

Coated Steel Products in the Indian Context

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Steel is a versatile material. The unique position of steel among the family of various products remains unchallenged even today. Indeed, life without iron and steel remains almost unimaginable. Steel is recyclable and eco-friendly.

During the last decades or so, the world has seen many innovations in the process of steel making and vast technological upgradation for making steel competitive. Steel producers all over the world are giving major trust on value addition and production of superior quality of products for high-end applications in a cost-effective and eco-friendly manner.

However, the only demerit of steel is its natural tendency to corrode. Corrosion eats away steel, causing significant loss to the economy and sometimes leads to accidents.

Coil Coating

Coil Coating, the continuous coating of steel coils, is a step in the manufacture of industrial products for use in building facades, white goods and many other special applications.

Coatings provide corrosion resistance, colour and surface structure of steel coils. Once the metal strip has been coated, the panels are cut, shaped and fitted, which often involves high complex processing stages such as deep drawing and roll forming. The coating surface should be able to withstand mechanical damage, heat, chemicals and moistures. For instance, a building has to withstand wind, rain and sun attack and in the white goods sector, steel surfaces are exposed to variety abuses during their lives.

Besides the above, there is a multiplicity of applications for coil-coated materials. For each material used and each step in various production stages, there is an acknowledged state-of-the-art application which requires current knowledge about material and its processing.

Coil Coating Process For HSS Galvanised Steels

(i) Thermal Drying Process

In the thermal drying process for High Strength Galvanised steel, the metal strip is heated to a temperature of 240 degree centigrade for 20-30 seconds in continuous curing ovens so that

the solvents evaporate and paint crosslinks. The strip is then cooled to room temperature. The process is expensive as well as environmentally unfriendly.

(ii) Water-based UV curable Primers

This is a simplified drying process which involves initiating crosslinking by using Ultra Violet (UV) radiation than the thermal process. This represents a complete departure from the traditional method as primers are required to have a new formulation with different raw material based on a new binder and crosslinking agents. They have to be sensitive to UV light and curable within seconds. Solvents are no longer needed for such a primer formulation and viscosity is adjusted by adding water. Dwell time in the oven is reduced to only 5 seconds compared to 25 seconds in the traditional process. The advantages of the UV system are as follows:

- Low energy consumption
- Reduced environmental pollution
- Paint quality is as good as the solvent system, if not better
- Smaller plant foot print.

Compared with conventional system, which involves many operations like degreasing, pre and post treatment, curing the primer etc. the use of UV- curable pretreatment of primer enables a great deal of complexities to be removed.

(iii) Flash Cooling Technology For HSS Galvanised Steel

The demand for HSS Galvanised steel has increased manifold in the recent years and a wide range of such steels have been developed. Thanks to the improvement of the coating process, these steels are increasingly hot-dipped galvanised after rolling instead of zinc-coating by electro deposition. Flash Cooling system developed by Five Stein uses high concentration of hydrogen in cooling gas and optimized blowing conditions to achieve the necessary cooling rates for HSS and watermist with nitrogen for Advanced High Strength steels (AHSS).

The advantages of using high concentration of hydrogen in cooling atmosphere are:

- Lower alloying elements for better zinc adherence and weldability
- Reduced strip fluttering in the cooling

section due to low gas impingement

- Smaller re-circulating blower and associated circuit and lower electricity consumption.
- Dramatic increase in cooling efficiency.

Chromium Coating & Chromium-Free Coil Coating

Traditional Coil Coating primers contain chromium compounds such as strontium and zinc chromate to achieve the necessary corrosion resistance of the final product. However, hexavalent chromium (chromium VI) compounds have been classified as CARCINOGENS (category 1 and 2), as being toxic and dangerous to environments, by Dangerous Substance Directive (DSD) of EEC long back. The steel technologists were convinced that an alternative, chromate-free primers should match or surpass the overall performance of their chromate containing rivals. After prolonged research, the foist generation universal chromate-free primers for exterior application was introduced by BASF in 1992. There was a further decisive breakthrough in 1995 when BASF's chrome-free universal primer on galvanised steel surfaces gave, superior results both over chrome-free and chrome-containing pre-treated coil.

