Paper No.: 12
Paper Title: FOOD PACKAGING TECHNOLOGY
Module – 07: Metal Packaging Materials

1 INTRODUCTION:

The commercial packaging of foods in metal containers began in the early 19th century, following on from the discovery in the 1790s by the French confectioner Nicolas Appert of a method of conserving all kinds of food substances in containers, a method to which the term canning is now applied indiscriminately, whether the container is made from tinplate, aluminum, glass or plastics. The earliest can makers were tin-smiths who turned out tin plate containers with skill and imagination, in a variety of sizes and shapes. Both ends were soldered to the body, with a hole about 25mm in diameter at the top. After can was filled through this hole a metal disc was soldered into place. Mechanization of the can making process was made possible by the development of a method called double seeming, to attach ends to the soldered can body. Even though many of the fundamental manufacturing processes, such as double seaming and body forming were developed in the late 19th century, the evolution of can making continues. Related technologies such as metallurgy and food engineering are also advancing, creating new applications for the metal packaging materials. Of the total estimated world market of metal cans about 78% is accounted for drink cans and about 18% for processed food cans. The remainder are aerosol and general line cans. Drink cans may be divided into those for non-carbonated drinks (liquid coffee, tea, sports drinks etc.) and carbonated beverages (soft drinks and beer), many of which pass through a pasteurisation process.

2 CONTAINER PERFORMANCE REQUIREMENTS

Metal packages for food products must perform the following basic functions if the contents are to be delivered to the ultimate consumer in a safe and wholesome manner:

1. Preserve and protect the product
2. Resist chemical actions of product
3. Withstand the handling and processing conditions
4. Withstand the external environment conditions

5. Have the correct dimensions and the ability to be practically interchangeable with similar products from other supply sources (when necessary)
6. Have the required shelf display properties at the point of sale
7. Provide easy opening and simple/safe product removal
8. Should be constructed from recyclable raw materials.

In addition, these functions must continue to be performed satisfactorily until well after the end of the stated shelf life period. Most filled food and drink containers for ambient shelf storage are subjected to some form of heat process to increase the shelf life of the product. The heat process cycles used to achieve this are particularly severe and the containers must be designed so as to withstand these conditions of temperature and pressure cycles in a steam or water atmosphere. After heat processing, when the can temperature has returned to ambient, there will normally be a negative pressure in the can, i.e. a vacuum. Under these conditions, the food product itself does not provide any strength to the can to resist external loads.

In the case of carbonated beverage cans, which form the bulk of drink cans filled, once the container is closed, the carbonation pressure continues to provide significant physical support to the container until the moment of opening. In the case of still liquids, such as juices, nitrogen gas may be used to provide the necessary internal pressure for rigidity and compression strength.

3. MERITS AND DEMERITS OF METAL PACKAGING MATERIALS

Metal cans are impermeable to moisture, gases and light. They are produced from readily available and highly recyclable materials. Metal cans are compatible with many products and offer high stacking strength, thermal stability and a good surface for decoration, printing and coating. They have potential for high-speed manufacturing and filling. Many designs today offer easy opening ends that do not require the tools to get the contents. Two-piece design of cans deletes the chances of leaking of its contents as there are no side and bottom seams.

But, the cost of setting up of a production line for cans is high. Food processors also need a variety of sizes for different products harvested in different seasons enhancing the cost further to achieve this diversity.

4. C O N T A I N E R D E S I G N S

Regardless of the particular can-forming process used, the shapes of metal containers are very relevant to their cost, physical performance and compatibility with the filled product. For most metal food and drink containers the cost of the metal itself is 50–70% of the total container cost. The amount of metal in any particular container is the most significant cost item, and this is related to the metal thickness, temper and its surface area. In can design, metal thickness is determined by the need for physical performance in handling, processing and storage of the filled container. Surface area is determined by the volume contents and the shape of the container. For ease of manufacture and handling, most food and drink cans have a circular cross section. But, for different physical performance, cost and product uses, cans may vary from shallow to tall.

