

Post-Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products

Professor H N Mishra
Agricultural and Food Engineering Department
Indian Institute of Technology, Kharagpur

Lecture 28 Aseptic processing and packaging



The banner features a blue and black geometric design at the top with two circular logos. Below this, a blue bar contains the text 'NPTEL ONLINE CERTIFICATION COURSES'. The main title 'Post Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products' is in red, followed by the professor's name and department in black. The module and lecture titles are in green and red respectively.

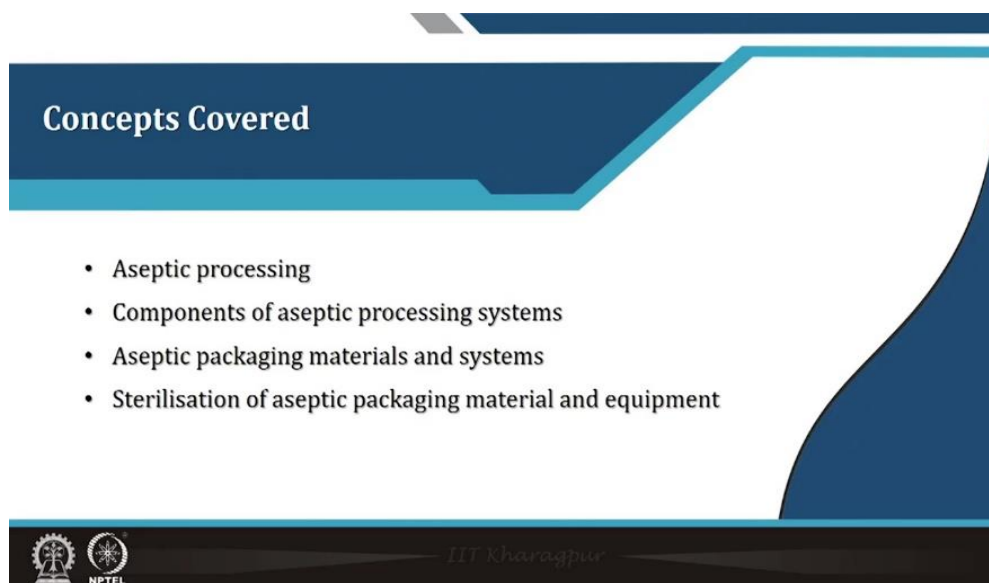
NPTEL ONLINE CERTIFICATION COURSES

Post Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products

Professor H N Mishra
Agricultural and Food Engineering Department, IIT Kharagpur

Module 6 : Juices and Concentrates
Lecture 28 : Aseptic Processing and Packaging

In this lecture a very important aspect of processing and preservation of fruits and vegetable products, particularly juices, paste, concentrates, beverages etc. is covered i.e., Aseptic Processing and Packaging.



The slide has a dark blue header with the title 'Concepts Covered'. Below the header is a list of four bullet points. The footer contains the IIT Kharagpur and NPTEL logos.

Concepts Covered

- Aseptic processing
- Components of aseptic processing systems
- Aseptic packaging materials and systems
- Sterilisation of aseptic packaging material and equipment

IIT Kharagpur
NPTEL

Aseptically processed and packaged products, fruits, and vegetable products, have gained popularity in the market as well as in the consumer mind in the recent past. In this lecture, the

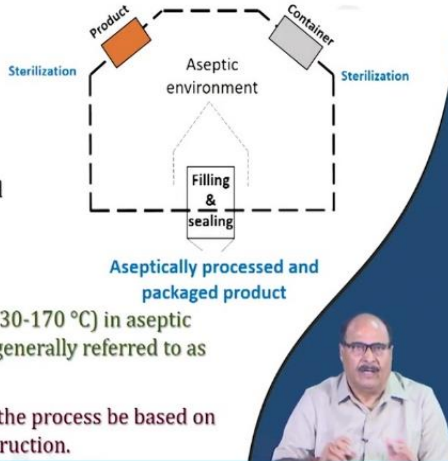
topics covered are aseptic processing, components of aseptic processing systems, and finally the sterilization of the aseptic packaging materials and equipment are discussed.

Aseptic processing & packaging

Aseptic processing and packaging are a method of preservation which refers to

- ✓ Heating of liquid food product i.e. commercially sterilized and holding at an elevated temperature followed by cooling, and
- ✓ Filling into a sterilized package and hermetically sealing with a sterilized closure in a commercially sterile environment.

- Since, very high temperatures are employed (130-170 °C) in aseptic commercial sterilization, these processes are generally referred to as UHT process.
- Processing at these temperature requires that the process be based on enzyme inactivation rather than microbes destruction.



