Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Welcome to the NPTEL online certification course on Modern Food Processing Technologies, Regulatory Aspects and Global Trends. Dear friends, in the last lecture we have covered controlled atmospheric packaging and modified atmospheric packaging. And now we will be discussing aseptic packaging. And in this the topics covered will be introduction, kinding versus aseptic packaging, aseptic processing methodology, aseptic packaging materials, composition of tetra pack aseptic cartons, advantages and disadvantages of aseptic packaging. Aseptic packaging can be defined as the filling of a commercially sterile product into a sterile container under aseptic conditions and hermetically sealing the container so that reinfection is prevented. This results in a product which is self stable at ambient conditions.

The term aseptic is derived from the Greek word septikos which means the absence of putrefactive microorganisms. The term aseptic implies the absence or exclusion of any unwanted organisms from the product package or other specific areas while the term hermetic means strictly airtight is used to indicate suitable mechanical properties to exclude the entrance of microorganisms into a package or gas or water vapor into or from the package. The term commercially sterile is generally taken to mean the absence of microorganisms capable of reproducing in the food under non-refrigerated conditions of storage and distribution. Thus implying that the absolute absence of all microorganisms need to be achieved.

In practice generally there are two specific fields of application of aseptic packaging technology. The first is the packaging of pre sterilized and sterile product. Examples are milk and dairy products, puddings, desserts, fruit and vegetable juices, soups, sauces and products with particulates. The packaging of non-sterile product to avoid infection by microorganisms and the examples of this application include fermented dairy products like yoghurt. The three major reasons for the use of aseptic packaging are first to take advantage of high temperature short time or HTST sterilization processes which are thermally efficient and generally give rise to products of a superior quality compared to those processed at low temperature for longer time that is the LTLT process.

The second to enable containers to be used that are unsuitable for in package sterilization and the third to extend the shelf life of products at normal temperature by

packing them aseptically. Now, canning versus aseptic packaging. The aseptic packaging technology is fundamentally different from that of conventional food processing by canning. In canning the process begins with treating the food prior to filling. Initial operations inactivate enzymes so that these will not degrade the product during processing.

The package is cleaned and the product is introduced into the package usually hot. The air that can cause oxidative damage is removed from the interior. The package is hermetically sealed and then subjected to heating. The package must be able to withstand heat up to high about 100 degree Celsius for high acid products and up to 127 degree Celsius and for low acid products which must receive added heat to destroy heat resistant microbial spores. Packages containing low acid food that is above 4.5 pH food must withstand pressure as well. Although conventional canning renders food products commercially sterile the nutritional contents and the organoleptic properties of the food generally suffer in processing. Moreover tin plate containers are heavy in weight and prone to resting and are of high cost. This is the process flow chart of canning and aseptic packaging. The in conventional process the product are filled in the package then it is sealed and they are subject to retorting where the high temperature is applied and then immediately it is cooled and then it is restored for or it can be distributed.

Whereas in the aseptic packaging the product and package both are sterilized product is sterilized by HTST processing and package is sterilized by some other means which we will be discussing later on and then it is cooled and then filled in the aseptic conditions then it is sealed and then stored or distributed. The aseptic processing methodology aseptic processing comprises the following the sterilization of the product before filling, sterilization of packaging material or containers and closures before filling, sterilization of aseptic installation before operation that is the UST ultra high temperature unit lines for products sterile air and gases filler and relevant machine zones. Maintaining sterility in this total system during operation, sterilization of all media entering the system like air, gases, sterile water and then production of hermetic packages. Now, sterilization of products in aseptic processing the design to achieve commercial stability 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 consist of heating the product to a desired UST temperature maintaining this temperature for a 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 high viscosity for filling.

More generally the term UST refers to inline continuous flow sterilization process which employ heat treatment within the temperature range of 130 to 150 degree Celsius

with holding times of 2 to 8 second. The upper end of the temperature range tends to be used for low viscosity products such as milk and the lower end of more viscous products. The quality advantages that accrue from the use of UST processes can best be understood by comparing the Z value for microbial destruction with the Z value for the loss of desirable safety factors in the food such as nutrients. This is the process flow chart of UST milk processing plant the product enters here and it is stored in this storage tank then it is cooled to by the cooling water. The product enters and stored in a reservoir from where the product at 5 degree Celsius it is passed through a heat exchanger and then it is heated up to 75 degree Celsius by the steam and then it is passes through the UST chamber where the steam is directly injected the steam is directly injected and then it is cooled and at that time the temperature is around 140 degree Celsius and this is the you can say that this is the maintaining the residence time up to 2 to 8 second and then it is passes where the cooled water is supplied to separate the condensate or to condense the steam and there it is reduced to 75 degree Celsius.

