# Tinplate as a Sustainable Packaging Material: Recent Innovation and Developments to Remain Environment Friendly and Cost Effective

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***Abstract:*** *Tinplate as a food packaging medium has survived for over 200 years. Sustainability of tinplate in the forthcoming era will depend on its cost effectiveness and environment friendliness. Steel and Tin constitute approximately 75% of the cost of production of tinplate. Efforts are primarily focused towards improving steel usage and reduction of tin consumption to drive cost effectiveness. Increasing awareness towards the environmental impact has driven the need to promote ecofriendly or green packaging, necessitating a renewed focus on conservation of natural resources. The efforts are not limited to the making of tinplate but also focus on opportunities to innovate at the upstream process of steel making and downstream process of can fabrication for improving sustainability of tinplate as a packaging medium. Tin being an important component that goes into the preparation of tinplate, due consideration has been given to identify the extent of Tin reserves. Innovation and development across the value chain which consists of preparation of Tin Mill Black Plate (TMBP) as feedstock for making tinplate; the tinplating process and the can fabrication process, are driven towards enabling reduce, reuse and recycle to achieve the twin objectives of cost effectiveness and environment friendliness.*

***Keywords:*** *Environment, Tinplate, Eco pickled surface (EPS), Innovation, Sustainability*

## I. INTRODUCTION

This paper tries to co-relate the history of tinplate technology and its usage to current development and technology up-gradation, driven by stringent market condition and environment conciseness.

Packaging is a very important component of a product and has multiple functions such as containing, protecting, transporting and informing to name a few. Packaging has come a long way since the use of materials such as leaves with a variety of substrates being used today, capitalizing on the advances in technology and human imagination.

In 1810, Peter Durand received the patent for the idea of preserving food in tin cans from King George III of England. The “tin can” immediately found acceptance and was used for international search for new territories and found its way across continents with Russia, Germany and United States being the initial beneficiaries who then commercialized production and used it to send products to South America and the Far East. Further developments through the 19th century ensured increased productivity in production of cans, sealing of cans, differentiation based on can shapes, pressurized cans and by the time of the World Wars, it was an integral part of packaging.

In 1938, the benefits of preservation of food in tin cans were further established through the chemical analysis of contents of a 100 year old canned product (can had been packed for an expedition but was not used), which was found to be in perfect condition.

Over the years, packaging innovation has led to more customer friendly designs along with usage of the right combination of forming technology, steel specifications (gauge consistency and clean steel – absence of non-metallic inclusions), infrastructure (particularly recycling infrastructure) and market conditions.

The tinplate can has evolved as the consumer demand has required it to, adapting, innovating and satisfying while preserving the qualities that provide its inherent value which is protection and strength. Further scope for development with lighter cans (current development in food processed can making suggests a further ~23% potential reduction).

**Competitive Position of Tinplate**

The packaging industry is positively correlated with the GDP growth of nations. The increase in GDP does facilitate in increase in per capita incomes and subsequent increase in higher disposable incomes. Packaging sales are hence expected to continue show strong growth with increased consumption and demand for consumer goods.

Packaging companies (known in the materials industry as "convertors") are engaged in the conversion of commodity raw materials into value-added consumer or industrial packaging. The commodity raw materials used for packaging can be demarcated into five main categories of packaging - Paper and Board (~34%), Rigid plastic (~27%), Glass (~11%), Flexible plastic (~10%), Beverage Cans (~6%) and Others (~12%).

**Table1. The preferences in applications for the various material substrates**

| Material | Packaging type | Preferred in applications |
|---|---|---|
| Paper and Board | Cartons, boxes, bags, wrappers | Light weight, lower cost, easy disposal and availability |
| Plastics | Cartons, bags, wrappers, pouches, bottles, containers, caps, pallets | Existing technology, light weight, corrosion resistance, versatility of use, attractive designing |
| Aluminium (Metal) | Collapsible tube, foils, containers, cans, closures | Good barrier properties, grease proof, shrink proof, tasteless and odorless |
| Glass | Bottles, jars, jugs | Transparent, good strength, high rigidity, gas and water-vapor barrier, chemically inert |
| Tinplate | Cans, containers, caps | Strength, good barrier properties, long shelf life, reusable, ease of recycling |
| Laminates (plastic and paper) | Pouches, films, tubes, bags | Strength, good barrier properties, grease resistance, heat-seal property, attractive designing |

Paper and Board industry has the largest market share and primarily uses cellulose which is obtained from certain plants and trees. Easy treatment, favorable cargo advantages and durability are the main reasons for choosing paper and cardboard packages in production. Technological advancements have ensured production in various shapes and forms along with ensuring lesser usage of raw material more robust yet thinner, lighter and cheaper cardboard production.

Rigid plastic is the second largest packaging category and is one of the faster growing categories which have also been at the cost of metal and glass packaging.

Glass packaging is used in packaging of alcoholic beverages, pharmaceuticals, chemicals and food products with alcohol and beer packaging being the major areas of usage. However glass demand is expected to slow down going forward.

A shift is expected from bulk purchases to smaller consumer packs with increase in nuclear families in urban areas whereas on the rural front, there has been growth in rural income and rising inflation. This has facilitated shift towards smaller pack sizes and driven flexible packaging growth. For example, sachet usage in personal care continues to grow along with rural driven demand for packaged foods like biscuits and snacks.

Beverage cans have found application in alcoholic and non-alcoholic beverages which use tinplate and aluminum predominantly as the metal substrates.

A comparative analysis of the various substrates shows that Tinplate is the most preferred substrate when important packaging parameters are considered. [1]

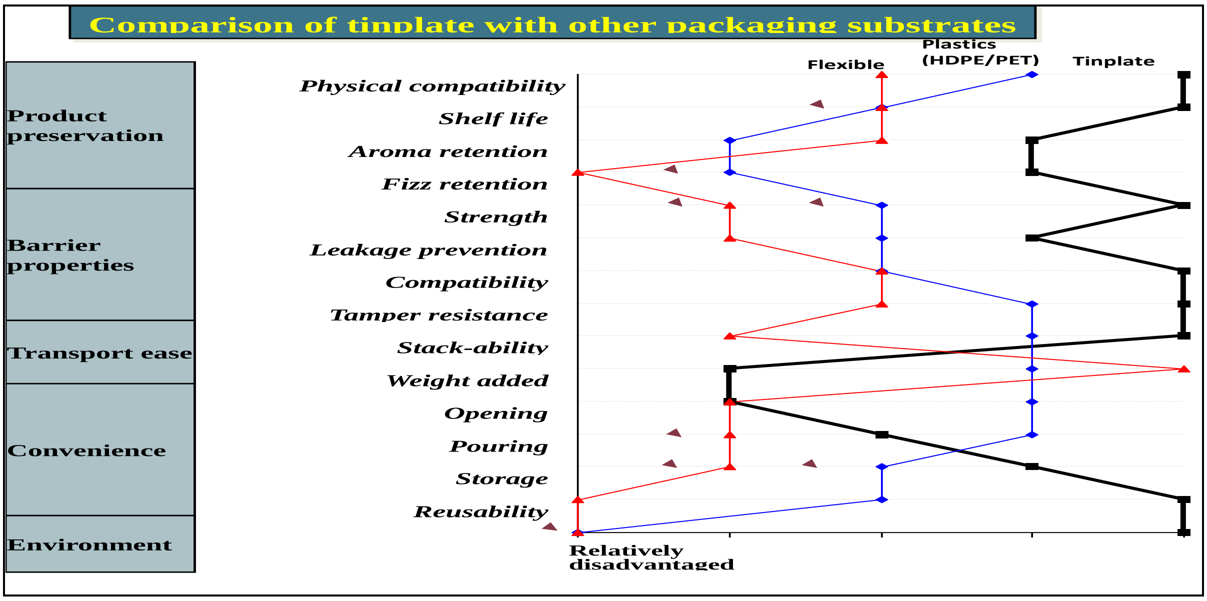



**Table2. Comparative chart for various substrates used for beverages packaging**

| Material | Barrier performance | Temperature tolerance | Environmental perceptions | Water tolerance | Seal ability | Decorative options | Strength | Recycle ability | Food compatibility |
|---|---|---|---|---|---|---|---|---|---|
| Paper | | | | | | √√ | | | |
| HDPE | | | | | √√ | | | | |
| PET | | | | | √ | √ | | | |
| Laminate | | | | | √ | √ | | | |
| Tinplate | √√ | √√ | √ | √√ | √ | √ | √√ | √√ | √√ |
| Aluminium | √√ | √√ | √ | √√ | √ | √ | √√ | √√ | |
| Glass | √√ | √√ | √√ | √√ | | | | | √√ |

