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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Dear friends, welcome to the NPTEL online certification course on modern food packaging technologies, regulatory aspects and global trends. We were discussing metals as a packaging material and we were discussing the manufacturing of the tin plate. The tinning process, tin plate is basically a steel product since it is essentially light gauge steel strip coated with tin on both surfaces. Large quantities of relatively strong tin plate are now manufactured by the technique of double reduction.

Thinner yet stronger tin plate can be produced by double reduction method which allows for more efficient material utilization in tin in kind making. After an initial cold rolling and annealing instead of temper rolling the steel is given a second cold reduction with lubrication of around 10 to 50 percent. The work hardening effect gives the steel additional strength, while the strip retains sufficient ductility for it to be formed into can ends and bodies. A two strand or three strand rolling mill can be used for double reduction.

In some plants a dual purpose mill is used which can produce double reduced material and operate as a conventional temper or skin pass mill. Double reduced steel shows very marked directional properties and the grain direction is always to be indicated and taken into account during forming operations with the final tin plate. Before entering the tinning line the strip is normally edge trimmed and inspected on a coil preparation line. A strip thickness gauge can also be installed so that off gauge or substandard black plate can be cut out. Coils of optimum weight are produced by welding strip lengths together.

There are two processes for the tinning of the black plates namely hot dip tinning process and electro plating process. Now the hot dip tinning process, hot dip tinning process is the process of emerging the steel black plate into a bath of pure molten tin at a temperature greater than 232 degree Celsius. The coating produced consists of a very thin inter metallic layer which first forms at the interface of the base material and the tin. For example, when dipping the black plate an iron tin alloy is formed followed by a layer of pure tin. The steel strip to be tin coated is first uncoiled and then subjected to a thorough cleaning and optionally pickling cycle.

Thereafter its entire surface is wetted with a fluxing agent suitable for the application usually a standard commercial product. This flux or soldering fluid activates the strip surface in preparation of the tinning process. The so called fluxing bath is followed by the

heated tin bath. Typically this is a resistance heated pot, but for high outputs the use of an induction heated pot can also be considered. Here the molten tin is held at the specified temperature and the amount of energy removed by the coated strip is substituted.

In this picture the tin coating process is presented. The steel enters from here and it is passing through the flux. The flux facilitates the coating of tin plate at tin as well as the iron plate and then it dips into the molten tin where the tin coating is done. After that it comes out from the that molten tin and then it is lubricated with palm oil and then it is rolled the coated steel. Due to since the steel sheet is at room temperature when it enters the temperature of molten tin depleted or decreases that has to be maintained by supplying heat from outside.

So that the temperature of molten tin is always maintained more than 232 degree Celsius which is the melting point of the tin. The advantages no waste from production process, no hazardous substance such as cyanogen and lead etc is used at all in the production process. The plating speed is very high which is several times higher than the electrolytic plating. Both thick coating and thin coating can be produced at around same speed. Thickness of tin layer is set by computer controlled air knife system, a contact free process which ensures particularly high surface qualities.

The coating and base metal is strongly bonded as intermetallic layer is formed during the hot dip process. Risk of whisker growth is very small since hot dip process makes crystal structure of tin uniform and minimizes its inner stress which minimizes risk of whisker growth. Now the electro plating process, in electro plating the item to be coated is placed on to a vessel containing a solution of one or more tin salts. The item is connected to an electrical circuit forming the cathode or the negative of the circuit while an electrode typically of the same metal to be plated forms the anode that is positive. When an electric current is passed through the circuit metal ions in the solution are attracted to the item.

For producing a smooth shining surface and electro plated sheet is then briefly heated above the melting point of tin. Presently tin plate is virtually processed only by the electro plating of tin on to the steel base by a continuous process. This is the manufacture of tin plate by the electrolytic process. The major reason for electro tinning, this is the major reason for electro tinning of steel trip replacing hot dip tinning process is because it gives a very high degree of thickness control including differential thicknesses of coating on the two sides of the steel sheet. The electro tinning process also gives higher outputs of tin plate with superior quality and at lower production cost.

Further with the improvements in the plating technology the steel base chemistry the thickness of steel base and tin coating have been gradually sufficiently reduced. There are

four basic choices of electrolytic plating processes which can be used to deposit tin and these are alkaline stannate, acid sulphate, acid flouborate and acid sulphonate. The stannate process is based on either sodium or potassium stannate. For high speed plating applications the potassium stannate is used since it has very high solubility as compared to the sodium salt. Of all the tin plating processes the alkaline process has superior throwing power.

The most important aspect of alkaline tin plating is the critical need for proper control of the anode. If the tin anodes are not properly controlled during the plating process rough porous deposits results. A yellow green film is to be present on the anode during the plating operation in order to ensure excellent plating. Components of tin plate the coating of tin plate consists of four components excluding the steel base which represents the bulk volume of the tin plate. These four components are the iron tin alloy layer, free tin layer, oxide passivation film layer consisting of chromium and chromium oxide and the surface layer which is normally lacquer or oil.