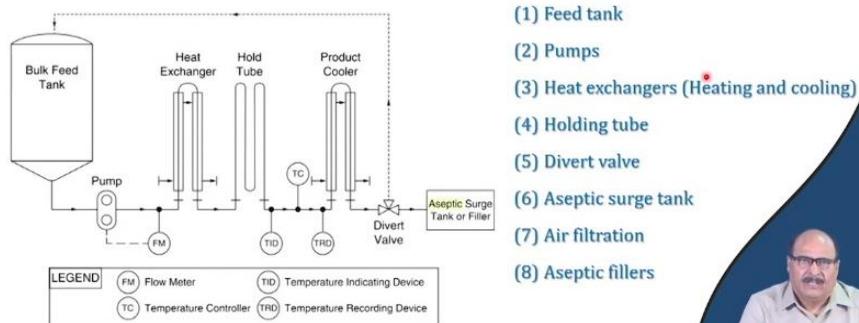
IIT Kharagpur

NPTEL

Aseptic processing & packaging

Aseptic processing and packaging are methods of preservation, which refers to heating of the liquid food product i.e., commercially sterilized and holding at an elevated temperature followed by cooling and filling it into a sterilized package and hermetically sealing with a sterilized closure in a commercially sterile environment. It can be seen from the figure that there are two lines, one is the product line and another is the packaging material line. So, both the products and packaging material are the specific systems. The product and the packaging material are sterilized separately. After that, they are brought to the filling room and packaging room, which are maintained under a sterile environment or in an aseptic environment. So, processing and packaging and then finally, filling and sealing are all performed in the aseptic environment. Since, in aseptic processing and packaging, very high temperatures are employed (130 or 170 °C), these processes are generally referred to as ultra-high temperature processes i.e., UHT processes. Processing at these temperatures require that the product sterilization process be based upon the enzyme inactivation, because under these high temperature ranges, it had been seen that enzymes give a higher resistance than the micro-organisms. So, most of these processes are generally based upon the enzyme inactivation kinetics.

Components of aseptic processing system



- (1) Feed tank
- (2) Pumps
- (3) Heat exchangers (Heating and cooling)
- (4) Holding tube
- (5) Divert valve
- (6) Aseptic surge tank
- (7) Air filtration
- (8) Aseptic fillers



IIT Kharagpur

Components of aseptic processing system

The figure shows the components of aseptic processing system. Aseptic processing is normally used for liquid food or even concentrator paste. There is a feed tank. Either pulp or paste or juice, whatever it is, is brought from a manufacturing unit, extraction unit and concentration unit. Any two of these are taken in the feed tank, in the aseptic processing line. From the feed tank, there are suitable pumps, which can feed these materials to the heat exchangers.

Through the appropriate pumping system, the material from the feed tank, is taken to the heat exchangers, where it is exposed to the calculated time and temperature combination, that is required for giving the desired commercial sterility. Once the material is brought to the specific temperature, then it is taken to the whole tube, where it is held for the desired time, so that the complete sterility is obtained.

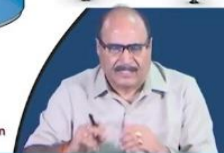
Finally, the product is again from the hold tube, is conveyed to the cooling line, where it is cooled, plot down and then sent to the filling and packaging line.

Feed tanks

- It is a product supply tank provided with a mixer to keep the product suspended while feeding the system.
- The outlet of this bulk tank is connected to a pump.
- The level sensor on the tank is used to control the level in the tank so that the pump does not run dry and cause unnecessary damage to the pump.
- Temperature in the feed tank can be controlled by having a jacketed tank or a steam coil.
- Coolants (water or ethylene glycol) can be circulated to keep the product under refrigeration or steam can be used to keep the product at an elevated temperature.



Source: www.tetrapak.com



IIT Kharagpur

Feed Tanks

The feed tank is the product supply tank provided with a mixer to keep the product suspended while feeding the system. Here, the proper mixing is required, so that there is not settling or solids etc. Therefore, a homogeneous uniform mixture is going out. The outlet of this bulk tank is connected to a pump. The level sensor on the tank is used to control the level in the tank, so that the pump does not run dry and cause unnecessary damage to the pump. Temperature in the feed tank can be controlled by having a jacketed tank or having a steam coil. Coolants (water or ethylene glycol) can be circulated to keep the product under refrigeration or steam can be used to keep the product at an elevated temperature.

Pumps

- Food grade pumps for the aseptic system are used to push the product throughout the system.
- Because of the process design and lethality requirements in the hold tubes, positive displacement provides a constant flow rate and hence a defined fluid velocity and residence time in the hold tube.
- Each stroke or revolution of the pump pushes a fixed amount of fluid regardless of other factors; thus, it positively displaces a fixed amount of fluid in the system.

External Gear Pump Gerotor Pump Lobe Pump
Internal Gear Pump Peristaltic Pump Vane Pump
Reciprocating pump

NPTEL

Pumps

The figure shows the schematics of the different pumps and how they work. Food grade pump for the aseptic systems is used to push the product throughout the system and because of the process design and lethality requirements in the hold tubes, positive displacement provides a constant flow rate and hence, a defined fluid velocity and the residence time in the hold tube. Each stroke or revolution of the pump pushes a fixed amount of fluid regardless of the other factors; thus, it positively displaces a fixed amount of fluid in the system.

Heat exchangers

- Product sterilization and cooling systems may be of the direct or indirect heat exchange type.
- Heat exchanger equipment used in aseptic processing include
 - ✓ Scarped surface heat exchanger
 - ✓ Plate heat exchanger
 - ✓ Tubular heat exchanger
 - ✓ Equipment involving direct steam injection

Heating & cooling in indirect heat exchanger

$$Q = m_h C_{ph} (T_{hi} - T_{ho}) = m_c C_{pc} (T_{co} - T_{ci})$$

Where,
 Q is heat transfer rate (kW)
 m_h and m_c are mass flow rate of hot and cold liquid (kg/s)
 C_{ph} and C_{pc} are specific heat of hot and cold liquid (kJ/kg °C)
 T_{co} and T_{ci} are temperature at exit and inlet of cold liquid (°C)
 T_{ho} and T_{hi} are temperature at exit and inlet of hot liquid (°C)

