deposit was calculated to be 2.6 cm, which was considered possible.

d. In a series of interconnected fluid bed dryers producing milk powder, fire occured due to self-ignition. Even after the fire was rapidly extinguished, smouldering continued in horizontal sections of exhaust ducting to the cyclone. The ducting had accumulated considerable deposits of powder. It took several hours to extinguish it.

Thus, it is seen that although milk spray drying is not considered a particularly hazardous process, conditions might be obtained which are prone to fire or even dust explosion.

The milk powder is an organic material and is combustible, though not readily. The powder might be present in the chamber in two different undesirable conditions : suspended in the air as a cloud, or in the form of deposits on the dryer interior surfaces. Both present a danger, as the conditions in the dryer may be such, with regard to temperature, that the deposit can catch fire and the dust can explode.

2. POSSIBLE CAUSES OF FIRE

a. **Self ignition.** Self ignition or spontaneous combustion is the most important cause of fires in milk spray dryers. A thick powder deposit may generate enough heat increasing the temperature rapidly. This would present a risk of fire. See item 3 for details.

b. **Ignition due to external source.** Glowing particles may enter the chamber alongwith the hot drying air. Such particles need to be in 3-5 mm in diameter at temperatures of about 600' C to present a problem (Beever, 1985). If such particles penetrate humid zone around atomizer, they can spark off fire. Likewise, **if the powder from the fines return pipe enter or remain in the air disperser,** it will create fire hazard. Similarly, welding ductwork may cause ignition of deposits inside.

c. **Friction between moving parts.** Friction between moving parts is a possible source of sufficient heat to initiate ignition. This can happen around the atomizer and possibly rotary valves.

Incorrect assembly of atomizer or **badly cleaned atomizer and milk distributor or nozzles in nozzle type dryer constitute danger areas.** Further, the atomizer, if not assembled properly, can work loose and fly off hitting the dryer wall. The mechanical spark so generated might be sufficient to ignite the dust cloud.

d. Electrical spark may be caused due to electrical equipment failure, which is unlikely. However, spray drying and the movement of powder can generate static electricity. Although this is not likely to ignite the powder readily, it will be safer if the dryer and its associated equipment are earthed.

e. Improper operation of dryer can be a reason of fire taking place. If the feed is switched to product too soon, before the dryer is fully heated up, damp patches will form on the wall which will provide good bases for further deposits. Insufficient drying after wet cleaning may also cause wet patches. Moist powder deposits are particularly dangerous (see item 3).

f. Improper stoppage of the drying plant, for instance, due to power failure, may cause a backdraught which carries milk particles into the air disperser and the inlet air duct, where they form deposits that can catch fire on restarting the plant.

3. SELF IGNITION OF MILK POWDERS

a. Milk powders contain oxidizable constituents such as fat, protein and lactose, higher the fat higher the danger. Due to their being exothermic, these oxidation reactions generate heat increasing product temperature. Higher temperatures increase oxidation rates: compared to at 20' C, the oxidation rate is 1000 times faster at 100' C and 100,000 times faster at 200' C (Beever & Crowhurst, 1989).

b. A thick deposit may generate more heat than that can be lost - called critical thickness - resulting in rapid rise in temperature. The temperatures of thick deposits, in the right conditions, can rise to 700' C presenting a serious iginition source for the dust cloud.

The following table gives the critical thicknesses of various milk powders at 100' and 200' C for self ignition (Beever, 1985):

Critical thickness for self-ignition of milk powders

Powder Type	Minimum Thickness for Self-ignition (cm) At 200° C	At 100° C
Skim milk powder	0.9-1.7	12-17
Whole milk powder	0.7-1.0	10-17
Buttermilk powder	0.8-0.9	10-13
Whey powder	1.3	32

The likely times of ignition are about an hour or less at 200' C and a few hours at 100' C.

c. The critical temperature for self-ignition is less if oil is present (atomizer oil leakage). Complementary sources such chamber illuminating light accelerate the self-ignition.

d. Thick wet isolated layers, such as left due to poor wet washing or due to incorrect start up, present great dangers. It is known that wet deposits oxidize faster than dry ones.

e. Powder deposits in high temperature regions are particularly dangerous, and must be avoided. Such areas are chamber ceiling where hot air is introduced, atomizer and air disperser.

f. Although, the downward flow of the air should prevent powder settling in the hot regions near the dryer top and under the roof, the turbulence caused by the rotary atomizer may produce eddies which can throw powder upwards and thin layers can accumulate even there. The figure below shows areas where powder deposition is possible, and temperatures in various regions.

g. Fines may build up in the corners where the cone slopes, on the exhaust and fines return pipes and on the chamber wall. Bulk powder can accumulate at the base and on the walls.

h. The self-ignition temperature decreases by about 15' C when the deposit thickness doubles. Beever (1984) gives minimum self-ignition temperature of skim milk powder to be 171', 156' and 141.5' C for layer thickness of 5, 7.5 and 10 cm, respectively.

i. Crystallization of lactose can occur at low temperature, hence decreases the self-iginition temperature.

