Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

Prof Prem Prakash Srivastav
Department of Agricultural and Food Engineering
Indian Institute of Technology Kharagpur

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Welcome to the NPTEL online certification course on Modern Food Packaging Technologies, Regulatory Aspects and Global Trends. In the last lecture, we have seen the different glass manufacturing processes and nomenclature of the glass containers. Now, in this lecture, we will be discussing about the strength factor for a glass container. The shape surface condition, applied stresses and glass weight all combined to determine the strength of a glass container. The sharp transitions in container shape for example, a rectangular cross section compared to a circular cross section lead to a high stress concentrations.

The small surface imperfections formed as a result of surface contract during the manufacturing process and subsequent handling operations can influence container strength. Good design will incorporate specific contact areas for example, nulls or small protrusions that concentrate abrasions, where they will have minimal effect on glass strength. Surface treatment also assists in reducing surface abrasions. The force applied to a glass container during its intended use depend largely on the function of the container.

Carbonated beverages and vacuum packed foods develop internal pressure stresses predominantly circumferential and longitudinal. In the cylindrical part of the typical glass bottle, the circumferential stress S depends on the bottle diameter D, the glass thickness X and the pressure P as follows. S is equal to P D divided by 2 X. The longitudinal stress in this part of the bottle is one half of the circumferential value S. Equation 1 does not hold for the non cylindrical parts of the bottle.

Typical pressures inside the carbonated beverage bottle at ambient temperatures are 400 kilo Pascal, 4 volumes are carbon dioxide gas per volume of beverage rising to about 700 kilo Pascal at about 40 degree Celsius, 1000 kilo Pascal at pasteurization temperatures. Bottles for carbonated beverages have target bursting the strengths well in excess of the equilibrium pressure of a carbonated beverage. The target bursting strength of a non refillable one day bottle is between 1240 to 1380 kilo Pascal and for a returnable bottle about 1720 kilo Pascal. Vertical load stresses are generated by stacking containers on top of each other or by applying a closure. These compressive forces produce tensile stresses in the shoulder and heel region of up to 690 kilo Pascal.

These stresses can be lowered by decreasing the diameter difference between the neck and the body by increasing the shoulder radius and by reducing the diameter difference between the body and the bearing surface. During hot filling or pasteurizing of glass containers the rapid temperature changes lead to the development of tension stresses on the cold surface and the compression stresses on the hot surface. With additional bending stresses being generated by expansions and contractions of the container. Thermals stresses can be reduced by minimizing the temperature gradient from the hot to the cold side decreasing the glass thickness and avoiding sharp commerce especially on the heel. Stresses caused by steady state thermal gradients may or may not cause failure depending on the degree of constant imposed by some parts of the container or another or by external mounting.

Consequently under minimum constant and maximum uniformity of gradient through the thickness very large temperature differences can be tolerated. Now, different types of closures the type of closure that works best will depend on the variety of factors including which jar, bottle or container you choose for your packing machine solution. It is recommend about both presentation and functionality when choosing a packaging closure method. The closures are divided into dispensing and non dispensing closures. Dispensing closures work well for products that will be used in measured amounts while non dispensing closures work better for beverages or more viscous liquids.

Now, non dispensing closures the continuous thread. The continuous thread caps can be metal or plastic or have various liner options categorized by threads which wrap continuously around a given finish. A few products that traditionally use continuous thread caps include peanut butter or mayonnaise. Lug caps also known as twist off caps. Lug caps are compatible with containers whose threads are not non continuous.

Lugs on the interior of a lug cap correspond with the non continuous threads and close by a partial rotation. Now, the dome caps a style of closure where the top surface is rounded. Dome caps create a sleek appearance and are often used in conjunction with round bottom jars. Pale lid this is made up of SDPE lid with sealing gaskets. Phenolic poly cone caps, phenolic poly cone caps feature a LDPE cone or poly cone which is the inside diameter of a given container making phenolic caps ideal for chemicals essential oils and other aggressive products.

Ribbed closures series of vertical grooves around the outside edge which help the end user establish a grip to remove a given closure. Ribbing can be found on many styles of plastic caps such as lotion pumps, snap top caps as well as standard non dispensing plastic closures. Smooth closures the opposite of a ribbed closures, smooth closures are

often preferred for their visual appeal. Smooth closures can be found in many styles including lotion pumps, snap top caps, flip top caps and standard non dispensing plastic caps. Tub lids flexible plastic closure with grooves which made to a particular plastic tub and provide a leak proof seal.

Now, the dispensing closures this top caps injected molded dispensing closures which make reveals and orifice when pressure is applied to a designated area on the top of the cap commonly found on sunscreen and other cosmetic containers. Fine mist sprayer a style of dispensing closure which produces a fine spatter free mist. Glass dropper closure with a plastic bulb and glass pipette which extends into a given container when the plastic bulb is squeezed product is drawn into the pipette and dispensed as needed commonly paired with Boston round bottles and wires for cosmetics essential oils and fragrances. Orifice reducer plug or fitment which reduces the flow of a given product. The pump allow products to be only dispensed with each stroke.

Lotion pumps and treatment pumps are available generally speaking lotion pumps dispense more product per stroke than treatment pumps. Reike pail lids lid for plastic HDPE pails which has a spout for dispensing product. Sifter fitment a plastic or metal disc which snaps over the bead a rim of a given container which regulates the amount of product usually a spices or meat rubs dispensed when shaken. Snap top cap a type of dispensing cap that features an orifice of various sizes with a hinged lid to prevent leakage. Spice cap dispensing closure which has built in sifter holes to dispense product when shaken.