NPTEL

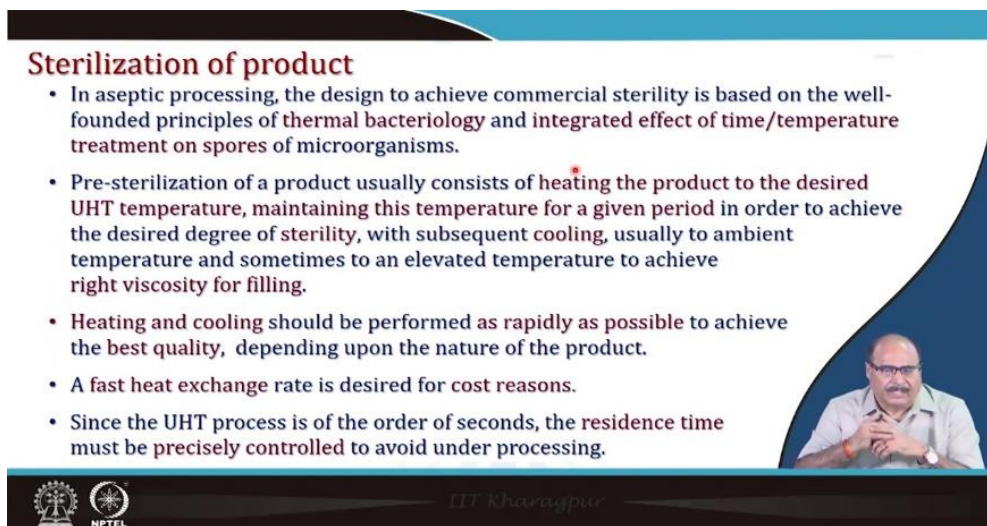
Heat exchangers

Then from the pump process, the material goes into the heat exchanger. The heat exchangers are the systems, which are the product sterilization and cooling systems. They may be of direct or indirect heat exchangers type. Heat exchangers equipment used in the aseptic processing line include scraped surface heat exchangers, plate heat exchangers, tubular heat exchangers, equipment involving direct steam injection etc.

Heat transfer can be calculated by using the following equation.

$$Q = m_h C_{ph} (T_{hi} - T_{ho}) = m_c C_{pc} (T_{ho} - T_{ci})$$

where Q is the heat transfer rate (kW), m_h and m_c are the mass flow rate of the hot and cold liquid (kg/s), C_{ph} and C_{pc} are the specific heat of the hot and cold liquid (kJ/kg °C), T_{co} and T_{ci} are the temperature at the exit and inlet of the cold liquid (°C) and T_{ho} and T_{hi} are the temperature at the exit and inlet of the hot liquid (°C). Accordingly, using this equation one can calculate the heat transfer rate and accordingly, the heat required to get the desired sterility can also be calculated.



Sterilization of product

- In aseptic processing, the design to achieve commercial sterility is based on the well-founded principles of thermal bacteriology and integrated effect of time/temperature treatment on spores of microorganisms.
- Pre-sterilization of a product usually consists of heating the product to the desired UHT temperature, maintaining this temperature for a given period in order to achieve the desired degree of sterility, with subsequent cooling, usually to ambient temperature and sometimes to an elevated temperature to achieve right viscosity for filling.
- Heating and cooling should be performed as rapidly as possible to achieve the best quality, depending upon the nature of the product.
- A fast heat exchange rate is desired for cost reasons.
- Since the UHT process is of the order of seconds, the residence time must be precisely controlled to avoid under processing.

Dr. Khanna

NPTTEL

Sterilization of product

In the aseptic processing, the design to achieve commercial sterility is based on the well-established principles of thermal bacteriology and integrated effect of the time or temperature treatment on the spores of the microorganisms. Pre-sterilization of a product usually consist of heating the product to the desired UHT temperature, maintaining the temperature for a given period in order to achieve the desired degree of sterility, with subsequent cooling usually at to ambient temperature and some time to an elevated temperature to achieve the right viscosity for filling. Heating and cooling should be performed as rapidly as possible to achieve best quality depending upon the nature of the product. A fast heat exchanger rate is desired for cost reasons. Since the UHT process is of the order of seconds, the residence time must be precisely controlled to avoid any under processing.

Characteristics of the heat exchange systems used for aseptic processing

Equipment Type	Product Quality	Aroma Retention	Energy Saving	Capital Cost	Space	Pulp Capability	Fouling Length of Run	Turn-down*
Steam Injection/ Infusion	Excellent	No	Poor	High	Fair	Fair-Good	Excellent	Fair
Plate Heat Exchanger	Good	Yes	Excellent	Low	Excellent	Limited	Limited	Good
Tubular: • Small Tubes • Large Tubes	Medium Poor	Yes Yes	Fair Fair	Medium Low	Good Fair	Good Good	Limited Good	Good Good
Swept Surface	Good	Yes	Very Poor	Very High	High	Fair-Good	Good	Good

(* Turn-down is the capability of the system to process at different rates to accommodate different number of fillers or different package sizes.)