The macroeconomic environment has been challenging for the packaging industry in recent years, given pressures on consumer spending and their exposure to fast moving consumer good (FMCG) products. The combination of Euro zone economic uncertainty and raw material and energy price fluctuations has been putting pressure on convertors.

On the supply side, key feedstock suppliers are key feedstock suppliers are typically large global suppliers that have the power to pass on higher commodity costs and increase prices to their customers when supply is tight, which in turn increases input prices for the packaging producer.

On the customer side, there are large and powerful consumer goods companies that may not wish to pass price increases to end consumers and use the threat to switching to keep suppliers in line. This makes it important for the value chain to be as competitive as possible. The packaging value chain is as given below.

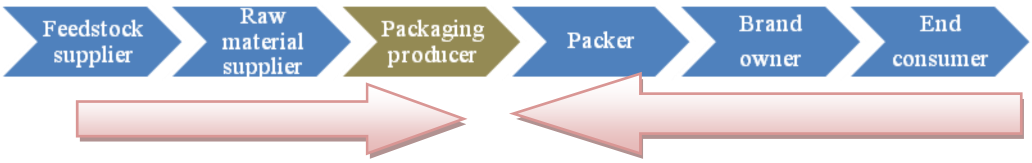



**Figure 1: Packaging Value Chain**

The competitive advantage hence will hence come from increasing the cost effectiveness of the Packaging value chain which needs to be driven by improving the cost effectiveness of the substrate that is being used so that the share of market can be increased.

The cost effectiveness of the usage of a substrate would depend on the following parameters.

- The raw material consumption accounts for approx. 65-70% of the total cost. Reduction in the usage of raw material per stock keeping unit through down gauging effectively leading to more cans per ton of raw material.
- Tin consumption accounts for approx. 7-9% of the total cost. The amount of tin coating that is done per unit area is the other area where reduction in costs can be brought about.
- Strengthening material strength by improving the mechanical properties of the substrate.
- Product development for customizing substrate parameters to end application to ensure optimization.

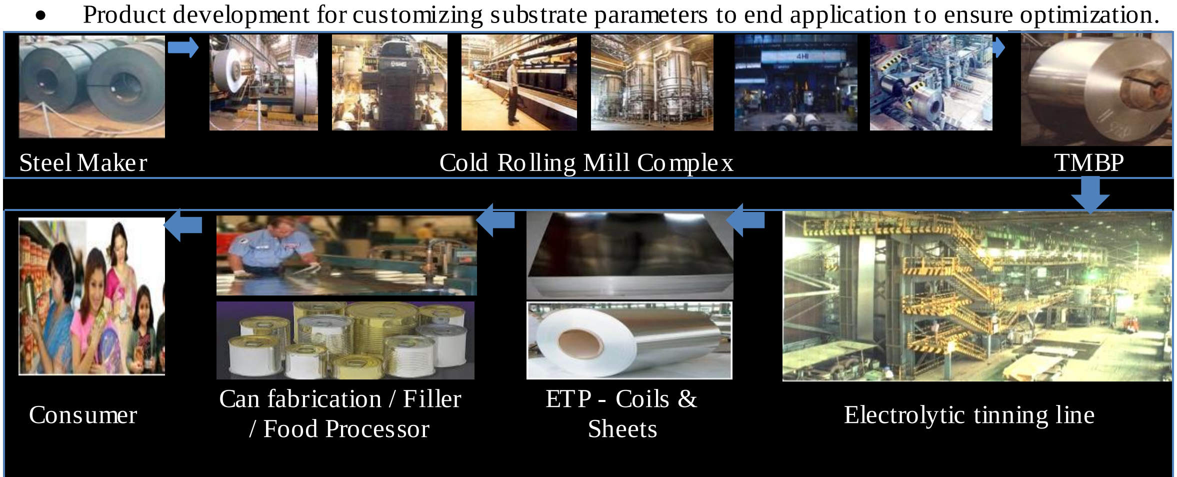



**Figure 2. Industry Value Chain**

**Innovations in manufacturing of TMBP**

***Acid Pickling replaced by Eco Pickled surface (EPS)***

Eco Pickled Surface, EPS, is a proven and patented process invented by The Material Works (TMW) to replace acid pickling of flat rolled steel. Like acid pickling, EPS removes mill scale from the surface of hot rolled steel, including stainless. Unlike acid pickling, EPS pickling is safe and completely harmless to the environment. [2]

Not only is EPS a better process than acid pickling, it produces a notably better steel product. The EPS process actually conditions the surface of the strip, making it very uniform and remarkably clean. It removes or mitigates mill surface defects and produces a surface texture that is optimized for paint adhesion and appearance. EPS even achieves this for high carbon/alloy and stainless steels, but without slowing the processing line speed as acid pickling requires.


**Figure 3. EPS processed coil** **Figure 4. EPS production line**

And EPS-processed steel resists rusting with no protective oil coating. After acid pickling, a thin film of oil is applied to prevent rusting of the bare steel surface. This is not needed with EPS – the surface is inherently rust-resistant and can be stored "dry". Such a clean, oil-free surface offers numerous advantages for fabricators and manufacturers:

1) Faster Laser & Plasma Cutting
2) Stronger, More Uniform Welds
3) 'Leaner' Paint Pre-Treatment
4) Reduces Toxic Welding Fumes

EPS Cells can also increase the capacity of acid pickling lines. This can work two ways:
(a) replace acid tanks with EPS Cells to convert an acid pickling line to an acid-free EPS line, or
(b) place an EPS Cell ahead of the acid tanks to perform a 'pre-descaling' that lessens the Load on the acid tanks, thereby achieving faster line speed. This totals four EPS Cell configurations:
That's one reason why the economics of EPS processing are so much better than acid pickling. Capital costs, variable costs of operation and space requirements of an EPS production system are much lower than an acid pickling line of the same capacity:

1. 20% Less Capital Cost
2. 30% Lower Operating Cost
3. 50% Less Space Needed
4. 50% Lower Installation Cost

**Zoom Reversing Mill (Cold rolling)**

As described in the foregoing section, unrolled portions are produced in the head and tail ends in conventional reversing rolling mills; then, the author thought that the unrolled portions would be reduced by weld-joining the portion to the head end of a base coil on the line as a leader strip prepared in advance. If a spot welding machine having a track record in strip passing of process lines is employed, relatively inexpensive facilities can be set up and the time of operation can be shortened due to short welding time.

Items to be checked at the occasion of development were how the strength and durability of the welded portion would be, whether or not adequate rolling tension would be obtained by spot welding, whether or not there would be a problem if rolling oil becomes involved, and so on.

