Chapter 13

Packaging – Packaging Materials and Specifications, Machines, Systems and Operational Aspects

Learning objectives

- To know about the need of packaging material for fluid milk,
- various formats of fluid milk packaging,
- fluid milk packaging machinery and its operation

Introduction

Milk contains very important nutrients which is important for the growth and development of human beings: proteins, carbohydrates, lipids, minerals and vitamins. Also, milk is a highly perishable commodity and serves a very good media for the growth of many spoilage causing as well as and pathogenic microorganisms. These pathogenic organisms may cause serious illness to the consumer. Milk is also susceptible to chemical changes such as oxidation of fat when exposed to sunlight and metallic surfaces. Milk is also sensitive to absorb the prevailing odour of surrounding environment. Hence, it is very important for us to prevent the contamination of milk by such microorganisms and to prevent the chemical deterioration of milk and also to protect the milk from objectionable odours of the surrounding. Packaging like any other packaging is an external means of preservation of

milk during storage, transportation and distribution. The word “packing” can bedefined as the enclosing of an individual product or item or several items in a package or container. In this chapter you would learn about the functions of packaging, levels of packaging, types of packaging materials and packaging machines and systems used in fluid milk processing industry.

Functions of Packaging

Food packaging performs four major functions such as ***containment, protection, convenience*** **and** ***communication***. The main function of packaging is containment. It means to contain the product. Packaging protects milk from external environmental factors and contaminants during transportation and storage, keeping them safe until they are consumed. Air and light cause chemical deterioration of milk particularly oxidative changes in milk. Packaging also provides security from theft and tampering and communicates essential information about products on the labels. Packaging also plays an important role in marketing and establishing brand awareness in an intensely competitive marketplace.

Levels of Packaging

Packaging can be classified into primary, secondary, tertiary and quaternary levels. Primary packaging refers to the one in which the productis in direct contactwith the packaging material, for example a bottle. Secondary packaging refers to a packaging which contains anumber of primary packages, for example, a plastic wrap containing a small number of bottles. The main function of secondary packaging is to provide mechanical strength and protection to the product. Tertiary packaging also called as distribution packaging refers to packaging of a product for efficient handling during distribution, for example, packaging of a large number of bottlesin corrugated boxes. Sometimes, corrugated boxes are also used as secondary packages. Quaternary level of packaging is also called as unit load or transport packaging and involves assembling of multiple containers into a single combined bundle suitable for materials handling equipment. For transport, such packaging is frequently stabilized and unitized through the use of pallets,strapping, shrink-wrapping, or similar means to form a single unit. For pasteurized milk, pouch serves as primary packaging and plastic crates are used as secondary packaging material to keep pouches intact from the stress and abrasion during transportation.

Packaging Materials

These packaging materials for fluid milk are flexible, semi-rigid or rigid. Commonly used materials include low density polyethylene (LDPE) film, paper and aluminum based laminates, multi-layered cartons and glass bottles.

Folding cartons: Folding cartons are containers made from sheets of paperboard (typically with thickness between 300 and 1100 mm). Such cartons are fed to the filling machine in a flat or collapsed form where they are erected, filled and sealed. Folding cartons, for example, are used for packing bulk/family-sized ice cream packs. The most common packaging material used for UHT milk is the paperboard laminate carton.

Corrugated fibreboard: Corrugated board is manufactured from three basic sheets – two liner boards and a central corrugated sheet or medium (flute). These materials can be varied as to weight, type and number and/or height of the corrugations in the fluting medium. The properties of a corrugated board depend largely on the type, number and position of the corrugations. Mostly corrugated fibreboards are used as secondary or tertiary packaging in the distribution and marketing of dairy products. Corrugated fibreboard box is manufactured in a very large and specialized machine called corrugator. Corrugated fibreboardswith different types of corrugations are shown in Fig.13.1. The simplest is referred to as single-face board and consists of one liner and one medium. It is usually used as a cushioning material for protecting objects in other containers during shipping. When a second liner is applied to the other side of single-face board, it is called as single-walled. The addition of further single-face combinations to single wall board results in double-wall and triple-wall constructions.