4.1 Can Configurations

The three basic types of cans are: three-piece cans, two-piece drawn and ironed cans and two-piece drawn and redrawn cans.

4.1.1 Three-piece Can

As the name suggests, it is made in three pieces: a body and two ends. The manufacture of three-piece cans involves the cutting of metal sheet into can-width strips on a machine called slitter. The slit strips are cut into body blanks and fed into a body maker, the first machine in an automatic can line. In the body maker, the body blanks are rolled, the corners are notched to remove the extra thickness of metal, and the side seam is curled into the ends and passed on to side seamers. Within three-piece category cans, there are three further classifications determined by the method used to join the side seam of the body cylinder. The methods are soldering, welding and cementing.

4.1.1.1 Soldered seams: For soldered cans, the edges of the blanks are bent, brushed with flux, passed over a gas flame and joined in a lap and lock seam while moving over a solder application seam, another burner smoothens the seam and wiper removes excess solder. The soldering seam is then treated with a lacquer. The body blank is flanged to receive the can bottom which is double seamed. The top of the can is usually applied after a filling operation. In the final step a spray coating is applied to the can interior, cured and tested for leaks.

4.1.1.2 Welded seams: The welded side seams are very strong and require a much narrower undecorated strip than that needed for soldering. In welding, the side seam is an overlap of the curled plate, which is subjected to a high-amperage electric current in a resistance welding process. The resulting exposed edge inside the can is coated in a striping operation using powder coating which is cured by infra-red or high-frequency induction heating.

4.1.1.3 Cemented seams: The cemented side seams permit all-round lithography with no base strip required at the solder point. The body former curves the sheet to form a cylinder and overlaps the edges. Cemented seams are produced by passing the body blank edges over an open flame and applying special cement with wheel. Chilling rolls then solidify the cement and trimming knives remove cement between adjacent body blanks. The exposed edges are coated with lacquer. A thorough test is to be followed before the cemented side seams are used for cans under pressure.

4.1.2 Two-piece drawn and ironed cans:

These cans were developed in 1960's. This method of can manufacturing eradicates the side seam and separate bottom. The two-piece can body has an integral side and bottom and is made in a process that thins the sidewall while maintaining the thickness of the bottom. The widest use of these is in the beer and soft drink markets. To make a D&I can, a disc of metal sheet is formed into a shallow cup with a die. The cup is then pushed through several dies, each slightly smaller than the previous one, so that the sidewalls are stretched and thinned. Since the cup is held on the original punch, the inside dimension remains constant during this process. Starting with the plate thickness of 292 µm, the sidewalls are reduced to 97µm, while the bottom thickness remains same. This process of pushing the cup through progressively smaller die rings is termed as the ironing of sidewall. As the walls are ironed, the bottom is domed to provide strength and stability. The maximum ratio of height to diameter is 2:1. The can bodies are then cut to length and cleaned in preparation for coating inside and out. The can is then necked at the top and flanged to receive a top. The necking in produced a can with a narrower top thereby saving material. After leak test the cans are prepared for filling.

4.1.3 Two-piece drawn and redrawn cans:

In D&R method the cup is pushed through each-succeeding die. The gauge of the bottom and the sidewall of container remains essentially the same as the starting gauge but the inner dimensions of the cup becomes smaller. One or more punching operation may be used depending upon the depth of the can to be produced. These subsequent drawings or "redrawing" can be done once or twice. After drawing and redrawing, the can body is necked in at the bottom to permit easy stacking and incrusted in narrow bands to provide extra side wall strength for vacuum packaging.

While coatings will not adhere to D&I cans during production and must be applied to after the can body is formed, they may be applied to the flat can stock in the D&R process prior to drawing. A typical can, eg. Fruits & vegetable would start with steel having 184.6 µm gauge and end up with a side wall of 179.5 µm. The maximum ratio of height to diameter is about 1.5:1.

4.2 Non-round Cross Section Containers

Non-round cross section containers are typically used for fish and meats that are heat processed, as well as for products such as edible oils, which do not need to be processed. Open trays of round or non-round section are used for baked food products or with lids as take away food containers.