After various basic data regarding the strength of a spot welded point were taken using a direct stress machine, experimental equipment of a spot welding machine shown in Figure 5 was installed in a pilot line, and then, testing was conducted.[3]

Figure 5. Experimental equipment of spot welding machine

**Achievement of applying Zoom into a practical mill**

If a leader strip is provided to both a head end and a tail end, the yield is significantly improved, but on the contrary it ends up with a result that the productivity is inhibited since it takes time to deal with the leader strip remaining in the inner periphery. At the occasion of the application into a practical machine, it was decided to employ a rolling method to finish through even numbered passes in a manner in which a leader strip is provided only to the delivery tension reel and connected to the head end of a hot coil using a spot welding machine, aiming improvement of productivity as well as reduction of unrolled portions with an eye to reversing rolling mills for use of normal carbon steel having high demand in emerging countries. The basic concept of the application into a practical machine is illustrated in Figure 6.

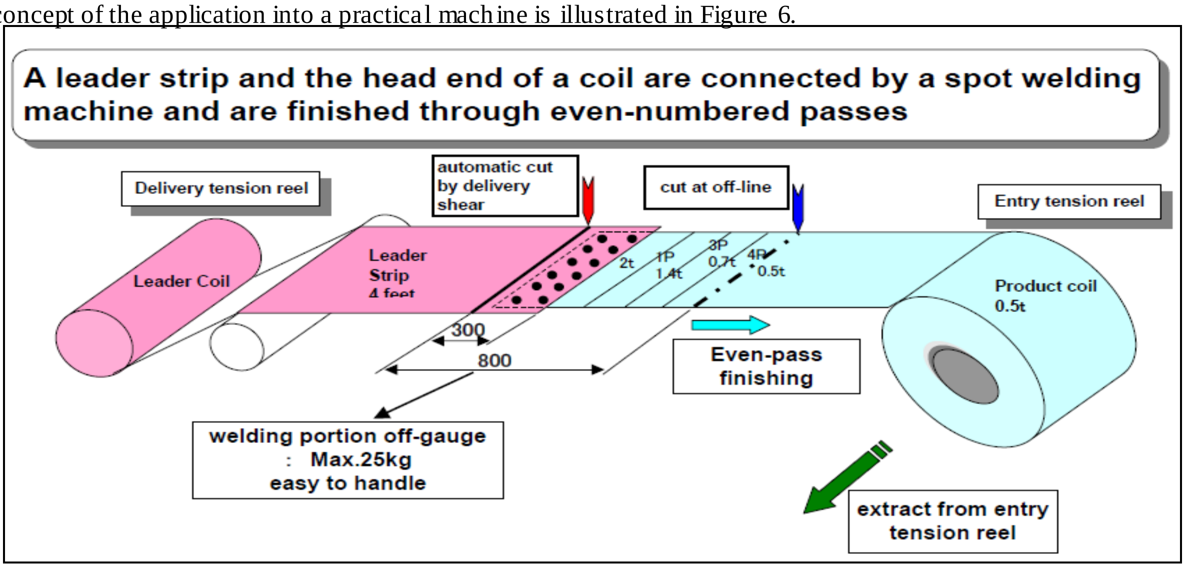



**Figure 6. Basic concept of Zoom-MillTM**

The welded portion is cut off from the leader strip by means of a delivery shearing machine after completion of rolling and is brought out using an entry coil car in a state of being attached to the product coil to be dealt with at an off-line location. This is due to that the facility for dealing with welded portions is not desired to be located on the rolling line, and also the time for dealing with on the line is not desired for productivity.

**Effects of Zoom rolling Method**

The effect of reduction of unrolled portions by means of this rolling method is illustrated in Fig.7.

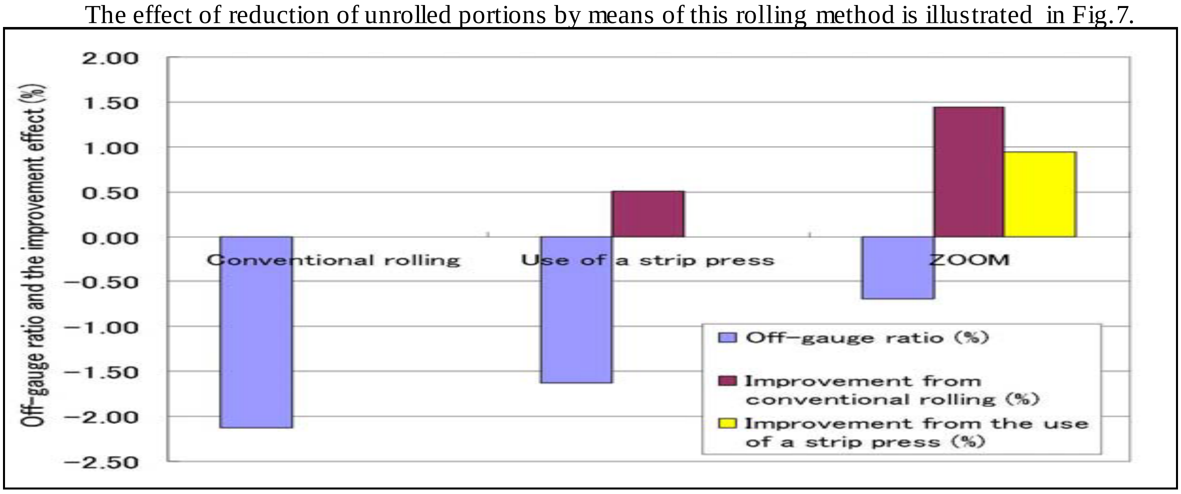



**Figure 7. Effect of reduction of unrolling portions**

The rate of off gauge by means of this rolling method is 0.7%, which is improved by 1.4% as compared with conventional rolling and also improved by 0.9% as compared even with the conventional rolling using a strip press. In the case of a mill having an annual yield of 250 thousand tons, it means that hot coils of 2,250 to 3,500 tons per year would not be necessary to be used, which brings about a great merit. In addition, since it is possible to roll from the head end by applying tension, this rolling method is thought to be superior in regard to the strip threading stability, strip thickness accuracy and strip flatness as compared with other off-gauge reduction methods.

**Effect of productivity improvement**

As illustrated in Table 3, it is known that processing time per coil (excluding rolling time) can be reduced in accordance with this rolling method, even though spot welding consumes some time, since it is not necessary to spend time waiting for a rolled coil being taken out to an off-line position, time for threading the next strip to the delivery tension reel and winding it several rounds in a state of holding it, and so on. Moreover, since a small coil (pup coil) of an unrolled portion is not produced, a work for taking out it by fastening with a band is eliminated.

**Table 3. Processing time per coil (excluding rolling time) Unit in Minutes**

| | Conventional rolling | | Zoom rolling | |
|---|---|---|---|---|
| Pass No. | Coil Change, Threading | Set-up, Coolant Spray | Coil Change, Threading | Set-up, Coolant Spray |
| 1 | 0.9 | 0.3 | 1.3 | 0.3 |
| 2 | 0.9 | 0.3 | 0.9 | 0.3 |
| 3 | 0 | 0.3 | 0 | 0.3 |
| 4 | 0 | 0.3 | 0 | 0.3 |
| 5 | 0 | 0.3 | 0 | 0.3 |
| 6 | 2.1 | 0.3 | 0 | 0.3 |
| TOTAL | 3.9 | 1.8 | 2.2 | 1.8 |
| | 5.7 | | 4.0 | |

Next, the production capability in the case of finishing through even-numbered passes will be described.In Figure 8 is shown production per unit hour (T/H) in the case in which averaged gauge products each having an individual strip width were rolled by finishing through 4 passes, 5 passes and 6 passes in a certain steelmaking plant.