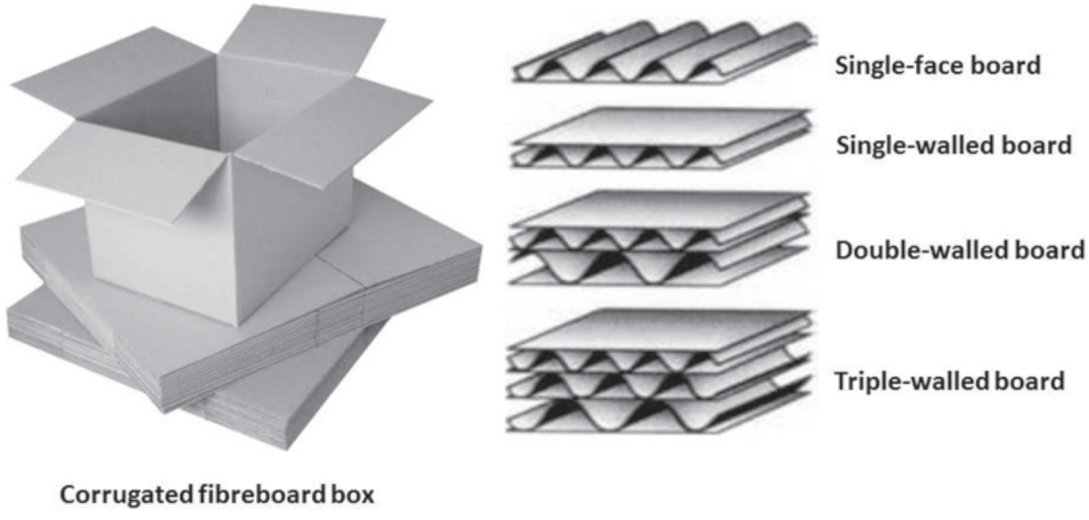


Fig.13.1. Corrugated fibreboardbox with different types of corrugations.

Composite containers: These containers usually consist of cylindrical bodies of paperboard or fibreboard with metal or plastic ends. Small containers with less than 200 mm in diameter are referred to as tubes or cans and are used for foods such as salt, pepper, spices, custard powders, chocolate beverages and frozen fruit juices. Large containers, known as fibreboard drums, are used as alternatives to paper or plastic sacks or metal drums for products such as milk powder, emulsifying agents and cooking fats.

Glass

Glass is one of the oldest packaging materials and thought to be discovered in eastern Mediterranean region of about 3000 B.C. Glass was used to contain cosmetics, perfumes and foods by ancient Egyptians, Hebrews, Romans and Persians.Glass is a hard substance that is made from limestone (about 10%), soda (about 15%) and silica (about 75%). Lesser percentages of aluminum, potassium and magnesium oxides may be included. Because of its outstanding properties, glass remains a most important material for food packaging. These properties are (a) chemical inertness, (b) non-permeability to gases and vapours,(c) strength, (d) resistance to high internal pressures, (e) excellent optical properties, and (f) surface smoothness. Glassin its natural state is usually transparent butcan have desired colours when incorporated with colouring agents during manufacturing process.Its main disadvantages are its fragility and heavy weight. Glass containers such as jars, bottles, etc. are made by various methods and different types of closures such as plug,crown, twist-off crown, wraps, heat seals, threaded screw closures, etc. are used for closing the containers.Milk for retail sale was traditionally packaged in refillable glass bottles. However, single-serve paperboard cartons and plastic pouches of various compositions and constructions dominate current market. Presently, sterilized flavoured dairy drinks are marketed in glass bottles (Fig.13.2) by some reputed dairy industries.

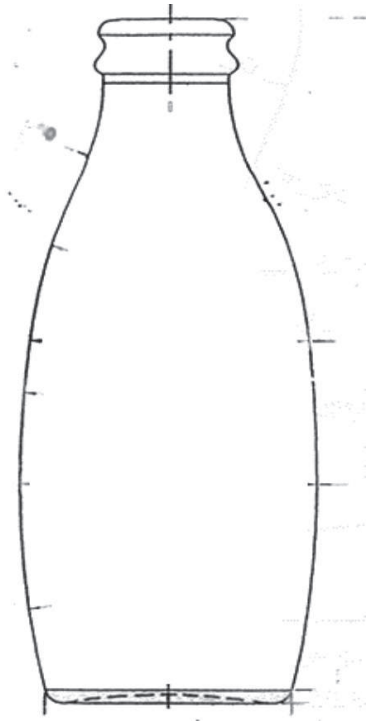


Fig.13.2. A typical glass bottle for sterilized flavoured milks

Metals

Four metals are commonly used for the packaging of food materials viz. steel, aluminium, tin and chromium. Tin and steel, and chromium and steel are used as composite materials in the form of tin-plate and electrolytically chromium-coated steel (also called as tin-free

