



# Galvanized Steel Growth Prospects in India

- Sanjay Sengupta

**S**teel is a versatile product. The unique position of steel among the family of various industrial products remains unchallenged even today. Indeed, life without steel remains almost unimaginable. Steel has become an important part of our daily life. Steel is recyclable and eco-friendly. Other metals have not been able to make a significant dent in its global consumption. Perhaps, the only demerit of steel is its natural tendency to corrode. Corrosion eats away steel, causing a significant loss to the economy. It has been estimated by experts that corrosion of steel cost about four percent of the GDP of an industrialized country.

## 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 in many other special applications.

Coatings provide corrosion resistance, colour and surface 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 mechanized damage, heat, chemicals and moisture. For example, a building has to withstand wind, rain and sun attack. In the white goods sector, the coated steel surface are exposed to variety of abuses during their lives.

Besides the above, there is a multiplicity of applications for coil coated materials. For each material to be used and for each step in various production stages, there is an acknowledged state-of-the-art application which requires current knowledge about the 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 2400 degree centigrade for 20-30 seconds in continuous curing ovens so that the, solvents evaporate and point cross links. 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 cross linking by using Ultra Violet (UV) radiation than the thermal process. This represents a complete departure from the traditional method as primar are required to have new formulation with different raw materials based on a new binder and cross linking 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
- Point 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 pre-treatment of primer enables a great deal of complexities to be removed.

**(iii) Flash Cooling Technology for HSS Galvanised Steel**

The demand for HSS Galvanized 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 galvanized 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 as an alternative; chromate free primers should match or surpass the overall performance of their chromate containing rivals.

After prolonged research, the first 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 galvanized 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 successfully with a high level of anti-corrosive activity. The difficulties lies in getting the two to work together, as these systems are critical for substrate paint 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 inter actions and to material selection.

**Zinc - Coated Galvanized Steel Products**

Galvanized 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 galvanized steel offers unique combination of high strength, good formability, light weight, 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 CANNOT BETERMED 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 galvanized 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 galvanized steel. During this process, steel coils are previous 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 Degree 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 galvanized steel, particularly in the automobile sector.

### Electro Galvanising

In the electro-galvanising process, zinc ions from the electrolyte is deposited on the strip surface (cathode) under the influence of electric current using either soluble or insoluble anodes.

The electrolyte is usually either zinc sulphate or zinc chloride or mixed. The electro-galvanized strips are past-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 autobody fuel tanks, exhaust pipes etc.

The investment cost of an Electro-Galvanizing Line (EGL) is almost the same as that of a Continuous Hot-dipped Galvanising Line (CGL) with G.A. However, EGLs do not have the annealing and temper-cooling facilities in-built in the system. Thus, to produce annealed electro-galvanized products, annealing and temper-cooling has to be done prior to electro-galvanising. This requires an additional investment cost on installing an annealing unit and Skin-Pass Mill, which makes the EGL process more expensive.

The cost of electricity in India is much higher than that of the developed countries. Hence in the Indian conditions, Continuous Hot-Dipped Galvanising Lines (CGLs) are more attractive.



### Advantages of Use of Hot-dipped Galvanized Steel in Highway Projects

Globally, hot-dipped galvanising is adopted widely for protecting almost all the steel structure and products in highways such as guard rails, lamp posts, traffic lights, signages, toll plaza, fencings, railings etc. There are many technical advantages of using hot-dip galvanising steel.

Among the Economic Advantages are the following:

- For protection of steel structures, good cleaning and surface preparation are very essential. The hot-dip galvanizing process has in-built chemical cleaning systems (like degreasing, pickling, fluxing etc.) which ensure an excellent and through surface preparation. The hot-dip galvanized coating is obtained by dipping such well-cleaned steel in molten zinc. Coating development is a natural phenomenon due to the inherent chemical affinity between cleaned steel and molten zinc at 450 degree centigrade.

- Galvanized steel is totally maintenance free that last for decades. On a life cycle cost basis, galvanizing is the most economic option for corrosion protection of steel.

Experts have observed that by choosing galvanizing process for all steel products used in the highway sector, National Highways Authority of India (NHAI) and the country will save huge funds that are otherwise spent in repetitive and periodic maintenance now being done.

### Corrosion of Re-bars in RCC

Corrosion of steel reinforcement in concrete is an electro-chemical process which requires access of an electrolyte and oxygen to

steel. The following protective measures have been identified by experts against corrosion which rely on minimizing or preventing the corrosive electro-chemical process :

- Impeding access of deleterious materials (Water, Oxygen, Salts, Carbon Dioxide etc.) to the steel surface.
- Slowing down the electro-chemical process through the use of inhibitors.
- Modifying the electrode through cathodic protection.
- Providing coatings to the steel reinforcement.