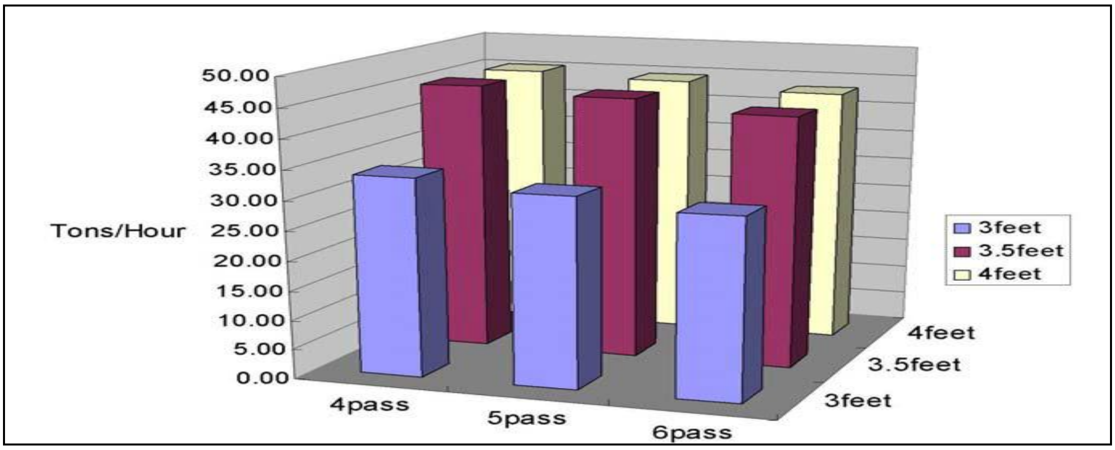



**Figure 8. Production rate for respective strip widths**

In spite of the same workload, the more the number of passes was increased, the lower the productivity became due to the increase of time for changing passes, acceleration/deceleration, and so on. In Figure 9 is shown a comparison of ordinary rolling through 5 passes and the case in which Zoom rolling method was applied when finished respectively through 4 passes and 6 passes.

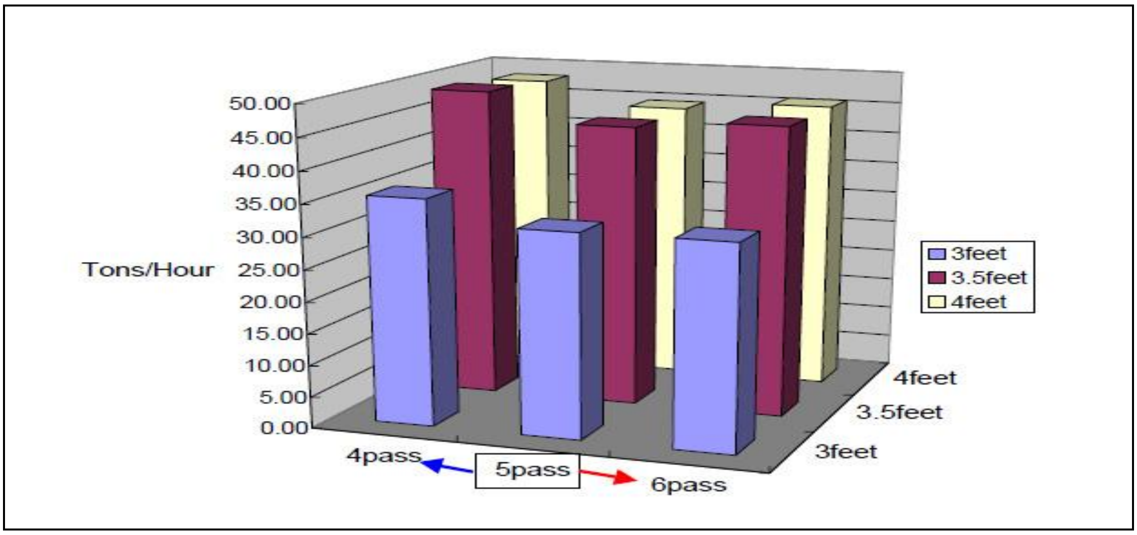



**Figure 9. Production rate for respective strip widths as compared with when Zoom is applied**

It is known that the productivity was further improved by applying Zoom rolling in the case of 4 passes, and even in the case of 6 passes, the productivity became improved as compared with ordinary 5-pass rolling due to contribution of shortened processing time per coil.

In Figure 10 is shown the effect of increased production due to Zoom rolling. The productivity has been increased by approximately 10% at 4 passes, and by approximately 2% at 6 passes.

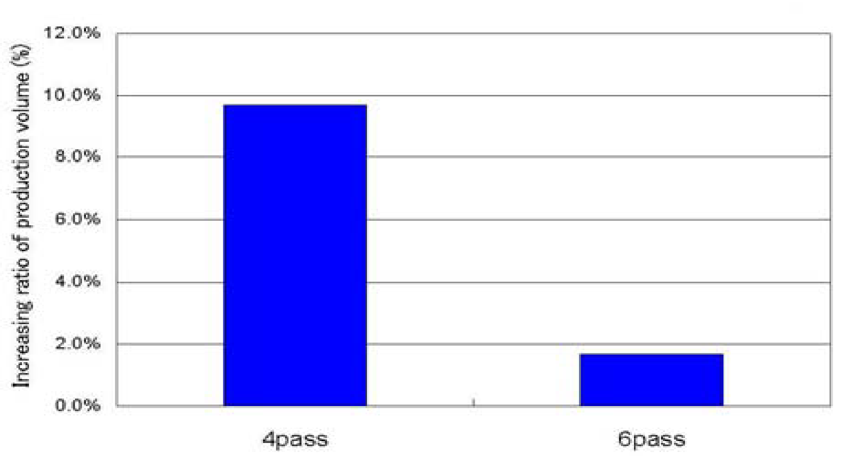



**Figure 10. Effect of production increase due to Zoom rolling**

In the case in which even-numbered passes are introduced into a practical operation, it is not possible to reduce the number of passes of all the processes, but it is necessary to increase the number of passes of substantially half the processes.

***Summary***

There has been developed a new rolling method and facility (Zoom-MillTM) that allows a leader strip and a product coil are connected using a spot welding machine and are finished through even-numbered passes in a reversing cold rolling mill. It is expected to reduce unrolled portions (improvement of yield) as well as improvement of productivity. In recent years, it becomes important to form a recycling-based society from the viewpoint of global warming prevention, and the promotion of 3R (Reduce, Reuse and Recycle) is required in every industrial areas. "Reduce (no production and no use of excessive goods)", which does not generate greenhouse gases, is particularly regarded to be most important. This rolling method is just a technology belonging to the "Reduce", so our company intends to work for development of products that are friendly to the environment, as well as to make an effort for spreading the use of this rolling method and its facilities.

## *Ultrasonic Strip Cleaning*

Replacing the conventional electrolytic cleaning by high pressure cleaning technique thereby *reducing energy consumption (Reduce*):

Essential customer demands for refined sheet products are good machinability in secondary manufacturing process and long term preservation of the final product. These qualities are fundamentally determined by the functional layer applied to the metal surface. The compound between the functional layer, e.g. the Zinc/Tin layer and the steel strip surface is primarily based on the adhesive strengths within the boundary surface. Deposits on the surface, such as abraded iron particles, oil or rolling emulsion remains, disparage the adhesion. The functional layer is not able to adequately fulfill the purpose; it is only irregularly applied or is easily removed under mechanical pressure.