steel). The term tin-plate refers to low carbon mild steel sheet coatedwith tin on both sides of the material. The coating of tin-plate consists of four compartments such as tin-iron compound layer, the free or unalloyed tin layer, the oxide layer and the oil layer. The combination of tin and steel produces a material that has good strength, combined with excellent fabrication qualities and a corrosion-resistant surface of bright appearance suitable for packaging processed foods. Tin-plate is used for the manufacture of two-piece and three-piece cans (Fig.13.3). The traditional method for packaging milk powders for retail purposes uses three-piece tinplate cans where the atmospheric air is withdrawn from the powder and replaced with an inert gas such as nitrogen prior to seaming the base onto the can. The main advantages of metal cans are (a) their high strength, (b) providing impermeability to gases and vapours,(c) resistance to high temperatures and (d) protection against light. The disadvantages of metal containers are (a) heavy weight, (b) high cost and (c) tendency to interact with contents and environment (internal and external corrosion).

Fig.13.3. A typical two-piece and three-piece cans for food packaging

Destruction or deterioration of a metal due to chemical or electrochemical reaction with its environment is called as corrosion. In food cans, internal corrosion is due to the reaction of the contents with the container walls. When food products especially high acid products like fruits and vegetables are packed in metal (steel) containers, they interact with the container leading to corrosion of the metal. Due to this, hydrogen is liberated and when sufficient quantity of it accumulates, it causes the ends of the can to bulge. This bulging is known as hydrogen swell. The best remedy is to coat internal surfaces with tin or other protective polymeric substances called as lacquers.

Aluminum is the earth's most abundant metallic constituent, comprising 8.8% of the earth's crust.Purified alloys of aluminum with small amounts of magnesium and manganesein the form of foil, tubes or retort pouches for packagingin the food industry. Aluminum foil is a thin-rolled sheet of alloyed aluminum varying in thickness from about 4 to 150 mm. It is essentially impermeable to gases and water vapour when it is thicker than 25.4 mm. It can be converted into a wide range of shapes and products including semi-rigid containers with formed foil lids, caps and cap liners, composite cans, laminates containing plastic and sometimes paper or paperboard, etc. The advantages and disadvantages of aluminum are similar to those of metal cans, except that aluminum is significantly lighter but also more expensive.It is also used for metallization of plastics and paper to provide improved barrier properties. Aluminum foil has an important role as light and gas barrier in the 5 or 6 layered laminate used for packaging of UHT milk.

Plastics

Plastic is derived from the Greek plastikos, meaning easily shaped or deformed. Food industry is a major user of plastic packaging materials. Plastics are usually divided into two broad categories: thermosetting and thermoplastic. Polyethylene, polystyrene, polypropylene, polyvinyl chloride, etc. are thermoplastic type of plastics. Mostly thermoplastics are being used for packaging of dairy products.

Polyolefins: Polyolefins form an important class of thermoplastics and include low, linear and high density polyethylenes (PE) and polypropylene (PP). Industry commonly divides polyethylenes into two broad categories based on their densities: high density polyethylene (HDPE) and low-density polyethylene (LDPE). The properties that make polyethylene film a popular packaging medium in dairy industry are its low price, nontoxic, excellent heat sealing property, flexibility, pleasing appearance and softness, chemical inertness. Low-density polyethylene (LDPE) accounts for the biggest proportion of the plastics used in food packaging due to its versatility. LDPE film accounts for a little over 50% of total PE in this sector because it provides strength, gloss, flexibility, and the good clarity. It can be extruded into film, blown into bottles; injection molded into closures, extruded as a coating on paper, Al foil or cellulose film, and made into large tanks and other containers. It is easily heat sealable. LDPE film is used for packaging of milk, oil, salt etc. For an equal wall thickness, HDPE gives grater rigidity to bottles than LDPE. HDPE films have a cloudy appearance, occasionally utilized as a liner for the bulk packaging of skim milk powder due to their high strength and barrier properties. Furthermore, HDPE is the most commonly used film as carton liner. However, polyethylene is not suitable for packing foods with strong aromas or the products, which have to be packed under vacuum. Chemically,

the polypropylene (PP) is similar to LDPE and HDPE. It is harder than either and has a less waxy feel. It can be converted into film and sheet or can be thermoformed to give thin – walled trays of excellent stiffness. PP has an excellent grease resistance. It has better mechanical strength and less prone to stress cracking than PE. It has poor low temperature performance and impact resistance. The properties of PP can be altered by orienting the film. The oriented PP (OPP) has better tensile strength, low permeability to water vapour, and oxygen gas. Polypropylene is non-toxic, and extensively used as packaging material for various food products. The advantages of PP are: low cost, good impact strength, processable by all thermoplastic equipment, low coefficient of friction, and good moisture and chemical resistance.