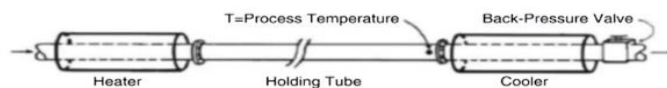
IIT Kharagpur

Characteristics of the heat exchange systems used for aseptic processing

The table shows a comparison of various types of heat exchangers. In case of steam injection or steam infusion heat exchanger, the product quality is excellent, but there is no aroma returns i.e., most of the aroma get destroyed. Energy savings in this case is also poor. Its capital cost is high, space requirement is fair. Turn down is the capability of the system to process at different rates to accommodate a different number of pillars or different packaging sizes etc. This turn-down is also fair for steam injection or steam infusion heat exchanger. In case of the tubular heat exchanger, like small tubes or large tubes, the product quality is medium to poor and the aroma retain. Energy saving is also fair to poor in this case. The capital cost in the small tubes is medium and in large tube is low. The turn-down here also is good. In case of plate heat exchangers, they give fairly good product quality, aroma retention is also good, energy saving is excellent, cost required is also less. Space requirements in this case is also excellent. The turn-down period is good.

❑ Holding tube

- A holding tube is an unheated section of the piping system that leads the fluid from the heat exchangers for heating to the heat exchangers for cooling.
- The holding tube is where the product achieves the predefined lethality.
- Additional heat cannot be applied to the hold tube, but it can be insulated to protect the heat from ambient cooling.
- Flow rate, diameter and length of the hold tube dictate the minimum temperature at the end of the hold tube that is needed to achieve the targeted lethality.



Holding tube



IIT Kharagpur

Holding tube

It can be seen from the figure; a holding tube is an unheated section of the piping system that leads the fluid from the heat exchangers for heating to the heat exchanger for cooling. So, from the heat exchanger, the holding tube holds the material for desired period and then it sends to the cooling. The holding tube is where the product achieves the predefined lethality. Additional heat cannot be applied in the holding tube, but it can be insulated to protect the heat from ambient cooling. Flow rate, diameter and length of the hold tube dictate the minimum temperature at the end of the hold tube that is needed to achieve the targeted lethality.

Time of residence


The time of residence is set by the volume of the holding tube and the rate of fluid flow delivered by a positive displacement pump.

$$t_{avg} = \frac{A_c L}{Q} \quad t_{avg} = \frac{L}{V_{avg}}$$

($V_{avg} = \frac{Q}{A_c}$)

Where, t_{avg} is average fluid residence time (s)
 A_c is cross-sectional area of the holding tube (m^2)
 L is length of the holding tube (m)
 Q is volumetric rate of flow (m^3/s)
 V_{avg} is average velocity (m/s)

- When the product quality is the main consideration, the holding time must be based on the mean velocity rather than the fastest particle velocity.
- The measured mean residence time is twice the residence time for fastest particle to travel through the holding tube under laminar flow conditions.
- For turbulent flow, the V_{max} is assumed to be 1.25 times the V_{avg} .
- In laminar or viscous flow (as in non-Newtonian fluids like sauces, soups, pulps and concentrates) the V_{avg} is one half of the V_{max} .



IT Khanna

NPTEL

Time of residence

The time of residence is set by the volume of the holding tube and the rate of fluid flow delivered by a positive displacement pump. Time of residence can be represented by the various equations.

$$t_{avg} = A_c L / Q$$

$$t_{avg} = L / V_{avg} \quad V_{avg} = Q / A_c$$

Here, t_{avg} is the average fluid residence time (s), A_c is the cross-sectional area of the holding tube (m^2), L is the length of the holding tube (m), Q is the volumetric rate of the flow (m^3/s) and V_{avg} is the average velocity (m/s). When the product quality is the main consideration, the holding time must be based on the mean velocity rather than the fastest particle velocity. The measured mean residence time is twice the residence time for the fastest particle to travel through the holding tube under laminar flow conditions. For turbulent flow, the maximum velocity i.e., V_{max} is assumed to be 1.25 times the average velocity i.e., V_{avg} . In the laminar or viscous flow (as in non-Newtonian fluids like sauces, pulps, and concentrates) the V_{avg} is one half of the V_{max} .

□ Air filtration

- Sterilizing air by filtration is used to maintain commercial sterility in critical areas of the aseptic system.
- Critical areas are those in which air contacts the sterile product or sterile packaging environment, which are therefore a potential risk for microbial post-process contamination.

The critical locations where sterile air is needed in the aseptic process facility include

- Overpressure of aseptic product tanks
- Overpressure of the sterile zone of the aseptic packaging equipment
- Heating or drying of the packaging materials
- Head-space injection into packages
- Blowing preforms and transport of bottle

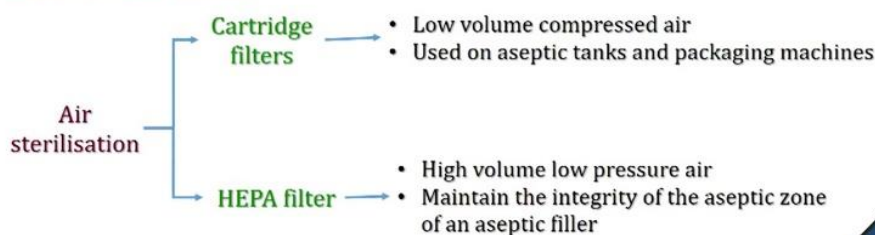


IIT Kharagpur

Air Filtration

Sterilizing air by filtration is used to maintain the commercial sterility in critical areas of the aseptic system. Critical areas are those in which the air contact the sterile product or sterile packaging environment, which are therefore a potential risk for microbial post-process contamination. The critical locations, where sterile air is needed in the aseptic process facility include overpressure of the aseptic process tanks, overpressure of the sterile zone of the aseptic packaging equipment, heating or drying of the packaging materials, headspace injection into packages or blowing performs and transport of the bottles.