Cold rolled strips are burdened with rolling emulsion and rolling residues resulting from the rolling process. Deposits of about 500 mg/m2 per side, consisting of rolling emulsions, abraded iron particles and other dirt are therefore likely. Steel strip burdened in this way has to be relieved of these residues resulting from the cold rolled process before it enters into further surface refining. In accordance with state of the art technology this procedure is executed in a malty-stage strip cleaning section. A combination of an alkaline spray cleaning with brush support for the removal of surface deposits, and electrolytic cleaning for deep pore cleaning and a final malty-stage rinsing with fully demineralized water is used in this section.

***Technology of High Pressure Cleaning***

The high pressure cleaning connects the cleaning of surfaces by active surfaces processes (liquids in the strip cleaning medium) with the mechanical removal by the kinetic energy of the fluid stream. The hot fluid stream bounces against the strip surfaces with high velocity. Loose surface layers get rinsed. More stable layers get broken up and also rinsed by the kinetic energy of the bouncing fluid. The lipid parts in the additive strip cleaner partly support the refining process.

The essential function of the lipids is the bond of removed disposals in the fluid. The removed film is bonded within the fluid phase and does not get in contact with the strip surface again. This prevents a regressing/recontamination. Without the lipids the only parts of the removed disposals swim on the fluid (drops, jet, full streaming etc.) because of their less density und nonpolar structure and is given off with another contact with the surface.

The cost efficient use of the high pressure cleaning requires the circulation of the cleaning medium through the high pressure pump. The cleaning media is a multiple phasing fluid, consisting of a fluid phase of the cleaner and included gas or foam bubbles.

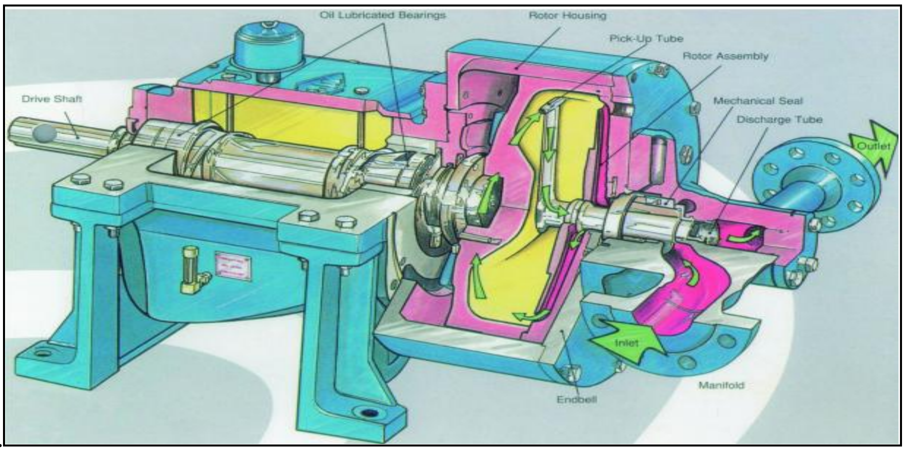



**Figure 11. High Pressure Pump**

***Technology of the Ultrasonic Cleaning***

The ultrasonic cleaning combines the cleaning of the surface by active processes on the surface (lipids in the strip cleaning medium) with the mechanical removal by kinetic energy of imploding gas bubbles. The ultrasonic oscillations lead to local pressure fluctuation in the fluid. In sections where the pressure goes below the gas pressure of the released gas or the stream pr3essure of the fluid, tiny cavitation bubbles develop. The bubbles rapidly implode because the artificial conditions which lead to the forming of bubbles only exist for a short time. The shock waves which are induced by the implosion of the gas bubbles (especially on the strip surface) blast away the dirt on the surface. Surface layers which are loses become removed. More stable layers are broken up by shock waves and also washed away. The lipid parts in the added strip cleaner partly support the cleaning process. The main function of the lipids is the binding of the removed dirtying in the fluid.

Beneath the high quality and reproducibility of the cleaning results materials can be cleaned mechanically but without any contact. Depending on the cleaning requirement you can therefore abstain from aggressive chemicals and high temperatures. The chemical additives (cleaning agents) which support the aqueous ultrasonic cleaning are added in a low percentage and are similarly important in the choice towards the required ultrasonic performance and the working frequency. Depending on the field of application the ultrasonic cleaning produces a high-quality and homogeneous cleaning result that cannot be achieved by any other cleaning process.

***Efficiency of the High Pressure and Ultrasonic Cleaning Technology***

Efficiency and quality of the high pressure and ultrasonic cleaning technology has been examined in different tests at the pilot plant for strips. The technological cleaning in the pilot plant for strips essentially consists of a pair of high-pressure spraying headers and an ultrasonic leaning tank. Detailed tests have confirmed that the cleaning efficiency for different kinds of steel strip is improved over the conventional strip cleaning section.