Polystyrene: Polystyrene (PS) is amorphous and in pure form, it is very brittle but when blended with chemicals like butadiene and copolymerized with acrylonitrile, it becomes tough. It is relatively cheap and has high water vapour and gas transmission rate, hence also called as "breathing film". PS is crystal clear, sparkling and is also used for thermoformed cups, trays and glasses for yoghurt, ice cream, meat, soft drinks, etc. However, it is unsuitable for heat sterilization, and deteriorates on exposure to sunlight.

Polyvinyl chloride: Polyvinyl chloride (PVC) has several overall balanced properties required by the food packaging systems: glass like clarity, good mechanical strength, resistance to water vapour, gases and chemicals, retention of flavour, excellent printability, and lower weight/ volume ratio. Due to these properties, PVC is commonly used for food packaging in various forms like films and sheets, bags/liners, shrinkable tubes/films, skin/ blister packs, film laminates, bottles and sachets.

Polyvinylidene chloride: Polyvinylidene chloride (PVDC) is a polymer based on the vinylidene chloride monomer. The film has excellent water vapour and gas barrier properties, besides outstanding characteristics like retention of odours and flavours, resistance to oils and fats, heat sealing characteristics, non-toxicity, abrasion, and chemical resistance. The laminates comprising of PVDC are widely used for the packaging of baby foods, snacks, chips, powdered soups and sauces, powdered coffee, coffee beans, sweets, biscuits and crackers, and powdered sugar. Saran, a copolymer of vinyl chloride and vinylidene chloride, is extensively used for food packaging. Saran is suitable for the packaging of several traditional dairy products such as sweet meats.

Nylon: The unique properties of nylon film are that it has high mechanical strength, high elongation capability, excellent resistance to cutting, perforation, abrasion and bursting, high chemical resistance to oils and fats, outstanding impermeability to gases and vapours, easy printability, easy metallizing. The film can be biaxially oriented, and its properties

remain unchanged between –30º to 120º C. The film is used in food packaging, especially where aroma retention is required.

Polyester: Polyethylene terephthalate (PET) is important polyester used in food industry. The main advantages of polyester films are that they are tough, sterilizable, very clear, chemical resistant, has low water absorption, low moisture vapour permeability, low gas permeability and are used as a laminate base. Its main applications include in metallized films, vacuum and gas packaging, shrink packaging, cured meat, and in boil-in-the-bag applications. This film is of great interest to the food packagers as it contains no plasticizers and is non-toxic.

Packaging Machine for Fluid Milk

Packaging of pasteurized milk: In India, pasteurized milk is largest consuming fluid milk in the form of pasteurized toned milk, double toned milk, standardized milk, full cream milk etc. These processed milks are packaged in low density poly ethylene (LDPE) film. Film has fixed width to suit machines of different manufacturers and it is around 325mm and thickness of the film varies with the pouch capacity, for 500ml it is around 55µm and for 1000ml it is around 65µm. The machine used for packaging is vertical-form-fill-seal (VFFS) machine and schematic diagram of functioning of this machine is illustrated in fig. 13.4.

