Batch and continuous Freezers

Introduction

Freezers used in freezing of ice cream mix can be classified as follows

a) Batch freezer: Horizontal, direct expansion type

b) Continuous freezer: Horizontal, direct expansion type

c) Soft– serve freezer: Batch and automatic continuous freezers of the direct expansion type

Ice-cream mix is frozen in single-batch machines or in continuous freezers. In general, both machines utilize a cylindrical chamber with double wall which acts as a jacket to contain the refrigerant. On the axis of the cylinder, a rotating dasher and scraper keep the mix thoroughly agitated and remove the ice from the refrigerated wall.

Ice cream contains a considerable quantity of air, up to half of its volume. This gives the product its characteristic lightness. Without air, ice cream would be similar to a frozen ice cube. The air content is termed its overrun, which can be calculated mathematically.

Freezing Ice Cream

Ice cream is an almost complete food. The mix is usually contains more than 60 per cent water. As ice is frozen, the ice crystals are suspended in the water, and very small air cells are incorporated into the mixture. When the drawing temperature is -5.6ºC about 50 per cent of the water in mixes is frozen. This means that in a mix having 38 percent total solids, the semi frozen ice cream extruded will have 69 per cent of its contents as solids suspended or dissolved in the remaining water, which amounts to only 31 percent of the whole. If freezing continued to a drawing temperature of -9.4ºC where 67 per cent of water is frozen out. As ice crystals are formed, they add to the solids already in the mix, and this increases viscosity and motor load requirements. To prevent coarse, icy ice cream, the product temperature should not be permitted to rise, but should not be lowered continuously until well hardened. When hardened to -15ºC, about 80 per cent of the water is frozen. If the temperature goes up to -14°C, about 78.5 percent of the water is still frozen; this one degree difference results in about1.9 per cent of the ice being melted. The freezing point curve shows that temperatures should be lowered continuously, that fluctuations cause iciness,and that at lower temperatures, there is a diminished effect. This information is more important in the proper management of packaging, hardening and cold storage of the product.

Ice Cream Freezers

Hand cranked ice cream freezer

There are two types of ice cream freezers: the batch type and the continuous flow type. Batch freezers are used in very small ice cream factories. Fast freezing is essential for a smooth product, because ice crystals that are formed quickly are smaller than those formed slowly. Therefore, it is desirable to freeze and draw from the freezer in as short time as possible. The freezing time and temperature are affected by the type of freezer used.

Batch freezers

In batch freezers, each batch must be measured, colored and flavored separately. They consist of the brine type; the salt and ice type; direct – expansion type(using ammonia or Freon as refrigerant), including vertical, horizontal, and single-, triple -, and quadruple – type freezers. Batch freezers made today are generally of the horizontal cylinder type with the freezing cylinder refrigerated with one of the halo carbon refrigerants, most often being R-22 or R-502. There is a mix supply tank located above the freezing cylinder, so that mix will flow by gravity into the cylinder when a valve is opened. The usual procedure is to charge the freezer, turn on the dasher and start the refrigeration. A slide or pivot on the bottom portion of the front door allows the ice cream to be drawn in to containers or bulk cans. The dasher is designed to propel the product toward the discharge port. Subsequent batches are put into the mix supply tank as soon as the previous charge is dropped into the freezing cylinder. Ice cream can be made by every 6-7 min by experienced operators.

The sizes of batch freezers vary according to the manufactures' designs, but 18-– 20 liters and 36-40 liters of 100 per cent over run ice cream are the two sizes found most often. If greater than 100 percent overrun is desired, then the mix charge must be reduced enough to prevent over flow of ice cream during whipping. Generally, ice cream made with batch freezers has both larger ice crystals and bigger air cells than ice cream made with the same mix on continuous freezers. Modern batch freezers are not much different from the earlier models except in better refrigeration systems.

In another one batch type, a charge of mix about half fills the machine. The brine(refrigerant) is then turned on, and the dasher and scraper started. In about 5to 10 minutes the operation is completed, and the batch is discharged by opening a gate in the front of the freezer. The mix has been frozen to a temperature of about -5°C and has increased greatly in volume by virtue of the whipping motion of the dasher blades, giving it the consistency of whipped cream. It is drawn off quickly into the containers, and rushed into the hardening room. Flavors, fruits, and nuts are added to the batch in the freezer just before it is drawn

Batch Ice Cream Freezer

Construction

In the batch freezer a definite quantity of the mix is frozen at a time. It consists of a tubular chamber fitted with a rotating dasher (Fig-17(A). The chamber is fitted with a mix tank and hopper for adding fruits and flavours. The chamber is surrounded by a refrigerated jacket in which ammonia or other suitable refrigerant is evaporated to provide the cooling effect.