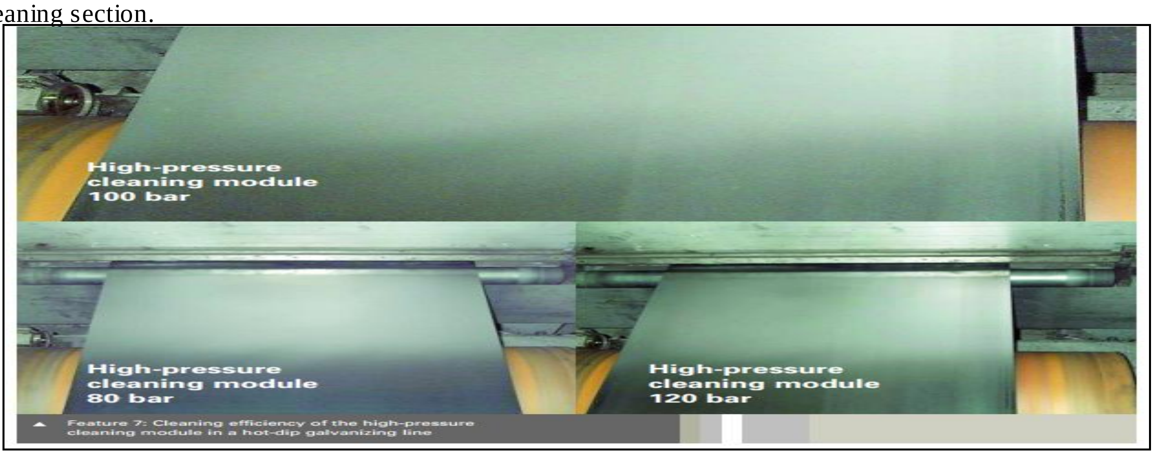



**Figure 12. High-pressure cleaning module**

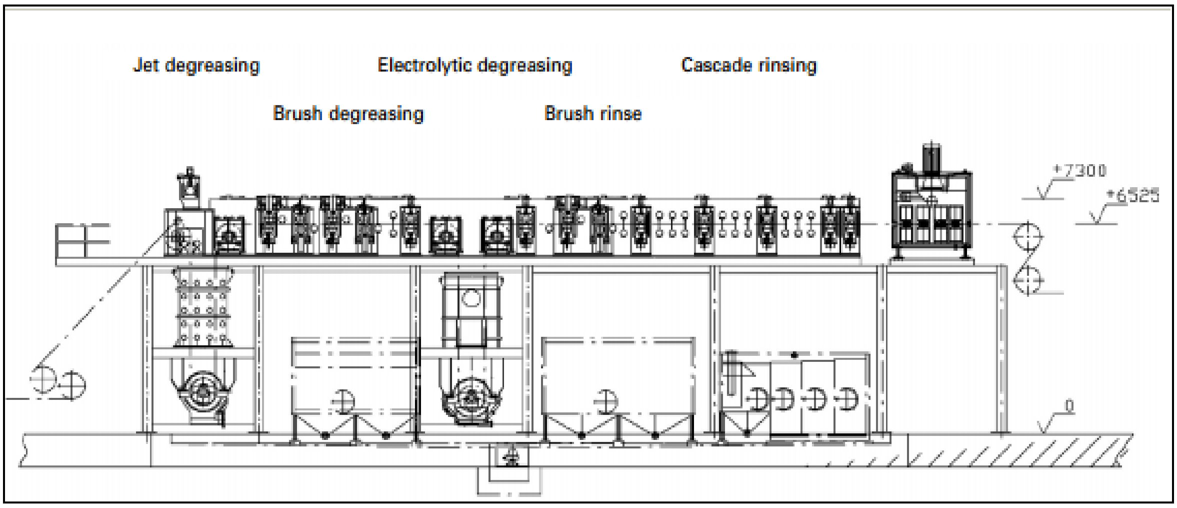



**Figure 13. High-performance Strip cleaning (Conventional Design)**

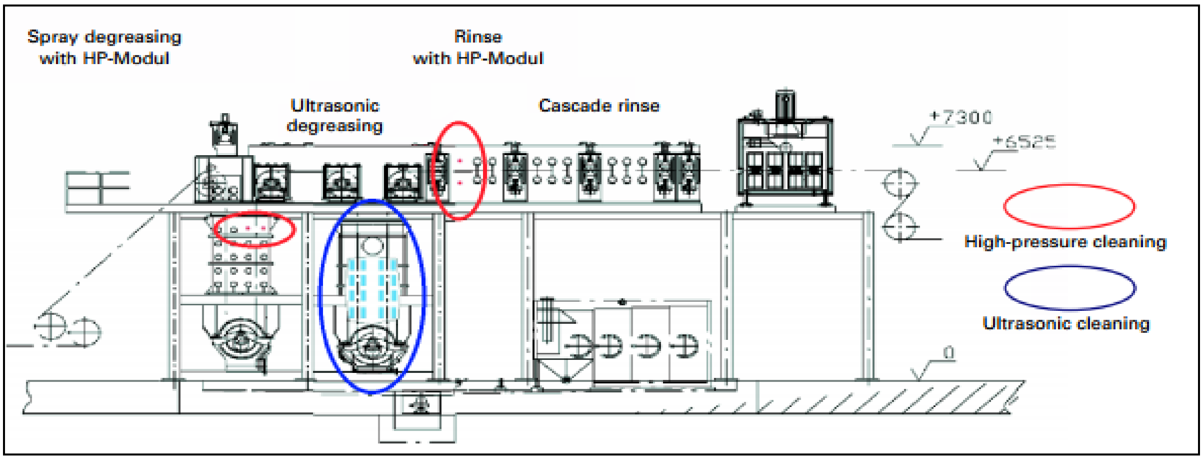



**Figure 14- High-performance Strip cleaning with high pressure and Ultrasonic Cleaning Module**

## II. INNOVATIONS IN TINPLATING TECHNOLOGY

*Replacement of consumable Tin anodes with insoluble anodes*: Improves product quality and productivity; recovery of metallic tin from tin sludge (*Reuse*)[4]

***Background of development***

Use of insoluble anodes only for electrolytic tinning line(6) Electrolytic tinplate, which are a kind of surface-treated steel sheet, have been long used as the material for containers. Conventionally, cast tin anodes were used in the electroplating process to produce tinplates: tin in the anodes are electrolytic ally dissolved and supplied to the base metal surfaces. However, this method has some problems in the product quality and equipment operation (which is explained later), and the long term dream of persons related to tinplate production was to replace all of the anodes of an electrolytic tinning line (ETL) with insoluble ones.

After years of research and development, Nippon Steel developed a method for chemically dissolving tin and supplying it in the form of ions and other related elementary technologies. Based on these technologies, they established a technology for the all-insoluble anode ETL, and was first to apply it to commercial production.

The problems with soluble anodes are as follows:

(i) The replacement of consumed tin anodes with new ones is labour intensive.

(ii) Tin anodes cannot be spent until they are completely depleted, which implies a waste of expenses incurred to form them by casting.

(iii) As tin anodes wear out, they change shape, requiring manual position adjustment. For this reason, it is difficult to shorten the anode-cathode (strip) distance to save power.

(iv)Since individual tin anodes wear out unevenly, the anode-cathode distance becomes uneven, leading to inhomogeneous coating thickness in the width direction.

(v) Because anode efficiency (tin dissolution) is higher than cathode efficiency (tin deposition on base metal surfaces), the tin ions accumulate in the electrolyte, making it necessary to discharge the

electrolyte partially (liquid loss) and dilute it with fresh liquid at regular intervals.
(vi) The edge overcoat is inevitable, which means that some of the tin is wasted. (To allow the anode to easily change work, it is not possible to install edge masks to prevent edge overcoat.)

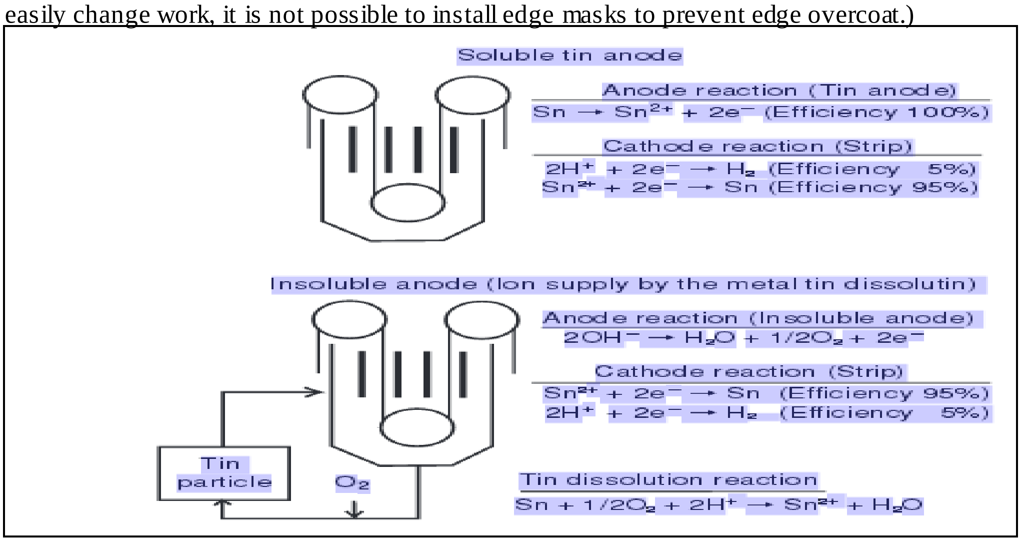
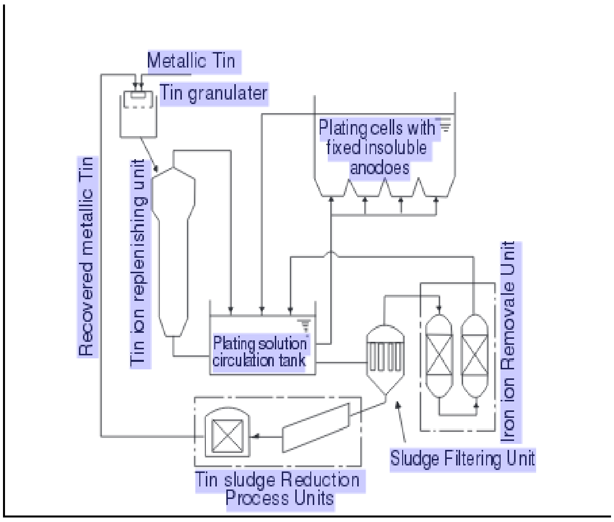



**Figure 15: Plating method of insoluble & soluble anode system**

Insoluble anodes as used in electrolytic galvanizing, and tin-free steel lines can solve all of these problems. The reason for the ex-tended use of soluble tin anodes for ETLs was that the only industrially applicable method of dissolving tin was the electrolytic ionizing method.