This figure gives the structure of the tin coating of the steel sheet. This is the normal or the black plate of steel substrate followed by the iron and tin alloy which develops during the hot dipping process and its thickness varies from 0.1 to 0.15 micrometers and then a free tin layer is there and the thickness varies from 0.4 to 1.35 micrometer followed by passivation layer which consists of chromium and chromium oxide and its thickness varies from 0.001 to 0.002 micrometers and after that a layer of oil or the lacquer is there which is having the thickness of 0.002 to 0.005 micrometers.

The passivation, the passivation is a widely used metal finishing process to prevent corrosion. In stainless steel the passivation process uses nitric acid or citric acid to remove free ions from the surface. The chemical treatment leads to a protective occasion of the process oxide layer or passivation film that is less likely to chemically react with air and cause corrosion. Passivated stainless steel resists rust. The three types of passivation are nitric acid, nitric acid with sodium dichromate and citric acid.

The process steps for passivating stainless steel are like this. The alkaline cleaning of the materials to remove all contaminants oil and foreign materials commonly uses detergents detergent cleaners like sodium hydroxide, micro 90 or simple green. After the process after that it is water rinsed and the water is generally deionized water or RO water in high precision industries followed by nitric acid or citric acid immersion bath to fully dissolve any free ion free ions and sulfides and expedite the formation of passive film or oxide layer formation followed by water rinsed again commonly with deionized water in high precision industries. Again a second water rinse is given again commonly with the deionized water followed by dry parts the test sample parts via specification standards using salt spray high humidity chamber exposure or copper sulphate testing. Now the

manufacture of tin free steel.

The tin free steel or TFS is an electrolytic chromium plated steel consisting of a thin layer of chromium and a layer of chromium and a layer of oxide deposited on a cold rolled steel based sheet or the black plate which gives it a beautiful lustrous metallic finish on both sides. It is also known as electrolytic chromium coated steel. Chromium coating has primarily been developed as an economical and high quality alternative to the tin plate. TFS offers outstanding corrosion resistance, lacquer adhesion and printability. The layer of chromium protects TFS against corrosion.

It is an economical and high quality replacement for the steel plate. Its appearance is less attractive that is lower brightness than the tin plate. The absence of tin makes TFS non appropriate for acidic food that is the foods having pH less than 4 because of lower corrosion resistance. TFS is not used without any biological protection for food products. This product protection is frequently given through lacquer.

TFS is excellent for lacquer adhesion and is always required to be lacquered on both the surfaces before use. The coating of TFS consists of three components excluding the steel base which represents the bulk volume of the tin plate. These three components are chromium metal layer, chromium oxide layer and layer of oil film. And this is given the typical bisection of a steel of the tin free steel is given in this where the base plate is the same as it is used in the tin cans and then the chromium and chromium layer is there, then chromium oxide layer is there and then oil film layer is there. The function of each of the layers are the role of steel substrate base is similar to that of the electrolytic tin plate.

It ensures the formability of the TFS during its usage and machining and provides strength to the finished products. Metallic chromium layer has a strong passivation capability and good corrosion resistance. But as it is cathodic coating it can only provide mechanical protection for steel base. Besides due to strong passivation capability of metallic chromium and extremely thin layer of passivation film is easy to produce chromium oxide. The chromium oxide layer has relatively high chemical stability and the electrode potential of the film is more positive than that of iron.

When surrounded by ordinary corrosive media it is a cathodic coating requiring coating to protect the contents. As an amorphous layer the layer can close pores of the metallic chromium layer and provide excellent coating adhesion. The oil film is applied to the strip to aid to de-piling of plates and to aid fabricability in can production. The role of the oil film is similar to that of the electrolytic tin plate. Oil film is necessary to reduce friction and scratches while handling the sheets.

The three most common oil types are di-octyl sabacate, butyl stearate oil and acetyl tributyl citrate. Production process of TFS. TFS is produced by an electrolytic treatment. The process is performed in a bath of chromic acid to deposit metallic chromium and chromium oxide on the black plate. Black plate coils are fed on to the TFS coating line being loaded on to the two uncoilers needed to allow continuous operation.

The tail end of the coil being processed is welded to the leading end of the next coil to be processed. This necessitates the two coils being stationary during welding. To avoid shutdown during welding lines are fitted with looping towers or accumulators which can hold varying amount of uncoiled plate. Most of the TFS coating lines incorporate side trimmers after the accumulator to cut the strip to the correct width. Many of the TFS coating lines incorporate tension or stretch levellers which apply controlled tension across the strip to remove distortions.

Chromium is deposited by electroplating in a bath of chromic acid to deposit metallic chromium and chromium oxide on the black plate. Plating is preceded by cleaning in a pickling and degreasing unit followed by thorough washing to prepare the surface. After coating the plate is given a light oiling to help preserve it from attack and to assist the passage of sheets through container forming machines without the damage of the coating layer. Finally the strips are sheared into sheets are coiled and then packed for shipment to the can manufacturers. This is the tin free steel making lines here the coil is passed through the loopers and which accumulates different amount of the black sheet.

So, that it can be welded and then it passed through the chromium coating and then it is passed through the oiler for the oiling and then it is either rolled in the coil form or cut into the desired size for the can manufacturing and then it is shipped to the can manufacturing units. That is all. Thank you.