The freezing chamber is made of a liner, usually of nickel silver or stainless steel, pressed inside a steel or copper tube which forms the inside wall of the cooling jacket. If the jacket is cooled by brine, it is constructed of copper with narrow passageways to increase turbulence and heat transfer. The outside is insulated with cork and covered with an airtight metal housing. If the cylinder is to be cooled by direct expansion of a refrigerant, the outer jacket is usually built of steel and properly insulated.

The functions of the dasher are

(i) To scrape the frozen film from the cylinder wall, carry it to the centre, and circulate it from one end of the freezer to the other so that rapid and uniform cooling takes place,

(ii) To beat the mix and hold air into it,

(iii) To eject the frozen mix rapidly when the batch is finished.

The dasher consists of an outer frame carrying either two or more sets of scraper blades, which turn in one direction at a speed of 60-70 rpm. (Fig-17(B))The central part consists of beater having a series of longitudinal rods or paddles which rotate in opposite direction. The dasher is mounted on a shaft furnished with rotary seals, so that it can be completely taken apart for cleaning. It is important to have the dasher in proper alignment and the blades must be sharp.

Operation

A batch of mix is dropped into the chamber, the refrigeration is turned on and dasher is started. The temperature of the refrigerant is very important and should be from -24 ^{o}C to -29 ^{o}C in order to get a rapid formation of ice crystals. The mix is cooled down to a temperature of about -5 ^{o}C in 6-10 minutes at which the refrigeration is turned off by means of a quick shut off valve and dasher allowed to rotate for 1-2 min to allow the mix to partially congeal. The mix will not absorb much air until a temperature of about -5 ^{o}C is reached. At this point, it will rapidly absorb air of 100-120% of its original volume. The ice cream is then drawn out of the chamber and into cans or packages which are placed in a room at temperature between -24 to -30 ^{o}C for hardening.

A slide or pivot valve on the bottom portion of the front door allows the ice cream to be drawn into containers or bulk cans. The dasher is designed to propel the product toward the discharge port. Subsequent batches are made in the same manner. The size of the batch freezers varies from 18-40 liters of 100% overrun. If greater than 100% overrun is desired, the mix charge must be reduced enough to prevent overflow of ice cream during whipping.

The beaters promote whipping, but when freezing at temperatures below -5 ^{o}C , air is less readily incorporated, and some may even be expelled. Ice cream made with batch freezers has both larger ice crystals and bigger air cells than ice cream made with the same mix on continuous freezers. Overrun control to close tolerance is difficult with batch freezers, and it may vary by 80-100 from the beginning of drawing the batch to completely emptying the barrel. This occurs because whipping continues all during the drawing time.

Continuous ice cream freezers

The process consists of continually feeding a metered amount of ice cream mix and air into one end of the freezing chamber. As the mixture passes through the freezing chamber it is agitated and partially frozen and then discharged in a continuous stream of about the same consistency usually obtained from a batch freezer. This partially frozen stream is delivered into packages, which are then placed in the hardening room to complete the freezing process. The modern machines for this purpose are known as “Continuous” or “Instant freezers”. One major difference in continuous processing is that freezing is done under pressure.

In the continuous freezer, following mix processing, the mix is drawn into a flavor tank where any liquid flavors , fruit purees, or colors are added. A mixture of the ice-cream mix and a controlled volume of air is pumped under pressure into one or more horizontal jacketed tubes, each provided with a rotating dasher and scraper. The mix is chilled to a temperature of about -6.1°C and is slowly and continuously forced out of a vertical discharge tube directly into the final containers. The mix then enters the **dynamic freezing process** which both freezes a portion of the water and whips air into the frozen mix. The internal parts of a continuous ice cream freezer**.** The "barrel" freezer is a scraped-surface, tubular heat exchanger, which is jacketed with a boiling refrigerant such as ammonia or freon. Mix is pumped through this freezer and is drawn off the other end in a matter of 30 seconds, (or 10 to 15 minutes in the case of batch freezers) with about 50% of its water frozen. There are rotating blades inside the barrel that keep the ice scraped off the surface of the freezer and also dashers inside the machine which help to whip the mix and incorporate air.

The continuous ice cream freezers may be classified based on the number of pumps used with or without hold back valve system. internal parts of a continuous ice cream freezer, the freezer with pump and hold back valve system, the freezer with three pump system. A microprocessor based continuous ice cream freezer is depicted .

Disk type of continuous ice cream freezer

The disk type continuous ice cream freezer in which mix is passed through a tank in which hollow disks containing cold brine are rotated. The disks cooled and aerated the ice cream mix which is discharged on the other end.