***Results of all-insoluble anode operation***

The developed technology presented above made it possible to produce electrolytic tinplates using only insoluble anodes (see Fig.16, solving all the past problems 5, 6)
(i) Improvement in product quality Fig. 17 compares the coating thickness distribution in the width direction of tinplates manufactured by both the conventional and developed methods. Resulting from the all-insoluble anode operation and provision of edge masks, very homogeneous transverse thickness distribution was obtained. Therefore, the welding work was significantly improved at car manufacturing plants.



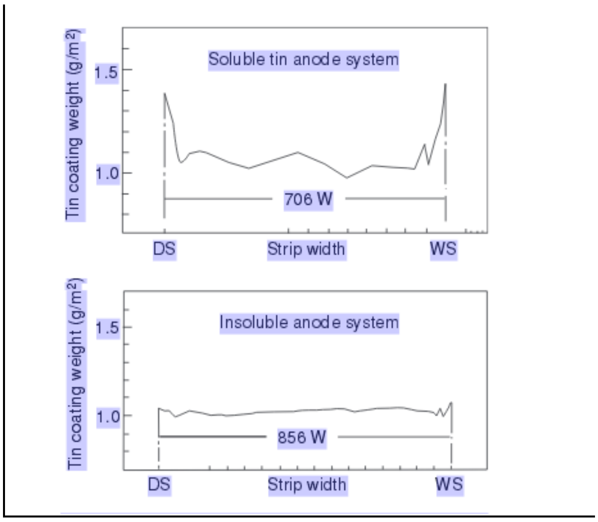




**Figure 16**
**Schematic diagram Insoluble Anode**

**Figure 17**
**comparing coating thickness distribution**

***Future prospects***

The all-insoluble anode system for ETLs that was first developed worldwide by Nippon Steel has expanded its applications in Japan and at overseas-based joint venture companies. In addition, the system has found applications at several overseas steelmakers through license, and many others are considering its introduction, which confirms the industrial value of the technology. New types of tinplate products that make use of the advantages of this epoch-making technology have been developed and marketed.

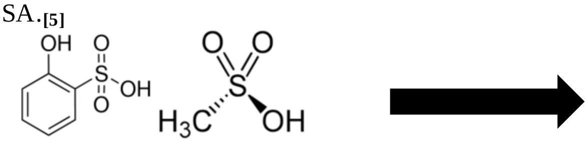
From the viewpoint of environmental protection, thinner gauges and lighter coating weights will be required for container materials, and the advantages of the insoluble anode method will be more significant.

**Phenol Sulphonic Acid (PSA) to Methan Sulphonic Acid (MSA) Conversion**

Replacing a toxic compound with non-toxic compound to reduce environment degradation (*Reuse*). Tin-plating of steel has been a foundational technology for modern food packaging, and turnkey electroplating technologies have been established over the last 70 years to serve the world's demand for safe food in cans. Now, with the cost of tin (Sn) metal having risen to 20-30 times higher than it was in the 1990s, and with greater concern over environmental release of toxic byproducts, legacy Sn electroplating lines are reconsidering switching to the more efficient and benign methane sulfonic acid (MSA) chemistry.

In typical modern tin-plating processes, continuous strips of steel move rapidly (500 m/min) through the following sequential process steps: cleaning, acid activation, electroplating Sn, fluxing, reflow melting to produce a mirror-bright finish and passivation to protect against oxidation. Some sort of fluxing agent is needed to ensure that the tin-hydroxide species left on the surface after tin-plating are soluble after high-temperature reflow melting; failure to do this results in a dull surface. One of the reasons phenol sulfonic acid (PSA/ENSA) legacy chemistries currently represent the largest installed base globally is the ability for "self-fluxing" to occur with dilute electroplating chemistry.

MSA-based technology has been enhanced by Dow over many years to improve its efficiency. Current chemistries produce bright conformal Sn coatings at high speed and with minimal sludge. MSA is also environmentally friendly as compare to PSA.[5]



Phenol sulphonic Acid (PSA) Methane sulfonic acid

**Table 3 :c**omparative chart between PSA and MSA

| **Phenol sulphonic Acid (PSA)** | **Methane sulfonic acid (MSA)** |
|---|---|
| PSA is a highly toxic compound and it has been classified as a "priority pollutant" | MSA (CH3SO3H, CAS RN: 75-75-2) is a clear, colorless liquid available as a 70% solution in water and anhydrous forms. |
| The acute toxicological effects of phenol and its derivatives are largely on the central nervous system. Acute poisoning can lead to severe gastrointestinal disturbances, kidney malfunction, circulatory system failure, lung edema and convulsions. | It is a non-volatile, strong acid that is soluble in organic solvents. Methane sulfonic acid is convenient for industrial applications because it is liquid at ambient temperature. |
| Emission of this hazardous organic compounds in wastewaters and drainage as a result of industrial usage needs substitution as it cannot be totally bio-degraded | Methane sulfonic acid is considered a particularly suitable supporting electrolyte for electrochemical applications, where it stands as an environmentally friendly alternative to other acid electrolytes. |

**Polymer coating of ECCS:** Recycled (Polyethylene terephthalate) PET usage on ECCS with a higher adhesion (*Reduce*).

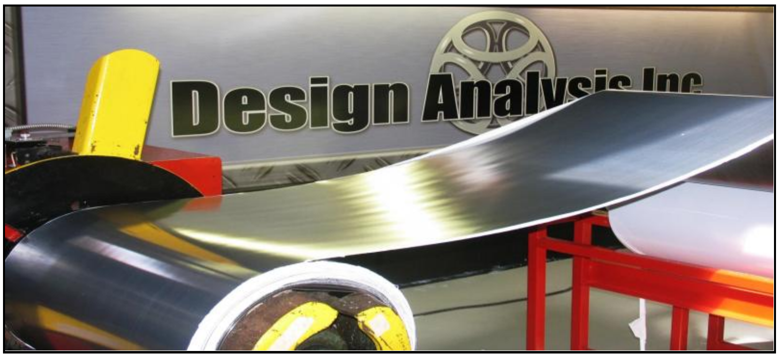



**Figure 18 – PET surface coating**

Recycled (Polyethylene terephthalate) PET used as surface coating with a higher adhesion compared to traditional strength as an innovative sustainable solution.[6]

The material employed is an eco-efficient, environmentally-friendly, chromium (IV)-free (non-carcinogenic) metal polymer. This thin, multilayered electrolytic chromium-coated steel (ECCS) laminate protected by a polyethylene terephthalate (PET) coating.

PET coatings provide an improved protection barrier effect between the food and chromium layers deposited on the base steel of the container. The layers and metal substrate combine together to give abrasion and degradation resistance against aggressive electrolytes and structural rigidity to the can.

The PET polymer is located in the internal wall of the container and contributes to preserving the organoleptic characteristics of food in time, preventing physicochemical interactions with the environment.