5. CLOSURE SYSTEMS

Closure systems for food and drink cans are by necessity very different in their mode of operation. Food cans require an aperture with either total or virtually full internal diameter of the container through which to remove the product, whereas the aperture for drink cans is designed to suit the method of consumption. Historically, food cans have required a can-opening tool to remove the plain lid. In more recent years, full aperture easy-open ends have been developed based on designs originally used for drink products. Whether plain or easy-open ends are used, the end panel for virtually all food and drink cans is mechanically seamed-on to produce a double seam that is capable of withstanding all the heat-processing cycles in use.

5.1 Easy-open Ends:

Easy open ends could be a stay-on tab found on the beverage cans or a ring-pull ends which is found on pet food or heat sealable flexible membrane. The bevcan end is a tab less design with a raised conical profile and a central 19.1 mm pour spout. It is opened by pressing downward a circular panel which pops inward without leaving any hazardous edges. The recent advancement in the easy open membrane lids, which simply peel away and often are teamed with a friction fit plastic lid for protection in the distribution chain.

5.2 Threaded Closures:

Screw-top cans are containers with threaded closures. A wide variety of threaded spouts and applicators have been available. A closure could be specified by the size of the outside of the threads on the container. There are no industry standards for threaded profiles, the caps from one manufacturer may not fit containers from another. Caps and containers must be purchased at the same time from the same source to ensure a good fit.

5.3 Slip Cover Closures:

Shallow cans with slip covers are made by blanking and drawing metal plate to the proper size and curling the edge. This category of closures includes simple reclosure type; firm reclosure type or friction closure type. There are still markets for highly decorated metal boxes, although the uses of these slip cover containers have greatly decreased due to the labour intensive cost of making these cans has soared and other types of mass-produced containers have developed.

6. CAN MATERIALS

Cans are made from either aluminium or steel. The steel can be chrome plated or laminated. The commonly called tin can is a misnomer. The sheet of these cans have only a thin coating of tin either on one side or on both sides.

6.1 Aluminium:

The composition of aluminium alloys for rigid containers varies according to the intended use, with up to 5 % magnesium, 1.5 % manganese and traces of iron, silicon, zinc, copper and titanium. As forming characteristics and resistance to corrosion improve, yield strength usually goes down and heavier gauges are required to have the same strength.

Aluminium alloys or tempers commonly used are: a fully hard material such as 3004 H-19 and a softer one such as 5052 H-34. Where 3004 or 5052 denote the aluminium alloy sheet and H-19, H-34 denotes the tempering. The hard tempered alloy H-19 allows the very thin gauges which make the container bodies economical. Shallow-drawn parts, such as can ends, use alloys with less ductility and medium temper of H-34 for average conditions.

6.2 Steel:

Ferrous metal used in fabricating cans include base steel or "black plate", tin-free steel which has thin coat of electroplated chromium and tin plate which has a thin coat of electroplated Grade-A commercially pure tin. Steel that has completed the tempering process is called 'black-plate'. Traditionally, it is used for spice containers and a number of industrial-packaging applications. It also forms the base of tin plate and electroplated chromium steel. Ferrous materials are used for ends and bodies in both two-piece and three-piece technologies.

An electrochemical passivation treatment, usually with sodium dichromate, stabilizes the surface and adds a thin film of metallic chrome to enhance the corrosion protection. Although the tin coating is only about 0.3 µm thick, it resists the corrosion not only by the protective layer of tin on its surface but also a cathodic reaction that minimizes oxidation at any pin holes or base spots. Tin coating also prevents the iron from being dissolved in certain beverages and food products.

6.3 Can Linings and Lacquers:

Metals used in can packaging often do not provide corrosion resistance, surface abrasion resistance and product-container compatibility. As a result, a variety of lacquers and lining materials have been developed to protect outer and inner surfaces and are also known as enamels. These are usually applied by roller or spray to flat sheet or coil and cured by oven or ultraviolet-light curing process. The enamels protect the surface of can by serving as a barrier to gases, liquid and ions. Enamels generally are specified in terms of mg/in^2.

