

Food Packaging Technology
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Week – 01
Lecture – 07
Metal as packaging material – P1

Welcome back to NPTEL course, Food Packaging Technology. So, we had been discussing about different aspects of packaging in the last class. We have also discussed about the need and role of packaging and we also discussed about paper as packaging material and glasses packaging material. So, in today's session we are going to discuss about metals as packaging material. In under this we will be discussing about tin plate containers, tinning process and what are the different components of tin plate, then tin free steel, then aluminium containers, different types of cans and lacquers. Now coming to the metal packages, these are very robust and durable because of this they are used for canning.

They are also used to store canned products, dairy products, drinks, non-can food products. They are used to develop metal closures, metalized films, laminates and even they are used in non-food products like paints, varnishes, lubricants and cosmetics and other biological products and medicines. And the reason why we use metals as a packaging material is because it's easy to open, it is recyclable, it can be recycled and reused and it's convenient to transport and store and even it can be stored for very long time. It has a very long storage life and it is impermeable to gas, light and microorganisms but then these parameters it depends upon the kind of material that are being used and what is the shape of the material.

Now we have tin plate which is the older packaging material and this can be in the form of round, square or rectangular. The first tin cans were patented by Peter Durand in 1810 and it was based on the experiments of Nicholas Appert and he developed the process of sterilization and this was later called as appetization. Today, also we follow the same term sterilization or appetization. So, the name was given based on the name of the scientist and tins they are light in nature even from the consumer point of view it is easy to handle and they can carry it, it is much lighter and it reduces carbon dioxide emission during transportation so this is environmentally friendly also. Metal packaging materials, generally, contain aluminium and steel and these are recyclable and reusable.

Once, it has been opened and it can be reused for other purposes, also need not be for storing food, it can be used for storing other things. In this picture, you can see different types, a variety of packaging materials are shown here. All these packaging materials are

metal containers and they can be cylindrical, rectangular. We also have boxes here. Now metal cans mainly used in the food industry are of two types that is two pieces can and three pieces can. This generally, contains one body that is cylinder part and it may have one or two lids depending upon the type of can.

If it is a two piece can, it will have one lid and if it is a three piece can, then it will have two ends *i.e.* one lid and the other bottom part. These lids are seen to the can. Inside this the contents are stored. Generally, because the sturdy nature of the can, the can doesn't need a secondary packaging. They can be the number of secondary packages or the tertiary packages can be brought down. We also have beverage cans which are lightweight. Though they are lightweight, they are unbreakable. They can resist the impact during transportation. They are puncture resistant. They can withstand very high temperature and pressure. They are good barriers to light, gas and oxygen. Mostly the cans used for packing beverages are two-piece cans and the metals, they can also be used for developing closures, lids, crown cogs. This helps in keeping the contents airtight. Also, they ensure neutral taste which is very much important in baby foods or infant foods processed fruits and vegetables, jams, dairy products and other delicacies like sauces. So, the contents from the tin or the container or the lid, it should not leach to the contents inside and it should not interfere with the flavor of the product. We also have drums and pails. Drums and pails are large containers. These are generally three-piece steel or stainless-steel containers, which are aseptically filled. Then we have containers for aerosols. These can be three piece or two pieces. These are generally used for whipped creams. We have trays and foils; they can be rigid semi-rigid aluminum trays and these are made from aluminum rolls or aluminum alloys. Generally, the thickness of this aluminum sheet will range from 70 to 300 microns and apart from this we can also develop tubes using the metals. These metal tubes are used to store tomatoes, paste, mayonnaise and then concentrated milk spread in food industry. We generally find these things stored in tubes. This is easy to use and easy to take the contents and these have minimum interaction with oxygen and light. You might be familiar with the toothpaste which is also a tube container and which is excluded from the metal.

Composition and properties

The packaging materials they are divided into three different classes that is aluminum coated plates; under this we have tin plate in free steel polymer coated and steels. Another class called stainless steel. Then we also have containers of minor elements like nickel, copper and titanium. Now, coming to steel based or tin-plated steel material steel based is also called iron-based materials components. Of this will be tin steel and chromium, which are used to develop the composite material or to form the tin plate and we can also form electrolytic chromium coated steel. So, it is denoted as ECCS and since it does not contain any tin it is tin free steel that is why it is called TFS. So, we