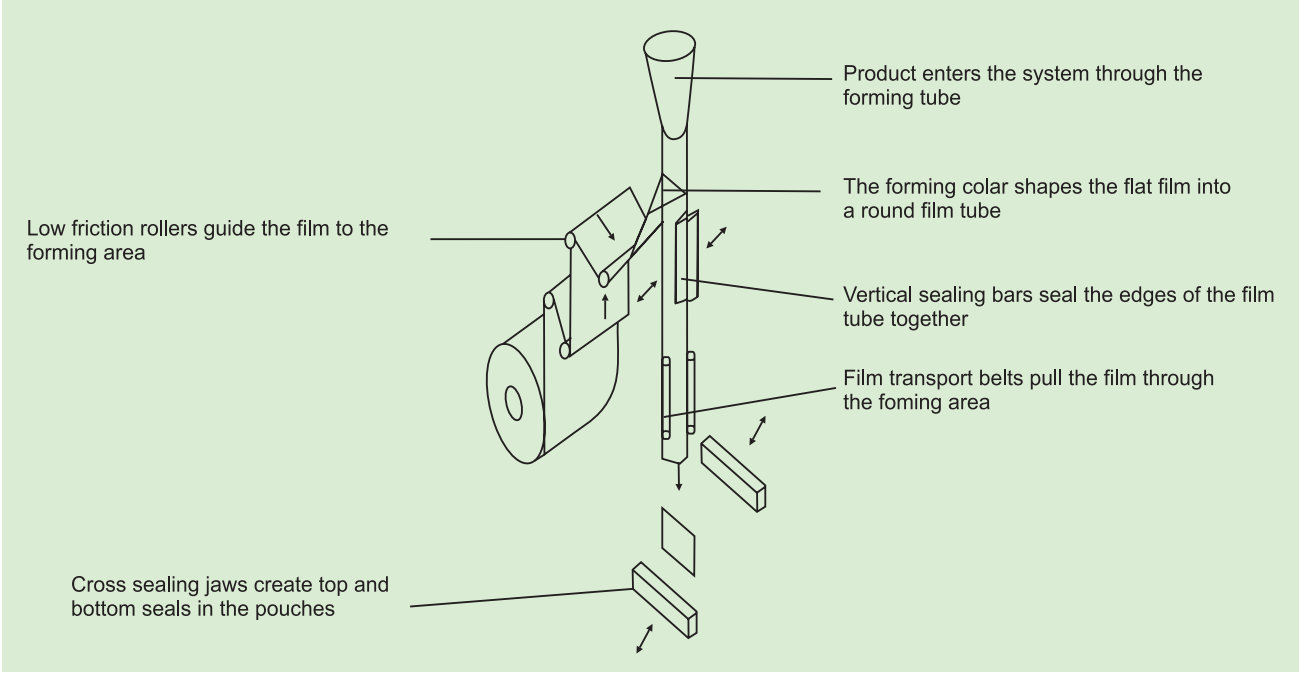


Fig.13.4. Schematic diagram of vertical-form-fill machine

Typically, VFFS machine has four parts. They are,

i) **Pouch Forming Unit**: This unit is responsible for unwinding film into the machine and form pouch to fill milk into it. Here, roll-fed flexible packaging film is unwound from a feeder roll. Then film is moved up through roller guides over a forming collar and then down, forming inverted cone tube. In order to provide extra film for the vertical seal, the width of the film will be greater than the circumference of the forming tube.

ii) **Sealing unit:** Continuous motion machines operate on the principle that both vertical and horizontal pouch seals are made when the film is in motion. The long seal is the static bar, which is a heated bar with heating element and thermocouple. Another moving bar emboss against this bar to seal the pouch vertically. The horizontal seal is responsible for three major functions—to seal the top of the previously filled bag, to create the bottom seal for the soon to be filled bag and to cut or separate the completed bag from the bottom of the new bag. Horizontal sealing unit consists of two jaws, front and back jaws operate as a pair. Each jaw will have one or two heating elements as well as a thermocouple for temperature control and either one of these jaw is moveable (operate pneumatically) and has knife to cut the pouch after sealing.

iii) **Filling Unit**: It consists of over head tank located above the top of the machine, facilitate mixing of the milk for uniform composition and uninterrupted gravity feeding to the machine. Filling of milk is based either on volume basis or weight basis. Based on timer, milk is delivered into pouch after horizontal seal cuts the pouch.

iv) **Control Unit:** This facilitates the volume adjustment to a fixed level such as 500m or 1000ml. Also, it controls the all logical circuit of machine involved in unwinding of film, moving of pouch after forming tube, temperature control of sealing unit, water temperature and pressure for sealing head.

Operational Aspects of VFFS Machine

Before start-up with milk, machine needs to run with water for couple of minutes to verify sealing quality and quantity. Once the sealing is perfect with water, then switch to milk.

1. Turn on the manual mode and ensure water supply and water temperature are at desired level.
2. Ensure the proper film is loaded to roll carrier
3. Switch on the UV lamp to destroy the microbes present on the packaging material.
4. Replace filter (provided at the end of filler tube) for ever batch and fix with new filter

5. Ensure sealing rubber is intact and there is no wear and tear on it.
6. Set the volume of milk to be filled.
7. Press the fill and seal knob to fill the pouch and seal
8. Check the sealing intact and weight of the filled pouch
9. Switch to auto mode once the all the desired parameters are set.