Then it is further reduced to 25 degree Celsius by passing through the heat exchangers and then it is further reduced to less than 25 degree Celsius from here either it is sent to the filling line or to the reservoir for further filling. The 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. Various heat transfer methods are used, but essentially the systems can be divided into direct and indirect heat exchange methods. The indirect heat exchange where the product and the heat exchange fluid are separated by the heating surface.

There are three types tubular heat exchanger, plate heat exchanger and scraped surface heat exchanger. In the direct heat exchange where steam is condensed in the product by for heating and vapour is removed from it by evaporation resulting in cooling. There are two means of heating one is steam is directly injected into the product or steam in fusion where the product is injected into the steam. These are the characteristics of the heat exchange systems used for aseptic packaging and this is the effect of different heating systems on the product quality, aroma retention and energy saving, capital cost, space requirement, pulp capability, fouling length of run and the turn down. Turn down means the capability of the system to process different rates to accommodate different number of fillers or different packages sizes.

The three main sterilization processes for packaging material are in common use either individually or in combination irradiation, heat, chemical treatments. These will each be considered in turn separately. These are the sterilization of the packages either it can be sterilized by irradiation or by heat or by chemicals. Again for irradiation it can be used the ionizing radiations or the pulse light or UVC light or plasma whereas, the heat either

in the form of saturated steam or in the form of super heated steam or in form of hot air or in form of hot air and steam both in combination and the chemicals. Now, let us discuss each one by one in irradiation the ionizing radiations.

The particle irradiation technique using gamma rays from cobalt 60 or cesium 13 have been used to sterilize the interior of shield, but empty containers. Specially those made of material which cannot withstand the temperatures needed for thermal sterilization or that because of their shape could not be conveniently sterilized by other means. The radiation dose of 25 kilo gray or more is generally accepted to be sufficient to ensure sterility. The packages are sealed into microbial proof container prior to the irradiation treatment. It is also possible to use low energy that is 80 to 150 kilo electron volt large area electro beams for the surface sterilization of packaging materials and containers including preform bottles and caps.

Pulse light by storing electrical energy in a capacitor and releasing it in a short pulse high peak power levels can be generated. The use of intense and short duration pulses of broad spectrum white light that is having wavelength of 200 to 1000 nanometer to sterilize aseptic packaging material underwent considerable research and development. The duration of the pulse range from 1 micro second to 0.1 second and the flashes are typically applied at a rate of 1 to 20 flashes per second. Despite a successful field trial this system has not yet been commercialized.

Surface topography has a complex influence on the efficacy of pulse light treatments for surface microbial reduction. Now the UVC as it is given in the picture that ultraviolet rays is within the 200 to 400 nanometer and the it is categorized into 4 parts that is the long UVC that is generally known as UVA middle wavelength UV ultraviolet rays that is UVB and the short wavelength that is UVC and the vacuum UV. The generally this UVC light is used which is having 248 and 280 nanometer is used for the sterilization purpose with an optimum effectiveness of 253.7 nanometer. Mercury vapor lamps emit UVC at 253.

7 nanometer wavelength. UVC irradiation is generally used commercially in combination with hydrogen peroxide. The plasma normal non thermal plasma that is NTP is electrically energized matter and is composed of highly reactive species including gas molecules, charged particles in the form of positive ions, negative ions, free radicals, electrons and quanta of electromagnetic radiations that is the photons. At near room temperature the NTP can be used for the surface decontamination of packaging materials and a low pressure microwave plasma reactor has been evaluated for sterilization of PET bottles. Now next sterilizing medium is heat. Among the heat the saturated steam, the most reliable sterilant is steam.

However in order to reach temperatures sufficiently high to achieve sterilization in a few seconds the steam and thus the packaging material with which it comes into contact must be under pressure necessitating the use of a pressure chamber. In addition any air that enters the pressure chamber with the packaging material must be removed to prevent it interfering with the transfer of heat from the steam to the package surface. Finally, condensation of steam during heating of the packaging materials surface produces condensate which if not removed could remain in the container and dilute the product. The superheated steam, superheated steam was the method used in 1950s for the sterilization of tin plate aluminum cans and lids in the martinedole aseptic canning process. The cans were passed continuously through 220 to 226 degree Celsius saturated steam at normal pressure for 36 to 45 seconds depending on the construction material given that aluminum cans have a shorter heating time because of their high thermal conductivity.