Air filtration (Contd...)



HEPA (High efficiency particulate air) : 99.97% efficiency at submicron-sized (0.3 μm) particles in air which provide air free of viable microorganisms in aseptic filling lines.



IIT Kharagpur

The cartridge filters or HEPA filters can be used for air sterilization. HEPA (High efficiency particulate air) filter generally gives 99.97% efficiency at submicron-sized (0.3 μm) particles in air, which provide air free of viable microorganisms in aseptic filling lines.

Packaging materials

- Commercially sterile products are expected to have an extended shelf life. Hence the package should be
 - ✓ Impermeable to gases, water and the other vapours.
 - ✓ Effective barrier in transmission of light.
 - ✓ Inert, i.e. it should not impart any flavor or taints to packaged products.
 - ✓ Resistant to chemicals, radiation and heat treatment needed for sterilization of packaging.
 - ✓ Capable of hermetically sealed to provide barrier against microbial contamination.
 - ✓ Withstand insert damage.
 - ✓ Resist deteriorate changes.
 - ✓ Relatively less expensive.
 - ✓ Easily disposable.



IIT Kharagpur

Packaging materials

Commercially sterile products are expected to have an extended shelf life. Hence the packaging material should be impermeable to gases, water, and other vapours. It should provide effective barrier in transmission of light. Inert, i.e., it should not impart any flavor or taints to the packaged products. Resistant to chemicals, radiation and heat treatment needed for sterilization of the packaging material. It should be capable of hermetically sealed to provide barrier against microbial contamination. It should withstand insert damage. It should resist deterioration changes, relatively less expensive. it should be easily disposable.

Packaging materials (Contd...)

- **Metal container**
 - ✓ In use from the beginning of the commercial development of aseptic sterilization have all the intrinsic properties mentioned earlier.
 - ✓ The limitations to their use relate to the package geometry and relatively high cost.
- **Glass containers**
 - ✓ Very similar to those of metal containers with the additional disadvantage of fragility and high density.
- **Polyethylene and polypropylene**
 - ✓ Being thermoplastic are used for producing bottle packs.
 - ✓ The bottles may be either preformed or made just before filling in blow-fill & seal equipment.



IIT Kharagpur

Metal container

In use from the beginning of the commercial development of the aseptic sterilization process, it has almost all the intrinsic properties mentioned earlier. The limitations of their use relate to the package geometry and relatively high cost.

Glass containers

They are very similar to those of the metal containers with the additional disadvantage of fragility and high density.

Polyethylene and polypropylene

They provide various consumer attractive packages, flexible packages, in different forms etc. Flexible packaging material like polyethylene, polypropylene etc. are being thermoplastic are used for producing bottle packs. The bottles may be either preformed or made just before filling in the blow-fill and seal equipment.

Packaging materials (Contd...)

- **Co-extruded laminates**
 - ✓ As no single plastic material has all the desirable characteristics listed earlier, **co-extruded laminates** of one or more plastic materials having complementary characteristics are used.
 - ✓ **Aluminium foil** is used in lamination with plastic films improves the barrier characteristics of the package
 - ✓ **Paper** provides physical resistance to the package.

IIT Kharagpur
NPTEL

Co-extruded laminates

As no other single plastic material has all the desirable characteristics listed earlier, co-extruded laminates of one or more plastic materials having complementary characteristics are used. Aluminum foil is used in lamination with plastic films, which improves the barrier characteristics of the package. Paper provides the physical resistance to the package.

Aseptic packaging systems

- **Paperboard carton systems**
 - ✓ Fill-seal-prefabricated carton
 - ✓ Form-fill-seal carton
- **Bottle systems**
 - ✓ Fill-seal preformed bottles
 - ✓ Blow mold-fill-seal bottles
- **Cup systems**
 - ✓ Fill-seal preformed cup
 - ✓ Thermoform-fill-seal cup
- **Pouch systems**
 - ✓ Fill-seal preformed pouch: **Single serve packaging**
 - ✓ Fill-seal preformed pouch: **Bulk packaging**
 - ✓ Form-fill-seal pouch



IIT Kharagpur

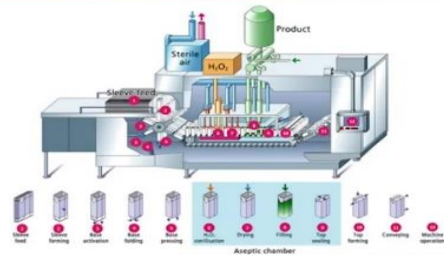
Aseptic packaging systems

The aseptic packaging systems are various paperboard systems, carton systems or bottle systems, cup systems, pouch systems. All these are prepared by different setup either using a form-fill machines or there are fill-seal preformed systems etc., which are used.