Vogt freezer

The principle of operation of Vogt freezer is same as that of the disk type freezer, but direct cooling system is used here and a tube shaped freezing cylinder which causes extremely fast freezing mixture. Metered amount of air and mix is forced into the freezing tube and emulsified there. The frozen mixture is forced out on the other end of the tube by pressure of a second pump. Ammonia is circulated by means of jet action so that it floods the freezing tube during operation of the machine.

Creamery package continuous freezer

Compressed air is passed through a filter, a pressure gauge and check valve which are provided in the line. Ice cream mix is pumped with the help of mix pump and enters the freezing cylinder along with air. Ice cream after freezing is pumped out with the help of discharge pump. A filling valve is provided between the freezing cylinder and discharge pump. The actual control of overrun of predetermined point is accomplished by controlling the output ice cream as compared to the input of mix. This could be done by actually changing the speed of the ice cream pump only. However, in practice, it has been found that a much simple method is to vary the output of ice cream by changing the pressure on the freezing cylinder,by means of air pressure regulator. The pipeline for ice cream should be kept as short as possible. Since flowing through lines, particularly around a bend,damages the ice cream texture.

Currently the manufacturers have come up with low temperature continuous freezers which can draw ice cream at-10°C, yielding extremely small sized ice crystals making the ice cream very smooth and preventing coarseness since more percentage of water in ice cream mix is frozen.

The schematic diagram of a vertical extrusion and continuous belt type freezing equipment is represented by

Operating the continuous freezer

The operator’s principal work is to regulate the amount of air being introduced into the mix to give the desired overrun and to regulate the temperature of the refrigerant on the freezing chamber. Once the machine is started, the refrigerant is shut off from the freezing chamber only when the machine is to be stopped. Usually there frigerant is shut off a few minutes before the last mix enters the machine, so that the rinse water (37.8ºC), which follows the mix, will pass through the freezing chamber without being frozen. The temperature of the refrigerant on the freezing chamber is adjusted to give the desired consistency when the product leaves the machine.

The operation of the continuous freezer demands care and management on the part of the operator. The following are the chief requisites for keeping the freezer operating properly:

1. Keep the ammonia jacket clean and free from oil, water and nonvolatile ammonia fractions.

2. Keep the scarper blades sharp and straight.

3. Keep the mix pumps in proper working condition

4. Make certain that there is always a plentiful supply of ammonia at the freezer.

5. Provide a steady suction pressure at all times, at which the freezer must operate to give ice cream of the proper temperature.

Precautions to be exercised

1. Have all mix line connections tight to prevent mix leaking out and air leaking in.

2. Check controls frequently to ensure proper operation.

3. Drain oil trap frequently to ensure that all oil, water, etc., has been removed from the system.

4. Never bend scarper blades. Never drop the freezer dasher. Be careful when removing it from the freezing cylinder.

5. Allow freezing chamber to warm up prior to rinsing with hot or warm water.

6. Check the pump motor to ensure proper lubrication and proper tightness of pulley belts.

7. Use extreme care in handling dasher in assembling or in dismantling the freezer use in order to prevent personal injury.

Cleaning of the Continuous Freezer

1. When the freezer is not going to be used for 2 h or more it should be taken apart, cleaned, and Sanitized. This is efficiently done after the last ice cream is drawn. The rinse water should not be over 37.7°C to rinse out the ice cream, and the dasher during this process should be turned only a few revolutions.

2. The dasher and other removable parts should be removed to a sink and thoroughly scrubbed with a hot (48.8°C) washing solution, rinsed, sanitized, and stored where they dry.

3. The freezing chamber and other parts must be scrubbed with a hotter (54.4°C) washing solution using special care to remove greasy film left on the surface and in the corners. The freezer should not be assembled until it is to be used.

4. Freezers are cleaned by the same CIP procedures used for pasteurizing equipment, the steps that should be taken in the CIP cleaning of freezers are

a) Rinse with water (37.78°C or less) until rinse water runs clear.

b) Flush for 20 to 30 minutes with 65.5°C to 71.1°C water containing 1 – 1.5 lb of alkali detergent for each 10 gallon of water.

c) Rinse until equipment is cooled. When acid cleaner is used, circulate cleaning solution containing sufficient acid (Phosphoric and hydroxy-acetic) to give0.15-0.6 % acidity, at 65.5° - 71.1°C and 1.5-2.3 m/sec velocity for 20-30min.

d) Drain and rinse with water at 62.8°C for 5-7 min.

5. During the cleaning cycle all dead ends, air valve connections and the like should be blocked and the freezer run for 10 sec per min.

6.While the circuits are assembled the sanitationcrews can run 82.2-93.3°C water through entire system each time after cleaning, and then, before starting the operation again, 100-200ppm chlorine solution can be run through the entire system.