According to another school of thought, if chrome-free treatment is to be used, the ongoing exposure series must be checked for compatibility and interactions. Chromate-free pre-treatment can be done and primers produced success fully with a high level of anti-corrosive activity. The difficulty lies in getting the two work together, as these systems are critical for substrate point and pre-treatment combinations. Chromate-free primers can be produced which are as effective as their chrome-containing rivals provided sufficient

attention is paid to these interactions and to material selection.

Zinc-Coated Galvanized Steel Products

Galvanised steel products are basically zinc-coated value-added products in which function of the zinc layer is three-folds:

- To retain the steel intact with its full initial strength.
- To provide the surface of steel a more pleasing appearance.
- To increase the life of any suitable system applied over it.

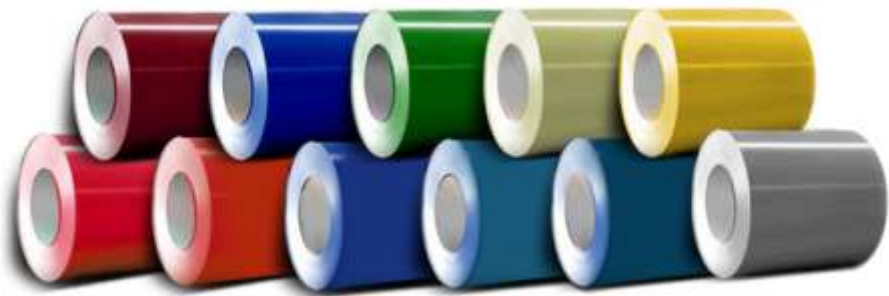
Two-fold Advantages of Zinc Coating

(a) Zinc coating protects steel from corrosive attack in most atmosphere, acting as a continuous and lasting shield between the steel and atmosphere, as long as the zinc sheath remains intact.

(b) Zinc acts as a galvanic protector, sacrificing itself slowly in presence of corrosive elements by continuing to protect the steel even when moderate areas of the bare metal has been exposed. This ability of zinc results from the fact that zinc is more electro-chemically active than steel. Of all industrial coating materials, zinc alone possesses this dual capability.

Zinc-coated galvanised steel offers unique combination of high strength, good formability, lightweight, corrosion resistant, aesthetic, high recyclability and low cost that is unmatched by any other material. Due to these qualities of zinc coating, the consumers of zinc-coated products are demanding a higher content of zinc-coated steel in construction, automotive, white goods and other sectors.

It may be mentioned here that when steel is immersed in the molten zinc, the chemical reaction enduring bonds the zinc



to the steel through the process of galvanizing. So, ZINC CAN NOT BE TERMED AS A SEALER LIKE PAINT, AS IT DOES NOT ONLY COAT THE STEEL, IT ACTUALLY BECOMES A PART OF IT. The Zinc goes through a reaction with iron molecules within itself to form galvanised steel.

Galvanising Processes

There are two major processes which are used in the manufacture of galvanised steel. These are Hot-Dipped Galvanising (HDG) process and Electro-Galvanising (EG) process.

• Hot-Dipped Galvanising

It is one of the basic and efficient corrosion resistant techniques for producing galvanised steel. During this process, steel coils are previously cleaned, pickled and then dipped in a bath of molten zinc to form a series of zinc/iron alloys integrated with the steel surface. As steel is removed from the bath, a layer of relatively pure zinc is deposited on the top of alloy layer. On solidification, the zinc assumes a crystalline metal structure called "Spangling". Spangles can be enlarged or reduced depending on end use.

In this process, the temperature of the molten zinc bath is kept at about 460 Degrees centigrade. Exposed to atmosphere, zinc is converted to zinc oxide which again reacts with carbon dioxide to form zinc carbonate that helps further corrosion resistance, protecting the steel from other elements.

Earlier, though hot-dipped galvanised products effectively met the corrosion resistance but had a limited formability and lacked in surface quality. Hence, they were used in non-stringent areas like construction sector but were found unsuitable for the automobile and white goods sectors.

However, with the dramatic innovations in technology during the last two decades like use of radiant tube furnace, coating control and specially with the development of the Galvannealing (GA) process, there has been a major shift in the use from electro-galvanising to hot-dipped galvanised steel, particularly in the automobile sector.

• Electro-Galvanising

In the electro-galvanising process, zinc ions from the electrolyte are deposited on the strip surface (cathode) under the influence of electric current using either soluble or insoluble anodes. The electrolyte is either usually zinc sulphate or zinc chloride or mixed. The electro-galvanised strips are post-treated with passivation solutions such as phosphate or chromate.