have the iron and it is base material onto which the chromium is coated directly. There is no thin layer in between, that's why it is called tin free steel and iron is the bulk chemical or the major base material here. Steel and stainless steel, they are produced from iron and other components. The composition of these components is different in these two things the steel and stainless steel, they are not one and same. The carbon content and the metal contents differ in each. Then iron ore, coal lime and ferro alloys are needed to make steel. We also need aluminum, chromium, manganese, silicon, titanium, vanadium. These are other components that are added to improve the properties of the steel. Steel can be made in two ways; by melting the contents in blast furnace or we can use electric furnace. Generally, the electric furnace is used for recycling or recovered steel. The recycled steel is melted using electric steel. Generally, if we are going to use natural sources then we use blast furnace in this the iron ore. The coke is melted at very high temperature and the carbon ranges between 0.03 to 2 percent because carbon is a contributing factor for the strength. Similarly, phosphorus and nitrogen; it contributes to stiffness of the container. The material now, there are four different types of steel we have on the left side you can see it as L, D, N and MR; their properties and their applications. Then composition is also given here. So, L, it is highly pure and it has very good resistance, highly resistant to corrosion. Generally, these are used for packing acidic foods like pickles and other things. Then we have D type of steel that is non-aging steel. It is dedicated for severe drawing operations. N stands for nitrogenized steel for higher rigidity such steels are used for developing drums and cannons. Then we have MR steel. These are most widely used steel plate and these are used for packing meat and vegetable products. These are not too corrosive. Tin plate steel, these are also called low metalloid steels that is L stands for low metalloid and then MR type they have high amounts of carbon, aluminum, phosphorous and copper. Now, tin plate steel, this is the main raw material, which is used for developing cans and metal boxes. So, it is made of mild steel and carbon content is below 0.08 percent and it is coated with a layer of tin. This coating is called tinning or tin plating. This technique is hot thinning technique and it is generally done by dipping the sheet into the molten tin. This gives a whitish gray color or dull matte appearance to the tin this process is like sandwich, this sandwich alloy of steel and tin it has a good hardness. It has high resistance to corrosion and this is a non-toxic alloy. Tin plating can be done by electrolytic deposition. It is another way of coating the tin and this generally includes pickling that is descaling, removing the unwanted parts and then making it smooth and then degreasing, washing, alkaline tinning and acidic thinning. Tin free steel or ECCS, electrolytic chromium oxide coated steel. This is a tin free steel; it does not contain tin instead it is coated with chromium and it is coated in the same way how the electrolytic coating is given. It is in the same way; the chromium is also coated. So, it can also be called as chrome iron. It can be written as ECCS. It contains chromium oxide which has a thickness of less than one micron and process is similar to electro tinning. The requirements for single or double cold reduced electrolytic chromium chromium

oxide coated steel that is ECCS steel, is given in ISO 11950. The specifications are given for both sheets and coils. There so, if you look at the figure here, it is a multi-layered structure of tin plate and tin free steel. In this you can see that the thickness of weight material. It can range between 100 to 350 microns and over the base material a tin coating is given which is not given in the tin free steel.

There's a tin coating or tin alloy which is put over which there's a pre-tin which has a thickness of 1.35 microns. Over this the passivation layer is put. In case of ECCS or chromium coated or tin free steel, you will not find the tin here instead the thickness of base steel will be much higher. It will have a chromium or chromium oxide layer over which the oil layer is given. The passivian layer it is a metal layer and this helps in preventing corrosion. It is generally done by treating the tin surface with nitric or citric acid. This elongates or prolongs the shelf life of the metal container or the metal sheet. Then we have stainless steel which is used for food packaging. Stainless steel is also denoted as SS. This is inert and non-corrosive and it is a reactive chromium which forms a passive coating and which creates a barrier to corrosion and chromium percentage is around 10.5 percent. It also enhances the durability of the product, stainless steel. They are generally heat resistant and they have a hard surface. It is clean reusable and it has a good finishing. Generally, 100 grades of stainless steel have been recognized and reported but they are classified into five major groups. These are precipitation-hardening, martensitic, ferritic, duplex and austenitic. So, these are the different groups of stainless steel. Now, you will be familiar with 304 stainless steel and 316 or 318 stainless steels. Usually, we use 318 or 316 stainless steels in food industry. The parameters or the properties are almost similar to 304 stainless steels but it also contains three percent of molybdenum. Molybdenum reduces chloride related corrosion and it adds extra strength to the container. Now, 304 stainless steels, these are generally used to develop grills and other kind of fabrications and it contains manganese carbon and nickel along with chromium. It has 24 percent of chromium. Then we have aluminum-based material. Aluminum is the third most abundant element on the surface of earth and aluminum is used to develop lighter thinner ductile materials. But aluminum, it cannot be welded. Coors company were the first or they were pioneers to use the aluminum cans. They started using aluminum cans in 1959 and thereafter it was continuously being used for the production of soda, energy drinks, sparkling waters and other kind of beverages. It has become the most sustainable beverage packaging material. It is mainly promoted because of its recyclable property. It can be used in different forms like bins, bottle caps, soft packages for liquids. It can also be used for bulk packaging capsules. Then bottle stops, medication tablets, blister packaging, etc. Usage of aluminum is still promoted because of its light nature. When we go for light nature, we have to use purest aluminum. We can also use magnesium or manganese as an additive but this will improve the resistance of the packaging material. Aluminum oxide which is extracted from bauxite for extraction purpose, we need very high energy and a primary aluminum is recycled and purified to