Aseptic Packaging of Milk

Aseptic packaging is packaging process, wherein a sterile product (most commonly UHT treated) milk is filled under sterile conditions into sterile packages in a sterile environment. Paper board cartons and multi-layered laminates are used commonly for aseptic packaging of fluid milk and other milk based beverages like flavoured milk, lassi, buttermilk etc. This process enhances the shelf life of milk from 2 days at refrigeration temperature to 120 to 180 days at ambient temperature.

Packaging Material for Aseptic Packaging

The filling systems could be either of the following two types: those in which the carton is formed within the machine from a continuous reel of material; and those in which the cartons are supplied as preformed, folded flat, which are assembled into cartons in the filling machine. The packaging material is mainly composed of printed-paper coated with aluminium foil and several plastic layers (Polyethylene-paper board-polyethylene-aluminium foil-polyethylene). The inner material side of the finished package is coated with a special layer facilitating the sealing process. Each layer has a specific function:

- The outer polyethylene layer: Protects the ink and enables the sealing process of the package flaps.
- The paperboard layer: Serves as a carrier of the decor and gives the required mechanical strength to package.
- The middle polyethylene layer: Binds the aluminium to the paper.
- The aluminium foil: acts as a gas and light barrier.
- The inner polyethylene layer: provides liquid barrier and prevent the entry of milk to inside laminate

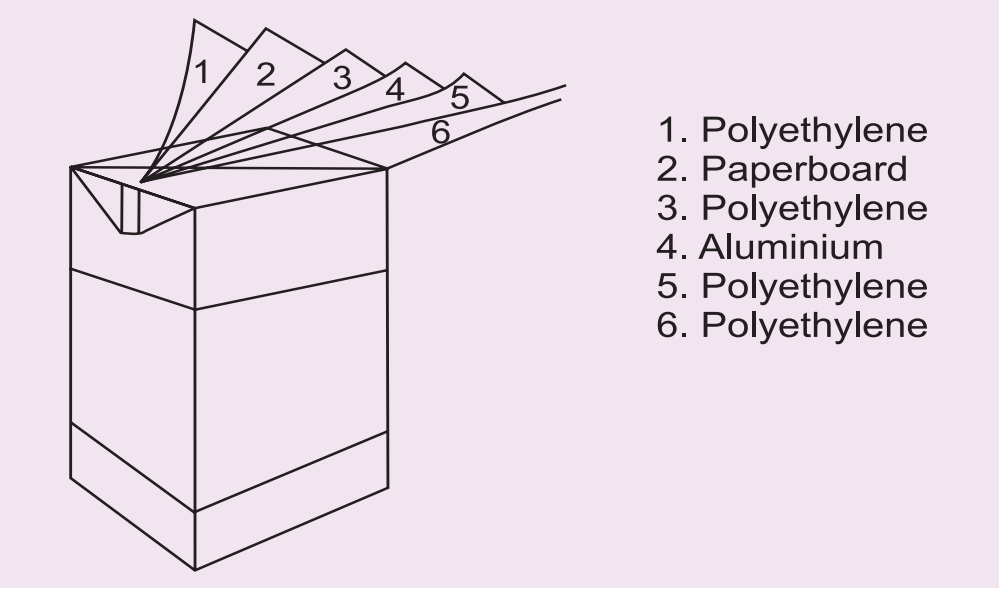


Fig.13.5. Multi-layers of laminate used in aseptic packaging

Aseptic packaging environment: Creating aseptic environment is very much essential during filling and packaging of UHT treated milk. Chemical sterilization processes for the packaging film include treatment with hydrogen peroxide (H_2O_2). H_2O_2 shows poor effectiveness at ambient temperatures, but at high sporicidal effect at 80°C makes it useful for packaging sterilization. It is first applied on the material and then evaporated by heating through hot air or infrared radiation.