The plating process controls the coating thickness and helps to achieve much thinner sheets as well as double, side coatings. These sheets have excellent surface finish and press formability for corrosion protection of auto body fuel tanks, exhaust pipes etc.

The investment cost of an electro-galvanising line (EGL) is almost the same as that of a continuous hot-dipped galvanising line (CGL) facility with G.

A. However, EGLs do not have the annealing and temper-cooling facilities in-built in the system. Thus to produce annealed electro-galvanised products, annealing and temper cooling has to be done prior to electro-galvanising. This requires an additional investment cost on an annealing unit and skin pass mill which makes the process more expensive.

The cost of electricity in India is much higher than that of the developed

countries, which makes the operation cost of EGLs more expensive. Hence, under the Indian conditions, continuous hot-dipped galvanising lines (CGLs) are more attractive.

Spangled Products

Spangles are flowery patterns observed on the surface of galvanised sheets, formed by the natural crystallization of zinc. Spangles are produced by adding small quantities of lead, tin or antimony into the molten zinc bath. Spangles are desirable in applications like corrugated sheets used for roofing or in applications where parts are not exposed or do not require painting. For other applications, the strip has to undergo a mini-spangle treatment, so that the spangles can be minimized.

Special Quality Zinc Products

• Galvannealed (GA) Products

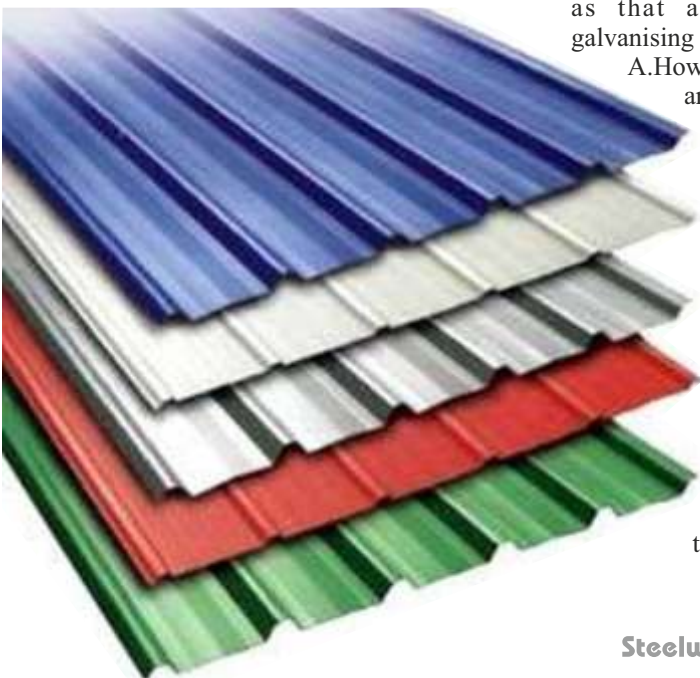
The Galvannealing Process was developed to satisfy the stringent quality requirements of the automotive industry for corrosion protection of outer and inner panels at optimum cost. In this process, an intermediate layer of iron and zinc is formed on the surface of the strip by diffusing iron (to the extent of 7 or 12 percent) into the zinc coating. The substrate characteristics become more important in the galvannealing process than in ordinary galvanising. Typical coating in GA products is 60-200 gm /m² (both sides). These steels are used in the automotive industry because of its improved manufacturing performance in models that use lighter and stronger grades of steel in automobiles.

• Galvalume or Zinalume

Galvalume (also known as zinalume) consists of 55 percent aluminium, 43.5 percent zinc and 1.5 percent of silicon by weight.

Galvalume provides a tough barrier between the atmosphere and the innercore of steel. Protection is offered by the corrosion resistance of the inner coating itself. Galvalume also protects steel from corrosion at cut-edges and scratches, achieved through the sacrificial protection of zinc in the coating. Galvalume has a life equivalent to about three times more than that of ordinary galvanised steel.

Advantages of using Galvalume are:



(i) **Corrosion Resistance** - Resistance to atmospheric corrosion particularly at the cut-edges and crack protection.

(ii) **Yield Advantage** - Aluminium makes up 55 percent of Galvalume by weight but it comprises 80 percent by volume. So, the coating weighs less, giving end-users more square feet per tonne than ordinary galvanised steel.