liquid metal and it is filtered using ceramic filter. It is cast into ingots. Ingots are the molds where the aluminums are stored. From this ingot, these are taken and they are converted to sheets. So, any imperfections on the surface of the ingots, they can be removed by polishing and then these are developed into sheets which can be pulled and used later. So, in this picture you can see different types of ingots, the first one is ingot which is developed in a home. In the commercial way, it is done in a mold like this. So, in a commercial scale, the ingots are put in cast like this. They are developed into blocks and stored for a later period. These ingots are made into sheets to be developed as containers or other purposes now these are the applications of aluminum. Along with this, you can also find the properties and compositions. Aluminum can be converted to foils or flexible tubings and they are given number of 1050. This is how the flexible tubes and foils are designated. This is a 1 xxx series. Then we have beverage cans. This is a three-piece can it has a number of 3104. Then two-piece 5042. Likewise, we have others like foils for lamination 8079. So, it belongs to 8 xxx series. Here, if you see the beverage can, it does not contain chromium. It has high amounts of manganese and whereas the easy open beverages or two-piece cans. They have all the ingredients but foils for laminations, they do not contain manganese, magnesium, chromium or titanium. Now 1 xxx series are commercially pure aluminum. These are unalloyed and iron or silicon. The common impurities that are generally seen and these are used for developing aluminum foils or extruded containers. We also have 3 xxx aluminum cans or aluminum containers, which has high amounts of manganese. Then we have 5 xxx series, which has 4-5% of magnesium and 0.5% manganese. These are used to develop rigid containers, especially cans and then 8xxx series. These have wider applications and the wider range of composition also. Then can manufacturing, we have two types of cans that is three-piece can and two-piece can. In the three-piece can, there's a cylinder body which is rolled from a sheet of tin steel, which is welded on the sides and the two ends are joined mechanically by crimping. In the two-piece box, the cylindrical body is stamped. So, it is seamless and it's easy to open. Two-piece cans are very common now. Three-piece cans were earlier used to store or to can the meat products but now they have been replaced with two-piece cans. So, these are examples on the above figure. You can see three-piece cans. They come in different shapes and size. Two-piece cans, again, they can be rectangular or cylindrical. They have a lid on the top the bottom part is part of the body itself. Now, let's see, how the three-piece can is manufactured. So, it consists of cylindrical body which is rolled from a piece of flat metal with a longitudinal weld joint. Usually, it is done by welding or soldering and together with two can ends which are seamed into each end of the body. Usually, these are made from tin plate. Now, let's see processes one by one. We have thin metal strips. Here, these are cut into desired sizes and then these are lacquered coating is given on the surface to prevent corrosion. These are dried. Usually, the lacquering is given on the internal side and after drying these are cut into the size of the containers. Then it is rolled into cylinders and both the edges are kept together and

welded or soldered. Then again lacquering is applied on the sides because when we are doing rolling or welding sometimes the lacquers may be removed. To overcome that once again, we lacquer it then it is cured and dispersed into the flanger and the edges are bent. Here the seaming is done and the lids, they are fixed on these flanges. Again, the stiffness is enhanced by beading and then it is palletized. This is to see how much force it can tolerate, when it is transported and stacked. Now, let's look into this demonstration. This is a two-piece container. Here, if you see there is no seam on the edges. The end is part of the body. So, this is called body and this is the flanger bent over here on the edges you will find or over which the lid is placed. This is a two-piece container because after seaming, you just pull it off and the lid comes out. So, this is a two-piece can whereas in the three-piece can. You will have a separate bottom. The bottom will also be separate and then it is also seamed here and then the contents are filled and inside this the lacquers are given. It's a coating on the surface which we'll be discussing in the coming session. Lacquer, it protects the contents from interacting with the container or the metals. If it reacts with the metal, it may contaminate the product or it may interact with the components of the content. So, to prevent that we apply lacquer. Just imagine that, this is a metal sheet and if you swirl it, just make it in a cylinder form. So, this will be the cylinder. First step in the can making is to form the cylinder. It is a cylinder formed like this and this both edges, they are welded together. We don't add adhesive or apply any material over here because the can it comes in direct contact with the food and nothing should leach into the product. Therefore, it is welding or soldering is done. So, it is just crimping here. It's like stapling the thing and then the sheet is passed into the flanging machine, where the flanges are developed. So, it is just a bending on the edges where the lids will come and fit. This is how the can is developed in three-piece, Now let's see the steps. There are 12 steps in a three piece and development first the strips are cut from a large coil these are large strips. They are lacquered on the internal side. Then they are dried or cured. Then these are cut into small pieces according to the length of the can body. They are converted to cylinders and the edges are welded using electric current and where the welding has been done. We are again spraying the lacquer. This is again cured and then it enters into the flanger where it is splashed at the bottom and top where the lids come and fit. Then for the three pieces can, the bottom lid will be the plain end. It is seamed to the body and it passed through the beader because beader gives the strength to the seam where the second piece has been attached. Then it is tested for pinholes, fractures, dents and also whether it can withstand pressure during stacking. So, this is how the three-piece can is developed. There are three pieces can and two pieces can. Three pieces can they can be developed using these 12 steps and two pieces can we'll be discussing in the coming session. So, let's wind up for today. Thank you!