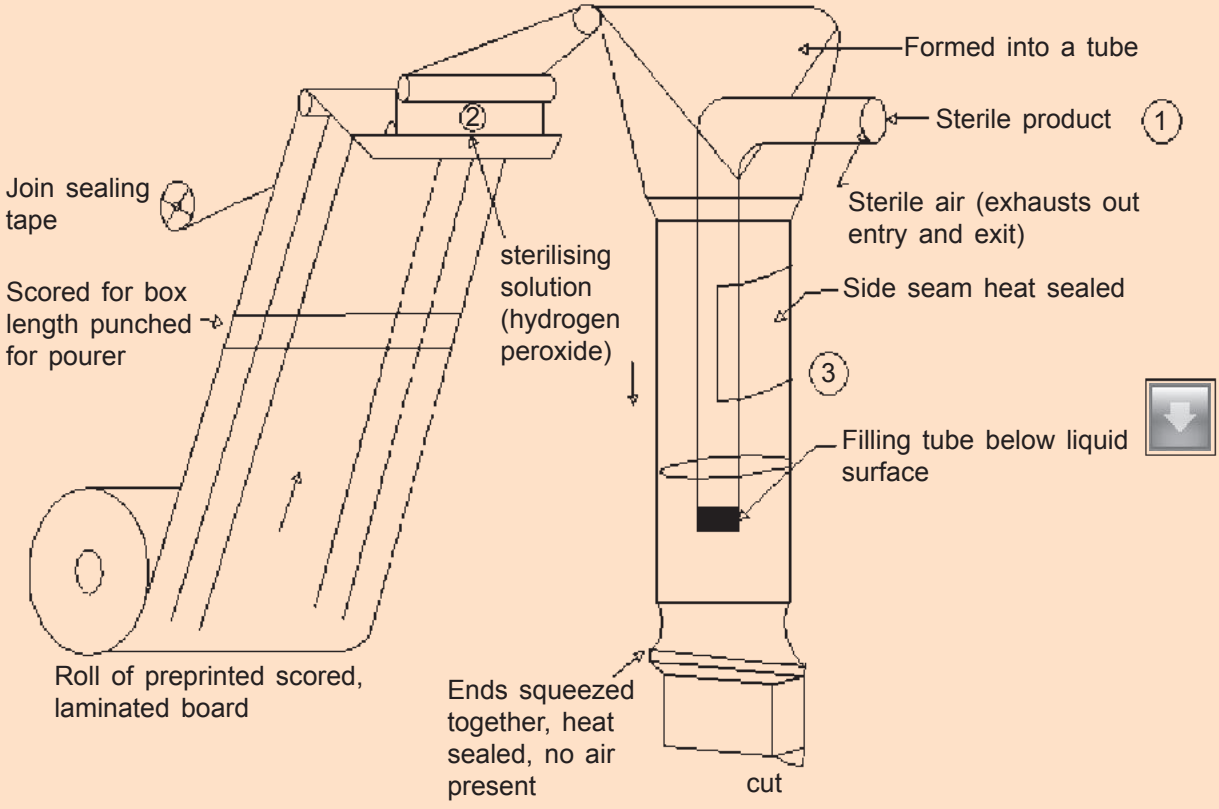
Hot air at 330-350°C (for 30 min) may also be used for milk tube sterilization. Sterilized air reduced to 180-200°C is used to evaporate H_2O_2 and when cooled to 50°C can be employed for pressurizing the filling chamber. Air filtration by means of depth filters (mats of compressed glass- or asbestos- fibre, or of sintered metal or ceramic) is effective in freeing air from bacteria. The filters themselves may be sterilized by fumigation, hot air or steam. UV radiation can also be used as a complementary treatment of already sterilized packaging. Aseptic barriers in the form of steam or circulated liquid sterilant become necessary with valves and fittings coming in contact with sterile milk. Detection of leaks by using a dye test is essential to check recontamination of the packaged sterile milk.

Aseptic Packaging Systems

Filling of commercially sterile milk in sterilized packages/containers in a sterile environment, and hermetically sealing the same to prevent recontamination of the milk can be achieved in two major ways: (a) using pre-sterilized preformed containers such as bottle and cans, and

(b) sterilizing the packaging material, forming it into suitable containers, filling the sterile product and sealing the package on the so-called form-fill-and-seal (FFS) machines. The latter employs a multi-layer laminate of polyethylene, polystyrene and/or polypropylene films, paper and aluminium foil.