(iii) **Formability** - Galvalume is suitable for all but severe forming operations. It can be easily bent, roll formed and drawn without sacrificing the coating adhesion properties.

(iv) **High Temperature Resistant** - Galvalume can easily withstand temperature up to 600 degree F without surface discolouration. Galvalume is, therefore, not only a superior material for roofing but also ideal for a range of other applications such as components in toasters, ovens and gas lighters.

(v) **Thermal Reflectivity** - Due to its good thermal reflectivity, Galvalume roofs combined with insulation makes it a cost-effective roofing system.

Limitations to the use of Galvalume

Galvalume coated sheets cannot be used in frame works in contact with wet concrete, products to be embedded in concrete, animal shelters where ammonia levels are consistently high, fertilizer storage sheds, containers, culverts where the material is buried in the ground, water tanks and in high alkaline environments.

• Galfan

Galfan is 95 per cent zinc and 5 per cent aluminium. When used as a substrate, the longevity of the products increases significantly. Galfan finds applications in mariner wire ropes, small springs, pre-painted building panels, appliances and automotive parts. Galfan is noted for its outstanding coating adhesion, making it an ideal material for deep-drawn and "zero thickness" bend applications.

• Galbo Sheets

Galbosheets are special zinc-coated products with good corrosion resistant property with good formability, durability and paintability. Galbo sheets are used in white goods manufacturing and in the production of colour coated sheets.

• Galvano Sheets

Galvanogalvanised sheets with ZERO

SPANGLES has been developed by Tata Steel. These are environmentally safe and economically advantageous. It has a superior surface finish and mechanical properties capable to meet the stringent quality requirements of the customers. High chrome passivation ensures better white rust resistance. Zero spangles coupled with skin passing and uniform

zinc coating ensures high corrosion resistance. It has superior formability.

Applications And Attributes of Zinc-coated Products

The various industrial applications and the key attributes of the zinc coated products mentioned above are shown in Table-1.

| Coated Products | Applications | Key Attributes |
|--------------------|--|--|
| Galvanised | Steel frame, air conditioners, roof and floor decking, prepainted building panels, agricultural storage bins, autobody inner parts | Formability, durability, range of coating thickness, strength and speedy installations, easy paintability, cost-effective. |
| Electro-galvanised | Autobody outer parts, Computer cases | Good surface finish, weldability, lectromagnetic shielding |
| Galvanneal | Autobody outer parts, pre-painted appliance wrappers | Weldability, paintability, durability, formability |
| Galvalume | Bars, painted roofing and side cladding | corrosion performance, for bare, coatings, paintability |
| Galfan | Pre-painted architectural panels, automotive | Corrosion performance, very good formability and paintability |
| Galbo | White goods manufacture, Colour coated steel sheets | Corrosion performance, formability, durability, paintability. |
| Galvano | General engineering | corrosion resistance, formability, durability, paint adhesion quality |

Life Span of Galvanised steel

The use of galvanised steel for autobody panels allows the present day automakers to guarantee a corrosion free life of 12 years or more adding only a fraction of the total cost of production. In the appliances manufacturing sector, galvanised steel sheets are used in white goods and other household products providing a corrosion free life of over 15 years. In the construction sector, zinc-coated products have a useful corrosion free life of about 40 years.

Recyclability of Coated Products

All types of zinc-coated galvanised steel products are recyclable. The Electric Arc Furnace (EAF) is the principal

recycling route of zinc-coated steel. According to industry sources, about 80 per cent of the zinc available for recycling in India is being recycled.

Environment

Zinc is a natural element that is essential to all forms of life, including humans, animals, plants and micro-organisms. While small quantities of zinc that washes off from coatings exposed to outer environment, this has very little and practically no adverse effect on the surrounding echo-system.

On a micro scale, the excellent corrosion protection provided by zinc coatings contributes significantly to the

durability and the life-expectancy of steel products which in turn help to conserve natural resources and thereby helps in the reduction of the cost of maintenance, repair and replacements for the industry.

Indian Galvanised Steel Industry

A Broad Sectorwise Consumption of GP/GC sheets/ coils in India

The broad sectorwise consumption pattern of galvanised steel in India is furnished in the adjacent table 1

B. Performance of Indian Galvanised Steel Industry

Production For Sale

Production sale is arrived at after deducting Inter-Plant Transfers (IPT) and producers' own consumption from gross

• **Production For Sale of GP/GC Sheets in India between 2007-08 and 2013-14 are shown in Table-2**

Table 2: Production For Sale of GP/GC Sheets In India: 2007-08 To 2013-14.