Paperboard carton systems

□ Fill-seal-prefabricated carton

- Preformed brick cartons, or sleeves, are manufactured from packaging factory by being die cut, creased, completed sealed longitudinally and distributed in the flat form.
- **The fill-seal aseptic filler is used to process aseptic food products in this carton type.**
- When packages are fed into filler, the sleeves or lay-flat-form of the cartons are shaped and sealed at bottom just prior to filling step
- **Both outside and inside carton surfaces are sterilized by the combination of 35% solution of vapor H_2O_2 and hot air.**



IIT Kharagpur

Paperboard carton systems

The preformed brick cartons, or sleeves, are manufactured from the packaging factory by being die cut, creased, completed sealed longitudinally and distributed at the plat form. The fill-seal aseptic filler is used to process aseptic food products in the carton type. When packages are fed into the filler, the sleeves or lay-flat-form of the cartons are shaped and sealed at the bottom just prior to filling step. Both outside and inside carton surfaces are sterilized by the combination of 35% solution of vapor H_2O_2 and hot air.

Paperboard carton systems (Contd...)

Form-fill-seal carton

- In these systems, the paperboard carton enters the aseptic form-fill-seal machine in the form of roll stock (web).
- The web paperboard carton is fed into aseptic machine and is sterilized by a H_2O_2 bath (30–35% concentration).
- It is then formed to the box by longitudinal seal.
- Hot-air is used to remove H_2O_2 from the material surface before filling.



Form-fill seal carton

In these systems, the paperboard carton enters the aseptic form-fill-seal machine in the form of roll stock (web). The web paperboard carton is fed into the aseptic machine and is sterilized by a H_2O_2 bath (30 to 35% concentration of hydrogen peroxide). It is then formed to the box by the longitudinal seal. Hot-air is used to remove H_2O_2 from the material surface before filling.

Bottle systems

Blow mold-fill-seal bottles

- A dry decontamination sterilization technique is applied to sterilize PET preforms before transferring to the blowing station with lower amount of H_2O_2 vapor.
- This results in much lower consumption of H_2O_2 per bottle as compared with preformed bottle systems.
- Heat from the oven of blow molding process provides the opportunity to remove H_2O_2 residue from material before forming the container.
- This system is a continuous process for which it is more complicated to maintain the aseptic zone than comparable other aseptic filling machines.

Fill-seal preformed bottles

- HDPE and PET can be pre-formed as a ready to use containers.
- Sterilized with peracetic acid and vapor H_2O_2 before use.
- In this aseptic system, packaging geometry, amount and uniformity of H_2O_2 vapor delivered from each nozzle and the flow distribution through the bottle interior are very important factors to be considered.



Bottle systems

Blow mold-fill-seal bottles

A dry decontamination sterilization technique is applied to a sterilized PET preforms before transferring to the blowing station with lower amount of H_2O_2 vapor. This results in much lower consumption of H_2O_2 per bottle as compared with preformed bottle systems. Heat from the oven of blow molding process provides the opportunity to remove H_2O_2 residue from


material before harming the container. This system is a continuous process for which it is more complicated to maintain the aseptic zone than comparable with other aseptic filling machines.

Fill-seal preformed bottle

HDPE or PET can be pre-formed as a ready to use containers. They are sterilized using H_2O_2 vapors. In this aseptic system, packaging geometry, amount, and uniformity of H_2O_2 vapor delivered from each nozzle and the flow distribution through the bottle interior are very important factors to be considered.

Cup systems

- Thermoform-fill-seal cup**
 - In this system, roll stock of high impact polystyrene (HIPS) is fed into the aseptic filler to thermoform the container shape and then filled with sterile product before sealing with sterile lidding film.
 - Shelf-stable coffee creamer and cold brew coffee in cup style container are processed from this system.
- Fill-seal preformed cup**
 - Similar to the aseptic fill-seal preformed bottle, the plastic cups, which are already formed as a container, are used to filling and sealing processes.
 - Sterilised with approximately 35% H_2O_2 solution for both outer and inner surfaces including the lidding material.
 - Used for fruit conserve with fruit pieces, etc.

 IIT Kharagpur

Cup systems

Thermoform-fill-seal cup

In this system, roll stock of high impact polystyrene (HIPS) is fed into the aseptic filler to thermoform the container shape and then filled with the sterile product before sealing with sterile leading fill. Shelf-stable coffee creamer and cold brew coffee in the cup style container are processed from this system.

Fill-seal pre-formed cup

It is the similar to the aseptic fill-seal preformed bottle, the plastic cups, which are already formed as a container are used for filling and sealing process. 35% concentrated H_2O_2 is used as a sterilizing agent and it is used for fruit conserves with fruit pieces.

Pouch systems

❑ Fill-seal preformed pouch

- Preformed pouch is typically made of multilayer or aluminum laminated films.
- They are completely sealed (all sides) under clean environment to minimize the microbial contamination and then pre-sterilized by irradiation process before shipping to food processor.
- This flexible pouch is generally packed as a roll stock or individual pouch on the rails.



Scholle aseptic fill-seal machine and preformed pouch.



IIT Kharagpur

Pouch systems

Fill-seal preformed pouch

Preformed pouch is typically made of multilayer or aluminum laminated films. They are completely sealed (all sides) under clean environment to minimize the microbial contamination and then pre-sterilized by irradiation process before shipping to food processor. This flexible pouch is generally packed as a roll stock individual pouch on the rails.

Pouch systems

❑ Fill-seal preformed pouch: Bulk packaging

- For aseptic bag-in-box systems, the preformed pouch, which is available in different gallon sizes with fitment attached on the pouch to provide the convenience are used. These are normally pre-sterilized by irradiation.
- There are different fitment styles depending on the application. The filling operation depends on the fitment styles.
- If the fitment is attached with a cap, the cap is removed after sterilizing and recapped after filling.
- For the spout with double membrane, the filling nozzle punches through the outer membrane fill the product inside the bag and then inner membrane is heat sealed by the machine.