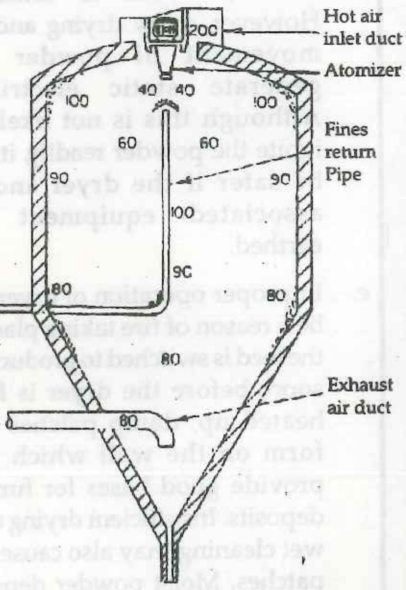

Figure : Typical temperature distribution (°C) and areas of powder deposition in milk spray dryer.

j. Small lumps or layers of powder, upto 5 cm thickness do not generally ignite below 130' C (International Dairy Federation, 1987). However, thick layers, say of 15 cm thickness or higher can be dangerous even at 80' - 90' C. However, it will take more than 24 hours before combustion starts.

4. MEASURES TO PREVENT FIRE

1) Air Supply System

a. Air must be drawn in from a clean and dry area to prevent the entry of dust in the air heater. The suction line must be fitted with 3-5 mm mesh filter which should be maintained regularly.

b. The air ducts - drying air supply and exhaust lines and other air ducts linking the various plant sections - should be provided with remote controlled valves, which are closed automatically in case of fire, to prevent it from spreading.

c. Powder must be prevented from depositing on the air dispersers and the ceiling which are the hottest parts of the drying chamber. These sections must be easily accessible for inspection by means of sigh glasses or in other ways. Extra attention must be paid to possible signs of fire immediately upon adjustment of the air disperser. If any deposition takes place in the disperser or chamber ceiling portion, it would be darkened and charred by the heat, and such particles will break off and appear in the powder. A continuous checking, say atleast every hour, should be done to ensure the cleanliness of the powder by testing for scorched particles in the powder. If such particles are found, particularly fairly soon after starting up, the plant should be stopped, and reasons for such particles be investigated.

d. Air carrying powder must be prevented from flowing back from the drying chamber into the air disperser or to the heater when the plant is stopped, after the operation or due to power failure, by backdraught. This can be done by shutting off the damper provided in the air inlet duct. Correct starting and stopping sequences must be followed.

e. A section of the roof of the drying chamber and the air disperser should be cooled by cooling air.

2) Feed System and Atomization

a. Atomization must be uniform and correct in order to avoid product deposits inside the chamber. The feed milk must have constant concentration and viscosity. Feed pumps and lines to atomizer must be checked regularly for performance and leakage. The feed pump failure or leaky feed lines may result in the outlet air temperature to rise.

b. The clogging of rotary atomizer or nozzles must be prevented. Regular inspection of atomizers once in 24 hours should be made. A filter should be provided in the feed line, and inspected regularly, to prevent its clogging.

c. The current consumption of the high pressure pump motor must be checked regularly. Deviations in current consumption may indicate incorrect atomization and partial/complete clogging of nozzles. A pressostat can be used to indicate atomization pressure.

d. Nozzle exteriors must be kept clean and cool at all the times, by shielding the nozzles and conducting a minor flow of cool and clean air around them.

e. Concentrate must not leak on to the roof of the chamber or over the air disperser. If detected so, the plant must be shut down and the deposits cleaned. An overflow detector may be fitted at the lower most point to give alarm in case of leaking.

f. A vibration senser can be used to detect out of balance condition of the disc atomizer.

3) Drying Chamber

a. The drying chamber inner surface must be smooth and flush and all obstacles must be avoided so that no or minimum deposits take place.

b. The chamber should have a readily accessible inspection glass with lighting.

c. Appropriate explosion vents should be provided.

d. The powder deposits in the dryer can be controlled by installation and proper maintenances of knocking hammers, vibrators, scrapers or air broomes.

e. When the fines return is from top, the inner pipe should be cooled by air flowing through the annulus of the concentric pipe.

f. If the fines return is below the disc the pipe should be accurately centred. If it is not so, the dry powder will be blown through the mist of the particles at the atomizer disc into the top hot section where it may deposit.

g. The fines return pipe outlet must be prevented from deposition and clogging. Irregular distribution of fines may lead to powder penetrating the mist. Fouling of pipe may be detected by monitoring the delivery pressure of the blower or fan.

h. In case the feed flow rate is decreased or the atomization process is disturbed the fines return must be stopped immediately.