The low growth in 2008-09 was due to the global crisis that started after October, 2008

• Imports of GP/GC Sheets By India

Imports of GP/GC Sheets by India between 2007-08 and 2013-14 are furnished in Table-3.

Table-3: Imports of GP/GC Sheets By India: 2007-08 To 2013-14 ('000 tonnes)

• Exports of GP/GC Sheets By India

Exports of GP/GC Sheets by India between 2007-08 and 2013-14 are shown in Table-4.

Table-4: Exports of GP/GC Sheets By India: 2007-08 To 2013-14 (000 tonnes)

India was a net exporter of GP/GC Sheets between 2007-08 and 2013-14. Apparent Consumption

• **Apparent Consumption of GP/GC sheets in India between 2007-08 and 2013-14 are shown in Table-5.**

Table-5: Apparent Consumption of GP/GC sheets In India:

2007-08 To 2013-14 ('000 tonnes)

Table 1

| Sector | Share in Consumption (%) |
|---------------------------|--------------------------|
| Construction | 46 |
| Consumer Durables | 12 |
| Drums/Barrels/Containers | 6 |
| Railways/Power/Irrigation | 6 |
| CPWD/PWD/Other Govt. | 5 |
| Tube Makers | 4 |
| Furniture Makers | 4 |
| Engg. Units | 4 |
| Colour Coated Units | 5 |
| Automobile | 6 |
| Others | 2 |
| Total | 100 |

N.B. The figures are indicative.

Table 2

| Year | Production For Sale | Y-O-Y Growth (%) |
|-------------|---------------------|------------------|
| 2007-08 | 4381 | - |
| 2008-09 | 4554 | 3.95 |
| 2009-10 | 5620 | 23.41 |
| 2010-11 | 5556 | (-) 1-14 |
| 2011-12 | 5681 | 2.25 |
| 2012-13 | 6287 | 10.67 |
| 2013-14 (P) | 6996 | 11.28 |

Data Source: JPC (P) = Provisional

Table 3

| Year | Imports | Y-O-Y Growth (%) |
|-------------|---------|------------------|
| 2007-08 | 268 | - |
| 2008-09 | 288 | 7.46 |
| 2009-10 | 292 | 1.39 |
| 2010-11 | 353 | 20.89 |
| 2011-12 | 368 | 4.25 |
| 2012-13 | 433 | 17.66 |
| 2013-14 (P) | 368 | (-) 15.01 |

Data Source: JPC (P) = Provisional

Table 4

| Year | Exports | Y-O-Y Growth (%) |
|-------------|---------|------------------|
| 2007-08 | 2026 | - |
| 2008-09 | 1530 | (-) 24.48 |
| 2009-10 | 1287 | (-) 15.88 |
| 2010-11 | 1312 | 1.94 |
| 2011-12 | 1443 | 9.98 |
| 2012-13 | 1554 | 7.69 |
| 2013-14 (P) | 1783 | 14.74 |

Data Source: JPC (P) = Provisional

Table 5

| Year | Apparent Consumption | Y-O-Y Growth (%) |
|-------------|----------------------|------------------|
| 2007-08 | 2617 | - |
| 2008-09 | 3018 | 15.32 |
| 2009-10 | 4513 | 49.54 |
| 2010-11 | 4658 | 3.21 |
| 2011-12 | 4885 | 4.23 |
| 2012-13 | 5230 | 7.06 |
| 2013-14 (P) | 5637 | 7.78 |

Data Source: JPC (P) = Provisional

Highest growth in consumption of Galvanised steel products in India was recorded in 2009-10 at 49.54 percent. In 2012-13 and 2013-14 the growth rate was around 7.06 and 7.78 percent respectively. In 2013-14, the growth rate was the highest among major flat products.

• Colour Coated Sheets

Colour coating usually refers to the application of liquid paint coat over the substrate in an automatic continuous process after pre-treatment. The pre-painted colour coated steel is a very high value-added product that combines the best properties of the substrate and organic coating additionally imparting it an aesthetic finish, high degree of durability and high corrosion resistant capability.