The hot air, dry heat in the form of hot air has the advantage that high temperatures can be reached at atmospheric pressure thus simplifying the mechanical design problems for a container sterilization system. Hot air at a temperature of 315 degree Celsius has been used to sterilize paper bored laminate cartons where a surface temperature of 145 degree Celsius for 180 second is reached. However, such a system is apparently only suitable for acidic products having a pH less than 4.5. The hot air in combination with steam, a mixture of hot air and steam has been used to sterilize the inner surfaces of cups and lids made from polypropylene which is thermally stable up to 160 degree Celsius.

In this process hot air is blown into the cups through a nozzle in such a way that the base and the walls of the cup are uniformly heated. The chemicals hydrogen peroxide is the overwhelming choice for use as a chemical sterilant. Other chemicals which have been used as a sterilant primarily for use in the systems for acid foods include various acids ethanol, ethylene oxide and peracetic acid. Hydrogen peroxide is not an efficient spore side when used at room temperature. However, the spore side will activity increases substantially with increasing the temperatures.

Therefore, most atseptic packaging systems use hydrogen peroxide at concentration of 30 to 35 percent as a sterilant for packaging material followed by hot air at 60 to 125 degree Celsius to dissipate residual hydrogen peroxide. Now, the filling once the product has been brought to the sterilization temperature it flows into a holding tube. The tube provides the required residence time at the sterilization temperature. The process is designed to ensure that the fastest moving particles through a holding tube will receive a time temperature process sufficient for sterilization. Since there is some loss of temperature as product passes through the holding tube the product temperature must be

sufficiently high on entering.

So that even the some temperature drop it will still at least be the prescribed minimum temperature at the exit of the holding tube. No external heating of the holding tube should take place. A deaerator is used to remove air as most products which are aseptically processed must be deaerated prior to packaging. The air is removed to prevent undesirable oxidative reactions which occur as the product temperature is increased during the process. The deaerator generally consists of a vessel in which the product is exposed to a vacuum or continuous flow.

The sterilized product is accumulated in an aseptic surge tank prior to packaging. The valve system that connects the surge tank between the end of the cooling section and the packaging system allows the processor to carry out the processing and packaging functions more or less independently. The product is pumped into the surge tank and is removed by maintaining a positive pressure in the tank with sterile air or other sterile gas. The positive pressure must be monitored and controlled to protect the tank from contamination. Seals and closures any aseptic system must be capable of closing and or sealing the package hermetically to maintain sterility during handling and distribution.

The integrity of closure and seal is therefore, of paramount importance. Two systems are manufactured in the tetra pack system the longitudinal and the transverse seam. In the longitudinal system a flat web of packaging material is used supplied in reels that flat material web is formed into a tube which is sealed longitudinally resulting in a cylinder shaped structure. The strength of this longitudinal seam is determined partly by a overlap seal and partly by a plastic longitudinal strip. This strip is first sealed to one edge of the packaging material web and once the packaging material tube is formed, sealed to the inner surface of the packaging material.

Both these operations this strip application and the actual longitudinal sealing are done by using sterile hot air and pressure. Transversal sealing is done below the level of the product in the packaging material tube. By constantly moving sealing and pressure jaws pressure is applied from the outside of the packaging material tube is squeezing the product from the sealing area. An electrical impulse is passed through the sealing jaw and heat is transferred from the outside to the inside plastic layer of the packaging material. The polyethylene layer is heated, melted and pressed together between a pair of jaws.

While pressure is maintained the melted plastic layer cools down and a bonding is effectuated between the two opposite packaging material surfaces. They are sealed transversely. This is the pictorial diagram of aseptic processing. The sterilized product is

fed to the surge or the holding tank and the sterilized packaging is again sent to the aseptic area where it is packet is formed as well as the sealed material vapor sterilization system and that will condense the steam and then it is conveyed on the after sealing it is it is dropped on the conveyor for the sterile filling chamber. This is the sterile filling chamber and after filling it is conveyed for the storage or the distribution.

The aseptic packaging materials, packaging materials must meet following factors. The packaging material must be compatible with the product intended to be packed and must comply with appreciable material migration requirements. Physical integrity of the package is necessary to assume contaminant of the product and maintenance of sterility. The material, the package material must be able to withstand sterilization and be compatible with the methods of sterilization. The package must protect the product from oxygen also package must retain the aroma of the product.