Hot dip galvanizing is a viable means of protecting reinforcement, particularly where durability of concrete cannot be guaranteed. Its use, according to experts, should be considered for aggressive exposures conditions, pre-cast construction and facades where long life, freedom from rust staining & low maintenance are important criteria.

Results from research and practical experience have shown that corrosion resistance of galvanized steel reinforcement to be superior to uncoated steel while the bond strength of galvanized and black steel to concrete are not significantly different.

The corrosion protection of galvanized coating ensures that the design strength of concrete is maintained and the possibility of surface rust staining and eventual corrosion of reinforcement and spalling of concrete is removed.

### Life Span of Galvanized Steel

The use of galvanized 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 appliance manufacturing sector, galvanized 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.

### Spangles Products

Spangles are flowery patterns observed on the surface of galvanized sheets, formed by the national crystallisation 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 those 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 spangles can be minimised.

### Special Quality Zinc Products

#### Galvannealed (G.A.) Products

The Galvannealing Process was developed to satisfy the stringent quality requirements of the automotive industry for corrosion protection of the outer and inner panels at an 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 7-12 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/m<sup>2</sup> (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 inner core 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 sacrificed 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 bend, 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 systems.

#### Limitations to the Use of Galvalume

Galvalume coated sheets cannot be used in frameworks in contact with wet concrete, products to be embedded in concrete, animal shelters where ammonia levels are constantly 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 percent zinc and 5 percent aluminium when used as a substrate, the longevity of galvanised products increases significantly.

Galfan finds applications in marine 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

Galbo Sheets are special type of zinc-coated products with good corrosion resistance 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

Galvano galvanised sheets with ZERO SPANGLE has been developed by Tata Steel. These are environmentally safe and economically advantageous. It has a superior surface finish and posses mechanical

properties which are capable of meeting 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 of the product. It has superior formability, bendability and paintability.

#### Recyclability of Zinc-Coated Products

All types of zinc-coated galvanized steel products are recyclable. The Electric Arc Furnace (EAF) is the principal recycling roof of zinc-coated steel. According to the industry sources, 80 percent of 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-organs. When small quantities of zinc that washed off coatings exposed to outer environment, this has practically no adverse effect on the surrounding eco-system.

On a micro scale, the excellent corrosion protection provided by zinc coatings contributes significantly to the durability and life-expectancy of steel products which in turn leads to conserve natural resources and thereby helps in reducing the cost of maintenance, repair and replacements for the industry.

#### Performance of the Indian Galvanizing Industry

#### Broad Sectorwise Consumption Pattern of Galvanising Steel in India

Sector	Share in Consumption (%)
Construction	46
Consumer Durables	12
Barrels / Drums / Containers	6
Railways / Power / Irrigation	6
CPWD / PWD / Other Govt.	5
Tube Makers	4
Furniture Makers	4
Engineering Units	4
Colour Coated Sheets	5
Automobiles	6
Others	2
<b>Total</b>	<b>100</b>

N. B. The figures are Indicative.

Broad Sectorwise Consumption Pattern of Galvanising Steel in India is furnished below :

### Production for Sale

Production for sale is arrived at after deduction of Inter-Plant Transfers (IPT) and producers own consumption from Gross Production. Production for sale of GP/GC Sheets /Coils in India between 2008-09 and 2014-15 are shown in Table-1.

The high growth of 23.41 percent in 2009-10 was due to a low base in 2008-09 – a year affected by global crisis. The growth of 10.67 percent in 2012-13 was aided by high production of 1.1 Mt by JSWL.

### Imports of GP/GC Sheets by India

Imports of GP/GC Sheets by India are shown in Table-2.

High import in 2010-11 was due to higher domestic demand imports declined in 2013-14 only to rise again in 2014-15

### Exports of GP/GC Sheets by India

Exports of GP/GC sheets by India between 2008-09 and 2014-15 are shown in Table-3.

Exports of GP/GC sheets were low in 2009-10 and 2010-11 in the aftermath of global crisis that started in mid-2008-09. High exports during the above period was 1.78 Mt in 2013-14 which was over 26.6 percent of production for sale. Exports came down in 2014-15 due to the lack of demand in the global market. India was a net exporter of GP/GC Sheets during the above period.

### Apparent Consumption

Apparent consumption of GP/GC Sheets/Coils in India between 2008-09 and 2014-15 are shown in Table-4.

The highest growth of 49.54 percent in 2009-10 due to a low base in 2008-09. The growth was high at 15.28 percent in 2012-13 but it came down in next two years due to lack of market demand.

### 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 sheet 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 substrate to produce the most effective, quality-assured products with the top coat compatible with environment.