Colour coating is done on various substrates to produce the most effective, quality assured products with the top coat compatible with environment.

The substrates usually used are:

- Hot-dipped Galvanised steel,
- Electro-Galvanised steel
- Galvalume
- Galbosheets
- Aluminium

Pre-treatment

Pre-treatment of the substrate is a very important operation required for better colour adhesion, formability of the pre-painted steel sheets.

Leading colour coated steel producers in India have introduced NO-RINSE technology in place of phosphating (phosphate coating) over Galvanised strip because of better bath maintenance, Uniform crystal structure of coating as well as to meet the demand of end-users for more flexibility of colour coated steel. The NO-RINSE coating pre-treatment is a very thin layer of chemical treatment that bonds the coating surface of steel to the, the subsequently applied paint to ensure excellent paint adhesion and corrosion resistance of the steel surface.

• Primer

After pre-treatment, a primer of uniform layer is applied on the pre-treated surface. The primer provides flexibility to the paint system and helps to provide corrosion resistance since it contains corrosion inhibitors. The primer is cured

in the oven with accurate temperature controls with great care and precision.

Various types of primers are available based on different resins like epoxy, polyester, polyurethane and PVC. Epoxy primers are preferred for use in roofing as it has chromate pigment for better corrosion resistance. The established dangers in using certain chromium coating have been discussed earlier.

It may be mentioned here that the success of the entire colour coating system depends on the PRIMER-THE CRUCIAL FIRST COATING LAYER applied on pre-coated metal sheets.

• TOPCOAT

After pre-treatment, primer surface is coated at uniformly coated thickness and then cured in the oven. The top coat contains combination of coloured pigments and additives which provide the required colour and other performance properties like ultra-violet resistance. The coated product is then rigorously tested before clearing for further applications. Most of the roofing and construction markets for colour coated sheets use top coats which are based on polyester, fluocarbon (PVOP), Silicon modified polyester (SMP) and plastisol for cost-effectiveness and durability.

Major Producers of Colour Coated sheet in India

Among the major producers of colour coated sheets in India, Essar steel Ltd. has

| Year | Exports | Y-O-Y Growth (%) |
|---------|---------|------------------|
| 2009-10 | 215 | - |
| 2010-11 | 260 | 20.93 |
| 2011-12 | 290 | 11.54 |
| 2012-13 | 330 | 13.79 |
| 2013-14 | 360 | 9.09 |

Conclusion

The Indian Galvanised steel industry has made considerable progress during the last decade. Indian Galvanised steel products have been well accepted in the global market. The leading producers are earnestly trying to produce superior products for high end applications.

Free trade Agreements (FTAs) with countries like Japan and Korea are hurting the interests of the domestic producers.

With the enhanced thrust on the infrastructure and manufacturing sectors

a colour coating line at Pune in Maharashtra with an annual capacity of 4 Lakh tonnes. Bhushan steel Ltd. has a colour coating line in Khopoli in Maharashtra with a capacity of 120,000 tonnes per year. Ultam Galva has a colour coating line also at Khopoli with an annual capacity of 80,000 tonnes. Tata Blue Scope joint venture on 50:50 basis is operating a metallic and colour coating / painting facility at Bara near Jamshedpur in Jharkhand which has an annual capacity 150,000 tonnes of zinc and aluminium steel branded as COLOURBOND.

Jindal South West (JSWL) has enhanced the capacity of its colour coating line at Tarapore to 2.76 Lakh tonnes per year. It has also commissioned a state-of-the-art new coating line at Vasind with an annual capacity of 1.50 Lakh tonnes.

Indian Steel Corporation, jointly promoted by Ruchi Group and Mitsui & Co. Japan has commissioned a 0.12 Mtpy capacity colour coating line at Bhimsagar village in the Kutch district of Gujarat. Its colour coated products branded as "Ultrashine XL" has been claimed to be India's first ever innovative colour coated profile sheet in 4-ft width.

Estimated Demand of colour coated sheet in India:

According to industry sources, the estimated demand for colour coated sheets in India in recent years were as follows:

by the present government, the consumption of Galvanised steel products are destined to reach higher levels in future years.

Acknowledgements:

- Articles by Dr. Lothar Jandel & P. Heffer et all in steel Times International- January 2005.
- Various articles by Dr. Amit Chatterjee, Formerly Advisor, Tata Steel and L. Pugazhenthay, ED, ILZDA.