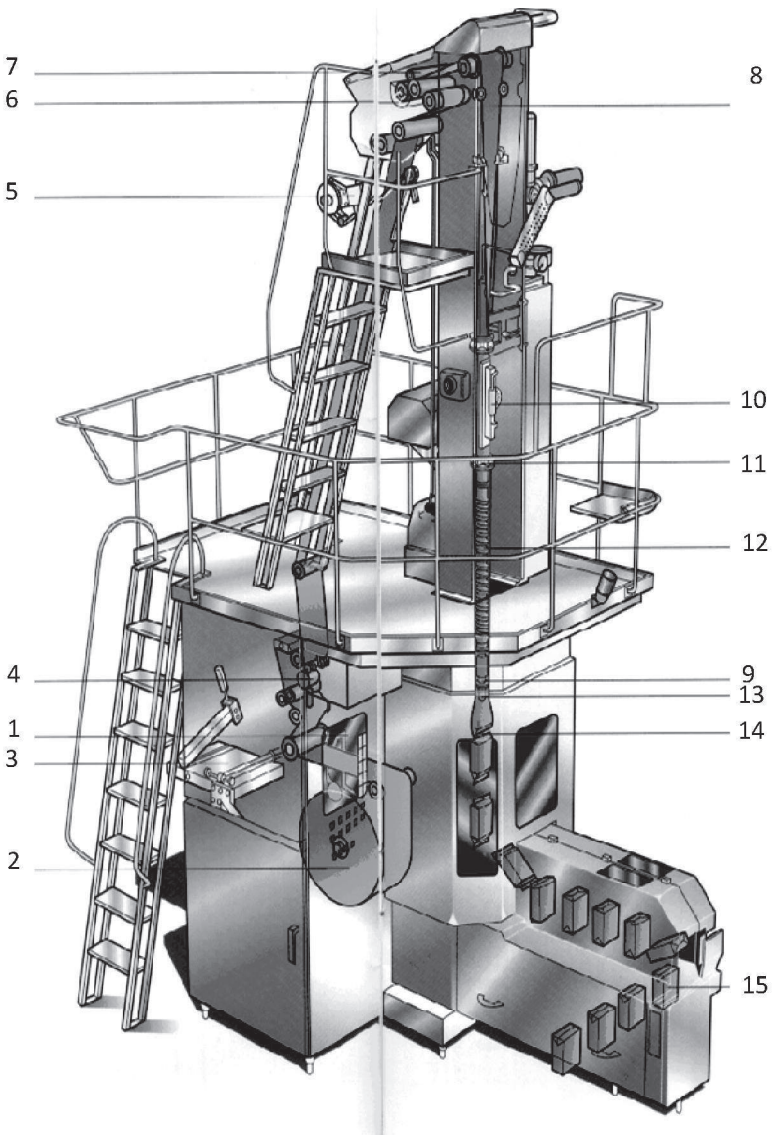
The most widely used FFS Tetra Pak systems using tetrahedron cartons, and Tetra-Briks or hexahedron cartons are characterized by continuous formation of the package below the milk level from a paper/PE/Al laminate strip which has been continuously sterilized by H_2O_2 boiled off by radiant heat in the region immediately above the milk surface thus giving a sterile atmosphere in the packaging zone as shown in figure 13.6 and 13.7. Tetra Pak also introduced Pillow Pak' to cut down the packaging cost of UHT milk.



1 Product sterilised and piped to the packaging machine
2 Packaging sterilised before entering the sterile area
3 Product and package combined within the sterile area

Aseptic packaging of UHT milk and other sterile foods saves energy by not needing refrigeration during its storage life

Fig 13.6. The forming and filling process for aseptic containers



1-Control panel

2-Reel

3-Manual splicer

4-Date stamping unit

5-Strip applicator

6-H_2O_2 bath

7-Roller

8-Shaping tube

9-Filling pipe

10-Heating element

11-Longitudinal sealing

12-Tube heater

13-Product leveler

14-Top sealing element

15 Packaged units

Fig.13.7. Aseptic packaging unit-Tetra brik

Activities Suggested

1. Visit packaging material manufacturing industry near to you and observe
2. Collect the milk pouch of 500ml and 100ml, measure their dimensions and thickness
3. What are the packaging materials used to ghee, butter and chocolates?
4. Collect aluminum foil and polyester film and check for pin hole using dye method

REVIEW QUESTIONS

1. What are the functions of packaging material with respect milk packaging?
2. List various advantages and disadvantages of glass as a packaging material?
3. Explain the various functional unit of vertical-form-fill machine with schematic diagram.
4. What is the principle of aseptic packaging?
5. Explain why we use multilayer laminates in aseptic packaging of fluid milk with the role of each layer.
6. Explain the forming and filling process for aseptic containers with schematic diagram