4) Separation and Transport System

a. Accumulation of powder due to blocking of cyclones and tranport ducts disturbs dryer operation and hence is a fire hazard. All such blockings must be prevented.

b. The core of the powder lumps will be charred if the blocking of a cyclone is prolonged. If the blocked cyclone is cleared through an inpection hatch, ignition may take place. **A cyclone that has been blocked for sometime must not be emptied without stopping the plant.**

5) Plant Operation

a. The plant should be operated properly. The feed should be switched to product only when the dryer is fully heated. Further, temperature control must be maintained during operation and at start-up and shut-down.

b. Cleaning must be thorough and visual checks must ensure to avoid leaving damp patches of product on the walls to which powder may adhere.

c. If knocking hammers etc. are not found to be very effective in controlling powder deposits, then the operating intervals should be adjusted such that the dryer is cleaned before deposits of critical thicknesses have built up on the walls. Cleaning must be much more regular with the sticky powders such as baby foods, dairy whiteners and whole milk powders.

d. During operation, regular inspection should be carried out of areas known prone to deposit formation.

e. The atomizer and rotary valves should be assembled properly and cleaned thoroughly. To ensure that these components have been properly assembled vibration monitors can be installed on the shaft of the atomizer, monitoring the temperature of bearings and the energy consumption of the motor.

f. All components must be maintained in prime operation condition and all safety systems such as explosion vents, suppression systems, interlocks, alarms and fail-safe devices must work correctly. Lubrication schedule must be maintained, and all oil leaks, especially atomizer oil leakage, must be immediately reported and rectified.

g. A thermostat in the inlet air duct may be installed that would sound an alarm and would cut off the air heating system if air inlet temperature exceeds a certain pre-determined value, say, 20' C above normal working temperature (Knipschildt, 1986).

h. Lack of feed to the atomizer or mal-function of the atomizer would result in higher outlet air temperature. The temperature may reach to very high level sufficient for self-ignition of powder deposits. Hence, it is essential that sufficient quantity of concentrate is available in the balance tank during operation. Feed tubes and atomizer duct should be thoroughly cleaned after optimum hours of operation.

i. In the air outlet duct also, a thermostat should be installed that would sound an alarm, cut off the air heating system if the air temperature exceeds the normal working temperature (usually should react at 120' C).

j. When the plant is stopped due to power failure or such other reasons and the plant is to be restarted later, the damper provided in the air inlet duct should shut off the air supply.

k. The ignition temperature of glowing powder deposits in the drying chamber decreases rapidly with the addition of small percentage of caustic soda which might have occured during evaporation due to mal-function of isolating valve between the process line and the cleaning circuit. Hence these valves must be kept in good condition, or the cleaning circuit should be kept out from the process line during operation.

6) Detection of Smouldering Powder or Fire

In the event that inside the dryer, powder begins to smoulder it is vital that this is detected as early as possible. Immediate detection can prevent a fire, or make its rapid extinction possible. For the detection of such eventuality various techniques can be employed.

a. All drying plants should be fitted with quick action temperature sensors in the exhaust air flow. The detection system may be so designed that fire alarm is given as soon as the set value (e.g. 110' C) is exceeded. If the temperature continues to rise, e.g. to 120' C, the extinguishing operation should be started automatically.

Similar temperature sensors should also be installed in air inlet duct and chamber.

b. Smouldering milk powder emits an extremely foul smell. An air flow sample may be conducted to the control room where the operators are able to smell immediately any powder starting to smoulder inside the plant. The air flow sample may be taken at the following points:

-in the exhaust air, after the cyclones

-in the exhaust air, from the final dryer

-over the vibrating fluid bed

c. The presence of sediment in dissolved powder, to be checked by the scorched particle test, is an indication of the quality of the powder, and a large amount of it is a sign that the dryer must be cleaned, or even that a fire may break out. This test should be conducted atleast every hour.

5. FIRE PROTECTION

Once a fire has been detected by smell, by the appearance of charred powder at the outlet or by operation of some detector, following action must be taken at once to avoid the risk of explosion:

a. The air flow should be switched off at once.

b. The product feed should be switched off.

c. Switches to water and the extinguishing system be activated.

d. The same should be done to auxiliary equipment into which burning material may have passed.

Water flow rate of 10 l/sec for dryers with diameter greater than 8.4 m would be helpful to extinguish the fire, or atleast to minimize heat damage to the chamber (Beever & Crowhurst, 1989).

REFERENCES

- Beever, P.F. (1984). Spontaneous ignition of milk powders in a spray-drying plant. **Journal of the Society of Dairy Technology**, 37, 68-71.
- Beever, P.F. (1985). Fire and explosion hazards in the spray drying of milk. **Journal of Food Technology**, 20, 637-645.
- Beever, P.F. and Crowhurst, D. (1989). Fire and explosion hazards associated with milk spray drying operations. **Journal of the Society of Dairy Technology, 42, 65-70.**
- International Dairy Federation, Brussels (1987). Recommendations for fire prevention in spray drying of milk powders, **IDF Bulletin** N' 219.
- Knipschildt, M.E. (1986). Drying of milk and milk products, in **Modern Dairy Technology Vol 1: Advances in Milk Processing**, Ed. RK Robinson, Elsevier, London.