Aseptic bag-in-box filling machine



IIT Kharagpur

Fill-seal preformed pouch: Bulk packaging


For aseptic bag-in-box systems, the preformed pouch, which is available in different gallon sizes with fitment attachment on the pouch to provide the convenience are used. These are normally pre-sterilized by irradiation. There are different fitment styles depending on the application. The filling operation depends on the fitment styles. If the fitment is attached with a cup, the cup is removed after sterilization and recapped after filling. For the spout with double

membrane, the filling nozzles punches through the outer membrane, fill the product inside the bag and then inner membrane is heat sealed by the machine.


Pouch systems (Contd...)


Form-fill-seal pouch

- Use of web-fed poly-laminate roll stock to form, fill and seal aseptic pouches.
- Roll-stock typically moves through a heated H_2O_2 bath to sterilize inner and outer surfaces of the pouch and then is dried with sterile air before it is formed, filled and sealed in an aseptic zone.



Fresco aseptic form-fill-seal (FFS) pouch making system



 IIT Kharagpur


Form-fill-seal pouch


Web-fed poly-laminates roll stock is used to fill and seal the aseptic pouches. Roll stock typically moves through a heated H_2O_2 bath to sterilize inner and outer surfaces of the pouch and then is dried with sterile air before it is formed, filled, and sealed in the aseptic zone.

Sterilization of aseptic packaging materials and equipment

Heat

- Product supply lines and fillers are commonly sterilized by moist heat in the form of hot water or saturated steam under pressure.
- Dry heat, in the form of superheated steam or hot air, may also be used to sterilize equipment.
- However, due to the relatively high dry heat resistance of bacterial spores, the time-temperature requirements for dry heat sterilization are considerably higher than those for moist heat sterilization.
- Systems employing moist heat are sterilized at temperatures ranging from 121-129 °C, while 176 - 232 °C is used for sterilization by dry heat.
- Sterilization of air by incineration usually is conducted at temperatures ranging from 260 °C to 315 °C.



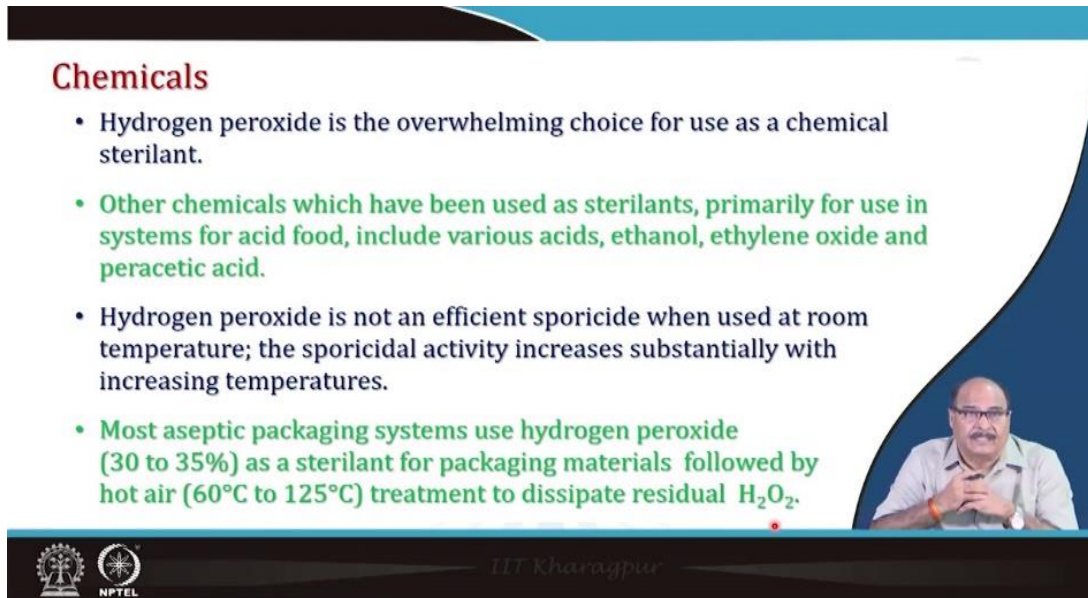
 IIT Kharagpur

Sterilization of aseptic packaging materials and equipment

Heat

Only heat is used for the sterilization of the aseptic packaging system and the materials. The product supply lines and fillers are commonly sterilized by heat in the form of hot water or saturated steam under pressure. Dry heat, in the form of superheated steam or hot air, may also be used to sterilize equipment. However, due to the relatively high dry heat resistance of

bacterial spores, the time-temperature requirement for dry heat sterilization is considerably higher than those for the moist heat sterilization. Systems employing moist heat are sterilized at a temperature ranging from 121 to 129 °C, while 176 to 232 °C is used for sterilization by dry heat. Sterilization of air by incineration usually is considered at temperatures ranging from 260 °C to as high as 315 °C.



Chemicals

- Hydrogen peroxide is the overwhelming choice for use as a chemical sterilant.
- Other chemicals which have been used as sterilants, primarily for use in systems for acid food, include various acids, ethanol, ethylene oxide and peracetic acid.
- Hydrogen peroxide is not an efficient sporicide when used at room temperature; the sporicidal activity increases substantially with increasing temperatures.
- Most aseptic packaging systems use hydrogen peroxide (30 to 35%) as a sterilant for packaging materials followed by hot air (60°C to 125°C) treatment to dissipate residual H₂O₂.