7. APPLICATIONS

There are three major markets for metal cans; beverages like beer and soft drinks; food and non-food, comprising such products as paints, chemicals, etc.

7.1 Beverage Cans:

The beverage can market has been the fastest growing segment of the industry. Two-piece cans are predominant in the beverages as they are well suited to long production runs with infrequent label changes. Majority of market uses aluminium in manufacture of two-piece beverage cans, though in some European countries steel is still in use.

Aluminium cans manufactured by D&I process are extensively used for pasteurized beverages such as beer and soft drinks. Beer contains carbonic gas and when it is pasteurized after sealing the internal pressure may rise to ten times the pressure in food cans. The beer can therefore has to be designed to contain pressures up to 7 kg/cm^2. Due to their lighter weight per cm^2, aluminium cans reduce transportation cost. Remelting of aluminium cans to make aluminium slabs requires only five percent of the energy used to make virgin metal from bauxite ore. Thus the economics of recycling of aluminium cans have become quite favourable. It helps control the costs of materials and clearly favours the aluminium beverage package.

7.2 Food cans:

Food cans are manufactured in a greater variety of sizes and shapes than beverage cans and are generally produced in shorter production runs with frequent change over between sizes and labels. Both three piece welded cans and two piece steel cans are commonly used. The welding process produces a high-integrity three-piece can that is lead free. Welding technology provides the flexibility to run various specifications. Two-piece cans, which eliminate the side seam, are well suited to short sizes but tend to use more metal in taller sizes.

Shallow drawn aluminium cans are used extensively for processed foods such as vegetables, certain meat products, fillets of fish and various sauces. Deeper cans drawn and ironed are used for vegetables in brine or sauces, soups. Crabs and lobsters packed in aluminium cans do not require parchment lining to avoid discoloration of the product. Tomato sauce and mustard sauce are corrosive products, so the foods prepared in them, if to be packed in aluminium can should not exceed total 3% acidity, expressed as acetic acid. Other fresh foods packed in D&R cans include meat, boned chicken, etc.

A few products like roasted coffee, milk powder are canned in dry state. Heat processing and canning in such cases prevents loss of volatile, and moisture pick-up by hygroscopic powders, etc. Dry packed foods may be hermetically packed under vacuum or packed in an inert gas like nitrogen. Aluminium cans have also been developed for packaging of high sugar products. The shelf life of various food products packed in lacquered cans have been reported to vary from about one year for beer to more than seven years for carrots and peas.

8. Conclusion

Competition among metal, glass and plastic packaging products will continue to be a major force in overall container industry. Metal cans have been able to maintain a large share of the market owing to technological advances permitting efficient high speed operation and conservation of materials and energy.

Recent innovations in the design and manufacture of metal packaging for food products include: large opening stay-on-tab ends for drink cans, widgets to provide a foam head to beer and chilled coffee, self-heating and self-chilling drink cans, full aperture food can ends which are easier to open, square section processed food cans for more efficient shelf storage, peelable membrane ends for processed food cans, two-piece draw and wall iron as well as two-piece draw redraw cans made from steel with plastic extrusion coatings.

The prime purpose of packaging in a metal container is the physical and chemical protection of the product to be marketed. A perfect lacquered can is an ideal container for food with respect to all these. This will ensure that metals will continue to have an extremely important part to play in the cost efficient packaging of foods for short or long term ambient storage conditions. The inherent strength of metal containers and the fact that they are impervious to light contribute to a high level of protection for the contained product over long shelf life periods.

Reference:

Hanlon JF, Kelsey RJ, Forcino HE. 1998. *Handbook of Package Engineering.* Technomic Publishing Co. INe. Lancaster, Basal

Page B, Edwards M, May N. 2003. Metal Cans. *In*: *Food Packaging Technology (Eds: Coles R, Mcdowell D and Kirwan MJ),* Blackwell Publishing, Oxford, UK

Robertson GL. 1993. *Food Packaging Principles and Practice*. Marcel Dekker INe. New York