A flip up spout cap a plastic dispensing closure with which reveals an orifice for dispensing product when a spout is lifted from the top of the cap. The trigger sprayer a type of closure which dispenses product at a steam or mist. Twist top caps dispensing closures which reveals an orifice when the top is twisted most commonly seen on glue containers. Twist top caps are great for dispensing viscous products such as condiments and lotions. Yorker spout caps a LDPE spouted dispensing closure which reveals an orifice when red cover is removed from the tip.

The functions of the closures a closure must make a satisfactory seal in line with the technical requirement of the product and maintain it till the content is used. It must be possible for the intending user to open the containers without any difficulty for example, jam jars more vacuum more difficult to open. If the product is used over a period of time it must be able to reseal properly and easily. The closures must not affect the contents. It must be possible to fit the closure under a specified condition that is it a speed required by the packaging line.

Closure may enhance the appearance of the product and give information about the product enhancing the sales appeal. Now let us discuss something about the cleaning operations. The air rinse the glass must be temperature conditioned to prevent condensate forming on the inside which would inhibit the removal of cardboard debris. The air pressure should be monitored to ensure that debris is not suspended and allowed to settle back on into the container. On-line water rinse where hot filling of the product takes place it is essential to ensure that the temperature of the water is adequate to prevent thermal shock at the filter filler that is not more than 60 degree Celsius differential.

The returnable wash systems the washer feed area must be checked to ensure that the bottles enter the washer cups cleanly. The washer full of bottles must not be left soaking overnight. In the longer term this would considerably weaken the container and could well create a reaction on the bottle surface between the hot end coating and the caustic in the washer. Where hot filling is taking place it is necessary to ensure that the correct temperature is reached to prevent thermal shock at the filler. Now, the certain test procedures are recommended for testing the glass bottles because they are constructed at a very high speed at a very high temperature though different test it has to pass.

The first of this is resistance test. The glass is subjected to a water saturated atmosphere at a constant temperature the samples are exposed to condensation which may lead to surface degradation. The test apparatus should have a provision of 4 test pieces and the materials used for the inner wash shall be corrosion resistant and shall not affect the test pieces. Test procedure include the water tank shall be filled with demineralized water having conductivity in Siemens lower than 30 micro Siemens per centimeter and a pH higher than 5. The cabinets internal temperature shall be controlled by means of a reference thermocouple keeping a temperature of the reference glass piece at 40 plus minus 1.5 degree Celsius. The test cabinets shall be in room with a with an ambient temperature of 23 plus minus 3 degree Celsius. Care shall be taken to ensure that droughts, dust, moisture and solar radiation do not interfere with the test cabinet. The reference temperature shall be reached within 2 hours of connecting heating. Condensation shall be seen to form on the glass pieces. The test is continued without interruption for the required time.

Both the internal reference and the external air temperature shall be regularly checked. Acid resistance test, this test consists of subjecting the glass to a sulphur dioxide saturated atmosphere at a constant temperature. The samples shall have condensation continuously forming on them. It is this condensation together with the quantity of sulphur dioxide that may cause surface degradation. The test procedure is the test cabinet contain 2 liters of demineralized water having conductivity of lower than 30

micron Siemens per centimeter.

When the cabinet is closed 0.2 liters of sulphur dioxide shall be added and the heating system switched on. The test consists of a repetition of 24 hour cycle as shown in the figure. Each cycle consists of a high temperature plus condensation period and an ambient temperature without condensation period. The temperature shall increase to 40 plus minus 1.5 degree Celsius in less than 1.5 hours. During the next 6.5 hour the test pieces shall be subjected to condensation in the sulphur dioxide atmosphere. Natural salt spray test, this test consists of subjecting the glass to a natural water saline atmosphere at a constant temperature. It is the water saline spray that may cause surface degradation and the test procedure is to the test cabinets shall be prepared and run for a minimum of 24 hours before the test piece are placed within it.

The neutral salt solution is made up by dissolving NaCl in demineralized water having conductivity lower than 30 micron Siemens per centimeter to produce a concentration of 50 plus minus 5 gram per liter at 25 plus minus 2 degree Celsius. The compressed air supplied to the spray nozzle shall be passed through a filter to remove all traces of solid matter or oil and shall be at an absolute pressure of 70 kilo Pascal to 170 kilo Pascal throughout a saturator at 40 plus minus 1.5 degree Celsius. The spray nozzle shall be made of inert material with baffles to prevent the direct impact of spray on the test pieces. Abrasion resistance test, this test involves subjecting the surface of the coated glass to rubbing with a felt pad in dry condition.

It is the type of pad, it is loading and the number of strokes that may cause surface degradation. And the procedure is the metal finger shall be approximately 15 millimeter to 20 millimeter in diameter and shall be driven to produce a frequency of 60 strokes per minute plus minus 6 strokes per minute alternating forwards and backwards. The stroke length shall be 120 plus minus 5 millimeter, the strokes shall be parallel and ensure a constant pressure over the zone to be tested. A circle shape with a diameter of 14.5 plus minus 5 millimeter, a test sequence shall commence within 30 minutes of the sample being cleaned.

The felt pads metal finger shall be lowered on to the glass surface and a load of 4 Newton applied perpendicular to the glass surface via the felt pad. Thank you very much.