IIT Kharagpur

NPTEL

Chemicals

Hydrogen peroxide is the overwhelming choice for use as a chemical sterilant. Other chemicals which have been used as sterilant, primarily for use in systems for acidic food, including various acids, ethanol, ethylene oxide and peracetic acid etc. Hydrogen peroxide is not an efficient sporicide when used at room temperature; the sporicidal activity increases subsequently with the increasing temperatures. So, a combination of hydrogen peroxide and its temperature is used. Most aseptic packaging systems use hydrogen peroxide (30 to 35%) as a sterilant for packaging materials followed by hot air (60 to 125 °C) treatment to dissipate the residual H₂O₂.

Radiation

Gamma radiation has been used for decades to decontaminate packaging materials for use in the aseptic system for packing acid and acidified food. Due to the penetrating powers of the gamma-radiation, packages are treated in bulk at commercial irradiators. A dose of approximately 1.5 Mrad is commonly used to decontaminate containers for acid and acidified food. Doses required to sterilize containers for use with low acid foods are considerably higher than those required for the high acid or acidified food. Average microbial counts on a plastic-food contact surface ranges from 0.3 to 10 organism per 100 cm².

Radiation

- Gamma-radiation has been used for decades to decontaminate packaging materials for use in aseptic systems for packing acid and acidified food.
- Due to the penetrating powers of gamma-radiation, packages are treated in bulk at commercial irradiators.
- A dose of approximately 1.5 Mrad is commonly used to decontaminate containers for acid and acidified food.
- Doses required to sterilize containers for use with low acid food are considerably higher than those required for acid and acidified food.
- Average microbial counts on a plastic-food contact surface range from 0.3 to 10 organisms per 100 cm²



IIT Kharagpur

- On a polyethylene food contact surface of paper board based laminates immediately after producing the packaging material, average total count has been reported to be 2-5 / 100 cm² (10 % yeast, 20 % molds and 70 % bacteria).
- Four to five decimal reductions are considered necessary to ensure that the spoilage is not in excess of 5 in 10,000.
- The risk of defectives can be calculated as follows.

$$R = N_0 S \times 10^{-t/D}$$

- Where, **R** = Risk (number) of defectives,
N₀ = Number of most resistant organism per cm²,
S = Food contact area (cm²),
t = time of the sterilization process, and
D = Decimal reduction time of most heat resistant organism.



IIT Kharagpur

On a polythene food contact surface of paper board-based laminates immediately after producing the packaging material, average total count has been reported as 2-5/100 cm² (10% yeast, 20 % mold and about 70 % is bacteria). Four to five decimal reductions are considered necessary to ensure that the spoilage is not in excess of 5 in 10,000 containers.

The risk of defective (R) can be calculated as follows.

$$R = N_0 S \times 10^{-t/D}$$

Here, N₀ is the number of most resistant organism per cm² of the food packaging contact surface, S is the food contact area in cm², t is the time of sterilization process and d is the decimal reduction time of most heat resistant organism.

Summary

- Aseptic processing involves sterilising the food and packaging material separately and filling and sealing in the sterilized environments.
- Predefined lethality in the product is decided by the extent of sterilisation in the heat exchanger and holding of the product in the holding tube.
- Air sterilisation is an important operation which keeps the processing area free from viable microorganisms and makes sterile environment.
- Different packaging materials and systems are available which can be used as per the nature of product and consumer requirements.
- Heat, chemical and radiations are the effective medium to sterilise the packaging material and equipment employed in aseptic processing and packaging.



IIT Khanna

Summary

It can be said in summary that the aseptically processed and packaged materials are stored well. Although they have good stability under normal atmospheric conditions, but the sealing should be proper, the residence time in the sterilization must be ensured, packaging should be properly sterilized. Both the product and the package should be properly sterilized. Then they are kept in the aseptic environment.

References

- Anonymous. (n.d.). Aseptic packaging system. 309-323.
- David, J. R. D., Graves, R. H., & Szeplenski, T. (2012). Handbook of Aseptic Processing and Packaging. In Handbook of Aseptic Processing and Packaging. <https://doi.org/10.1201/b13026>
- Food Safety Engineering. (2020). In A. Demirei, H. Feng, & K. Krishnamurthy (Eds.), Food Safety Engineering. Food Engineering Series. Springer.
- <https://www.engineeringchoice.com/positive-displacement-pump/>
- <https://www.tetrapak.com/en-in/solutions/processing/main-technology-area/buffering/aseptic-tank>
- <https://www.alfalaval.us/products/fluid-handling/valves/single-seat-valves/unique-ssv/>
- Singh, R. P. (2014). Introduction to Food Engineering. In Paper Knowledge . Toward a Media History of Documents.
- Szeplenski, T. (2012). The U.S. markets for aseptic packaging. In Handbook of Aseptic Processing and Packaging, Second Edition (pp. 19-32). CRC Press. <https://doi.org/10.1201/b13026-4>
- Toledo, R. T., Singh, R. K., & Kong, F. (2018). Fundamentals of Food Process Engineering. <http://www.springer.com/scrtes/5999>



IIT Khanna

The references used in this lecture are mentioned above.