**TABLE – 1 : PRODUCTION OF GP/GC SHEETS/COILS IN INDIA : 2008-09 TO 2014-15**

Year	Production for Sale	Y-o-Y Growth (%)
2008-09	4554	==
2009-10	5620	23.41
2010-11	5556	(-) 1.14
2011-12	5681	2.25
2012-13	6287	10.67
2013-14	6687	6.36
2014-15 (P)	6897	3.14

Data Source : JPC (P) = Provisional

**TABLE – 2 : IMPORTS OF GP/GC SHEETS BY INDIA : 2008-09 TO 2014-15 ('000 TONNES)**

Year	Imports	Y-o-Y Growth (%)
2008-09	288	==
2009-10	292	1.39
2010-11	353	20.89
2011-12	368	4.25
2012-13	433	17.66
2013-14	368	(-) 15.01
2014-15 (P)	441	19.83

Data Source : JPC (P) = Provisional

**TABLE – 3 : EXPORTS OF GP/GC SHEETS BY INDIA : 2008-09 TO 2014-15 ('000 TONNES)**

Year	Exports	Y-o-Y Growth (%)
2008-09	1530	==
2009-10	1287	(-) 15.88
2010-11	1312	1.94
2011-12	1443	9.98
2012-13	1554	7.69
2013-14	1783	14.74
2014-15 (P)	1629	(-) 8.64

Data Source : JPC (P) = Provisional

**TABLE - 4 : APPARENT CONSUMPTION OF GP/GC SHEETS/COILS IN INDIA : 2008-09 TO 2014-15**

Year	Apparent Consumption	Y-o-Y Growth (%)
2008-09	3018	==
2009-10	4513	49.54
2010-11	4658	3.21
2011-12	4538	(-) 2.58
2012-13	5230	15.25
2013-14	5428	3.79
2014-15 (P)	5518	1.66

Data Source : JPC (P) = Provisional

The substrates used are :

- Hot-dipped galvanised steel, electro-galvanised steel
- Galvalume, Galbo Sheets, Aluminium

#### Pre-treatment

Pre-treatment of the substrate is a very important operation required for better colour adhesion and formability of the product. Leading colour coated sheet producers in India have introduced NO-RINSE technology in place of PHOSPHATING (phosphate coating) over galvanized 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 the colour coated sheets. The NO-RINSE coating in pre-treatment is a very thin layer of chemical treatment that bonds the coating surface of steel to the subsequently applied paint to ensure an 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 damages 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.

#### Top Coat

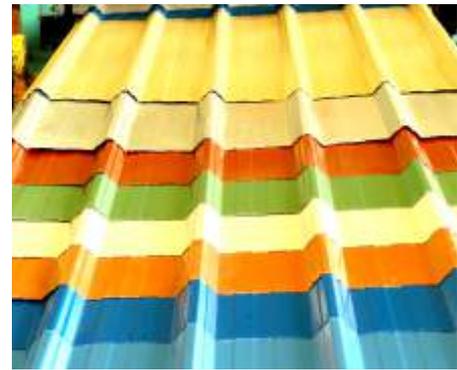
After pre-treatment, the primer surface is coated at uniformly coated thickness and then cured in the oven. The top coat contains combination of coloured pigments and additives which provide the required colour and other performance properties like ultra-violet resistance. The coated product is then 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 (PVDP), Silicon Modified Polyester (SMP) and plastiso for cost-effectiveness and durability.

#### Major Producers of Colour Coated Steel India

Among the major producers of colour coated sheets in India. Essar Steel Ltd. has 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. Uttam Galva has a colour coating line also at Khopoli with an annual capacity of 80,000 tonnes. Tata BlueScope 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 COLORBOND.

Jindal South West Ltd. (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. of Japan has commissioned a 0.12 Mtpa capacity colour coating line at Bhimsagar Village in the Kutch



district of Gujarat. Its colour coated products branded as "ULTRASHINE XL" has been claimed as 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 :

Year	Domestic Demand ('000 Tonnes)	Y-o-Y Growth (%)
2009-10	220	==
2010-11	280	27.27
2011-12	310	10.71
2012-13	340	9.68
2013-14	390	14.71
2014-16	430	10.26

#### Conclusion

The Indian galvanised steel industry has made considerable progress in the last decade. Indian galvanized 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 with countries like Japan and Korea are hurting the interests of domestic producers. With enhanced thrust on infrastructure and manufacturing sections by the Central Government, the consumption of galvanised products in India is destined to reach much higher levels in future years.

#### Acknowledgements

(1) Articles by Dr. LotharJandel and by P. Hefferet all published in Steel Times International in the January 2005 issue.

(2) Various articles by Dr. AmitChatterjee, formerly Advisor, Tata Steel and L. Pugazhenty, E.D., ILZDA