This is the sensitivity of different products like this milk is highly sensitive to the microorganisms. The sensitivity of the milk decreases the milk products is the product decreases with this with against the microorganisms. The milk is the high sensitive then water then yogurt then still drinks juices and then wine. Wine is the least sensitive to the microorganisms like for example, juice this is the high sensitive to the oxygen followed by still drinks followed by the water. Light milk yogurt is highly sensitive followed by wine juices followed by water and water is highly sensitive to off flavor take up then wine then yogurt and milk and juices then still drinks.

Now, the composition of tetra pack aseptic cartons. Aseptic package should not only protect the product, but also maintain the quality of the product. Hence, the structure as well as composition of aseptic packaging are more complex and vary depending on product application, package size and package type. Factors such as seal strength and integrity, package shape stiffness and durability as well as various properties determine the choice and or combination of materials required. Generally to achieve all required properties aseptic packages incorporate more than one material in the structure that is assembled by lamination or co extrusion process.

This is the tetra pack aseptic cartons are made up of three basic materials that together result in very efficient safe and light weight package. Each material provides specific functions for example, polyethylene protects against the moisture paper for stability and strength. Again polyethylene for adhesion the aluminum for barrier properties to oxygen flavor and light again polyethylene for the adhesion and again polyethylene which seals in the liquid. There are six layers providing total protection to any product filled in. Combining each of these materials has enabled tetra pack to produce a packaging material with optimal properties and excellent performance characteristics such as higher

degree of safety, hygiene and nutrient retention in food.

Preserving taste and freshness can be kept for months with no need for refrigeration or preservatives efficient. A filled package weight is 97 percent product and only 3 percent packaging material using a minimum quantity of materials necessary to achieve a given function. A good example of resource efficiency is its light weight along the lightest packages available. These are the that six layers that that we have already discussed that the PE that that protects from the microorganism light, but it is moisture, but it is not a barrier to the oxygen and odor and smell. The paper board also is not barrier to all the items mentioned here, but the aluminum is barrier to everything and after the aluminum there is a polyethylene layer and again polyethylene layer which provides the seal and this from the product side also it does not pass the liquid to flow from inside to outside and flavors also.

In India tetra pack offers the following packaging system currently. The TVA that is the tetra brick aseptic, TCA that is tetra classic aseptic, TFA that is tetra pheno aseptic, TWA that is tetra wedge aseptic. Here are certain examples of these different types of tetra packs. Advantages of aseptic packaging. Aseptic packaging has been growing in popularity amongst the manufacturers in recent years.

In fact, the Freedonia group reported that the demand for aseptic packaging is expected to rise at a 6.8 percent rate annually reaching to 6.4 billion dollar in the year 2020. This growth can be attributed to the various advantages aseptic packaging provides to manufacturers.

The increased shelf life. The aseptic packaging helps increase shelf life for select products by an estimated 6 to 12 months without refrigeration. The increased longevity of a products life span gives manufacturers more time to sell their product on retailers shelves and it provides the consumer with more time to use or eat the product before it expires. Reduce shipping and distribution cost. With the unique materials used in aseptic packaging select products can be stored at ambient temperatures approximately 68 to 77 degree Fahrenheit. Additionally, aseptic packaging is lightweight and compact when compared to more traditional packaging types.

These properties allow manufacturers to cut back on shipping cost by reducing shipping weight and eliminating the need to refrigerate products that would typically require cooler environments during distribution. No preservatives required. Manufacturers do not need to use preservatives with the use of aseptic packaging because the sterilization process protects against bacteria. This allows manufacturers to use real time ingredients and consumer prefer. Additionally aseptic packaging is a sustainable method that can

contribute to a manufacturers go green initiative.

The packaging is primarily comprised of renewable resources and uses approximately 60 percent less plastic than other options. Aseptic packaging also requires less energy to manufacture. Maintains quality of contents. The high tech aseptic packaging process helps preserve the overall quality of most food products. That means, taste, smell and even nutritional value will not be compromised and consumers can be confident that the product they purchase will be of high quality.

Along with advantages there are certain disadvantages also associated with the aseptic packaging and they are plant installation cost is high as compared to the canning. Gas transmission rate is of aseptic bag or package. Overcooked flavor in some products. Lack of equipment for particulate sterilization due to especially to settling of solids and thus over processing. That is all for today. Thank you very much.