**Characteristics**

a) Ecofriendly
b) Recyclable
c) High resistance to temp and pressure
d) Excellent Chemical resistance

**Advantages**

a) Better appearance
b) Cheaper price
c) Easy open ends
d) Triple food technology
e) Suitable for thermal processing
f) Higher shelf life

## III. INNOVATIONS IN CAN MAKING TECHNOLOGY

***Airless Aerosol Cans:*** Replacement of Greenhouse gases used in propellant by airless systems (To *reduce* hazardous waste generation and enhance *recyclability*).

Thin-walled steel or aluminium Aerosol is pressurized with one of several volatile hydrocarbon propellants, such as carbon dioxide, propane and butane. These propellants are "greenhouse gases" that contribute to global warming and smog formation.

In general it can be said that an aerosol can never is completely empty, consequently the post-consumer spray cans, however, are considered hazardous waste because they contain ignitable or chlorinated solvents or other toxins such as pesticides and phthalates.

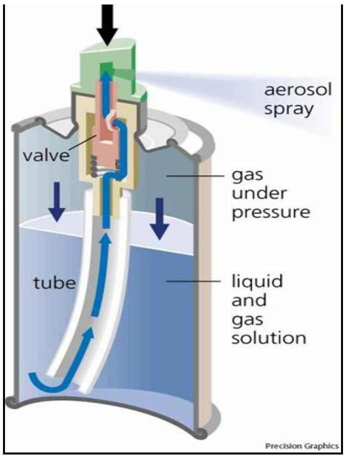



Figure 19 - Inner view

Figure 20 - Outer view

There are two main types of airless systems, but the most used is the piston airless system. A piston airless system uses a molded piston in the bottle, to help push the product out of its package. Airless systems by design create a vacuum. The piston helps maintain that vacuum.

Recently the pouch airless system is getting popular, capturing a significant percentage of the airless market. A pouch system is made of a rigid bottle containing a soft pouch with an airless pump. When the product is expelled, the pouch shrinks so that there is no air intake inside the pouch.[7]

**Self- Heating Cans: Self heating Cans reduce power consumption and are 100% recyclable**

A Self-heating can is an enhancement of the common food can. Self-heating cans have dual chambers, one surrounding the other, making a self-heating food package.[8]

The inner chamber holds the food or drink, and the outer chamber houses chemicals that undergo an exothermic reaction when combined. When the user wants to heat the contents of the can, a ring on the can when pulled breaks the barrier that keeps apart the chemicals in the outer chamber from the water. In another type, the chemicals are in the inner chamber and the beverage surrounds it in the outer chamber. To heat the contents of the can, the user pushes on the bottom of the can to break the barrier separating the chemical from the water. This design has the advantages of being more efficient (less heat is lost to the surrounding air) as well as reducing excessive heating of the product's exterior, causing possible discomfort to the user. In either case, after the heat from the reaction has been absorbed by the food, the user can enjoy a hot meal or drink.

Self-heating cans offer benefits to campers and people without access to oven, stove or camp-fire, but their use is not widespread. This is because self-heating cans are considerably more expensive than the conventional type, take more space, and have problems with uneven heating.

**Figure 21 - Coffee Can**


**Figure 22 - Food Can**

**Heating Technology**

The source of the heat for the self-heated can is an exothermic reaction. When the user pushes on the bottom of the can, a rod pierces the membrane, allowing the water and heating agent to mix. The resulting reaction releases heat thus warms the beverage surrounding it.[1]

The heating agent and responsible reaction vary from product to product. Calcium oxide is used in the following reaction:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s) \quad (1)$$

Coppersulphate and powdered zinc can also be used, but this process is less efficient:

$$CuSO_4(s) + Zn(s) \rightarrow ZnSO_4(s) + Cu(s) \quad (2)$$

Anhydrous calcium chloride is often used as well. In this case, no chemical reaction occurs; instead the heat of solution is generated.

**Advantages**

a) High Performance: Heat the food less than 2 minutes
b) Easy to Use: With the push of a button heating started
c) Heating agent is light weight and allows high food to heater ration.
d) Safe and sustainable.

**Lightweight Crown corks**

**Thinner gauge corks (To Reduce Carbon footprint in the Long term).**

The crown cork, the first form of bottle cap, was invented by William Painter in 1892 in Baltimore. It is also known as a crown seal, crown cap or just a cap. The company making it was originally called the Bottle Seal Company, but it changed its name with the almost immediate success of the crown cork to the Crown Cork and Seal Company. It still informally goes by that name, but is officially Crown Holdings. Crown corks are similar to the Pilfer proof caps, as usage of both products is to seal the bottle.

The crown cork was the first highly successful disposable product (it can be resealed but not easily). Prior to the invention of the crown cork bottle stopper, soda bottles had ordinary cork bottle stoppers and often had rounded bottoms so they could not be stored standing upright. The reason for this is corks have a tendency to dry out and shrink, which allows the gas pressure in the bottle to cause the cork to "pop." Storing bottles on their side prevents the corks from drying out and "popping." After the invention of the crown cork bottle stopper, this problem was eliminated, and soda bottles could be stored standing upright.[9]

**Crown cap top view** **Crown cap bottom view**

**Figure 23**

Innovation related to new generation of Light weight corks - a sustainable solution:

a) Improving sustainability through alternative designs as better optimizing prices
b) Down gauging from 0.22mm to 0.18mm
c) Challenging and eliminating PVC as competition
d) Focussing on transition from 0.24mm to 0.18mm which in long term will impact tons of thousands of crown produced annually.
e) Net resulting in reduction to over 60 thousand tons of lesser $CO_2$ emissions

**Re-closable cans**

This re-closable system is an innovative new product development for cans ranging from 200 ml to 1.0 liter. Its “user friendly” opening mechanism works by simply pulling up an integrated open/ closure strap, the sliding it backward for drinking and forward for closing. Resealed/ reclosed cans are pressure stable and entirely gas as well as liquid tight. A tamper–proof seal that covers and secures the opening strap, breaks when initially opened, Re-sealable ends are suitable for a variety of products and can be processed on existing filling lines without modification of same or capital investment. It helps reduction in downtime and better aesthetics (Reusable and Recyclable).[10, 11]


**Re-closable cans** **Re-closable cans** **Re-closable cap**

**Figure 24**

The cans can capable of being tightly closed again after opening. Benefits are:

a) Re-closeable end
b) Injection-molded polypropylene components and sealing ring,
c) Saving downtime of filling companies Cost effective
d) Low profile making the ends more stackable.
e) Filler benefits:
    1. Runs on standard filling lines
    2. High throughput (~1800/min)
    3. Fits standard can bodies and lids
    4. Efficient low-height, flat-stacking lid assembly
    5. Compatible with widest variety of lid diameters
f) Consumer Benefits:
   Re-sealable Closure
    1. Controlled portioning
    2. Longer freshness
    3. More portability
    4. Fewer spills
    5. Protection against

## IV. CONCLUSION

Packaging technology and packaging material has undergone a sea change over 100 years. This is mainly driven by changing culture of the society and life style, economic progress and government regulations. For sustainability the thrust will be on cost effectiveness, improving convenience features and ecofriendly operations. To remain cost effective tinplate technology is required to continuously work on reducing its weight, reduction of processing losses, conservation of natural resources. To improve convince feature continuous innovations in the value chain and collaboration with composite material is the mantra. For improving the environment friendliness continuous works on Reduce –Reuse –Recycle of natural resources is required across the tinplate value chain. Critical to success will be invention, innovation, creative thinking, and waste reduction across the value chain.

**Areas for future research**

Innovative plating technologies, alternative plating substrates, use of nano technologies for making steel lighter will be the areas of future research.

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