Innovative surface design with coil coatings

Modern techniques can provide coated strip for buildings with self-cleaning surfaces and for consumer appliances that are surface textured for aesthetic appeal. The colour range is enormous. Use of UV drying significantly reduces costs, energy consumption and environmental pollution, and new coatings provide both flexibility with hardness, to minimise damage during manufacture and assembly.

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Coil coating, the continuous coating of aluminium or steel coils, is a step in the manufacture of industrial semi-finished products for use in, for example, building façades, washing machines and caravans. Coatings provide corrosion resistance, colour and surface texture. Once the metal strip has been coated, the panels are cut, shaped and fitted, which often involves highly complex processing stages such as deep drawing and roll forming. The coating surface is expected to withstand mechanical damage, heat, chemicals and moisture. For instance, a building has to withstand wind, rain and sun attack, and in the white goods sector (washing machines, cookers, etc), surfaces are exposed to a variety of abuses during use.

These are just two examples which are representative of the multiplicity of applications for coil-coated materials. For each material used and each step in the various production stages there is an acknowledged state of the art which represents current knowledge about the material and its processing. Forward-looking developments must offer something novel that further advances the state of the art. Some of these are now described.

NEW SURFACE PROPERTIES FOR CONSTRUCTION PRODUCTS

Building surfaces are exposed to wind, rain, sun and pollutants, and in addition to their functionality, their design in terms of shape and colour are also important criteria. A building should look new for as long as possible, but surfaces can become soiled as a result of moisture and dust. There are various approaches to overcoming this problem.

Hydrophilic surfaces The lotus effect has been considered as a kind of panacea to prevent the adhesion of dirt for more than a decade. The lotus leaf with its finely textured and hydrophobic surface has the ability to prevent the adhesion of dirt. Unfortunately, this effect in a living plant cannot be transferred to the coil coating process. We can, however, attempt to derive mechanisms from such effects. In principle, the soiling of coil-coated surfaces can be reduced by making them hydrophobic, but the converse, a hydrophilic surface, ie, one that is easily wetted with water, can also prevent soiling. It is a highly cross-linked coating surface which permits excellent wetting with water as a result of its chemical structure. This enables dirt to be easily washed off with rain water. Such dirt-repellent surfaces are already being used, particularly in industrial areas in Asia where the surfaces retain their original good looks for longer than façades coated with conventional topcoats.

Fabrication-friendly surfaces Most coil-coated materials are further processed to make façades and roofs. Whereas the main benefit with hydrophilic surfaces lies with the end customer. The following example shows an innovation that generates advantages for the processor.

During processing of coated strip into products, paint systems must cope with all the mechanical operations which impact on the surface as a result of cutting, bending, deep-drawing and assembling. Interest focuses in particular on elasticity and hardness of the coating, but unfortunately these two properties are contradictory. Hard paint systems are not as flexible as soft ones, whereas soft, flexible surfaces can be damaged more easily by mechanical operations and so a compromise has always been required.

BASF has developed a new system, Polyceram SR, which provides coatings with improvements in surface hardness as well as better bending and deep-drawing strength. In this new system, the balance between flexibility to damage and flexibility has been raised to a new level by means of a sophisticated refinement of the coating. The materials coated with the new product permit good shaping and are more resistant to damage compared to those with a standard system of conventional flexibility (see *Table 1*).

Thermal control It is well known that dark-coloured surfaces heat up significantly in sunlight; for instance the

Fig.1 **A building where Paliocrom pigments have been incorporated in a high-grade PVDF topcoat**

temperature of brown roofs can easily exceed 80°C. This rise in temperature causes the metal to expand and this must be taken into account in structural calculations. Furthermore, heat is also transmitted from the surface into the building, which can become too hot in warm weather, even at moderate latitudes.

The use of new raw materials such as ones with a specific heat resistance or infrared reflectant pigments in dark topcoats has been successful in achieving a substantial reduction in heat transmission. These new surfaces absorb less radiation and reflect, on average, approximately 60% more heat than conventional coatings. Consequently, the metal surface remains 8–15°C cooler. Even greater differences are established under laboratory conditions where a temperature difference of 26°C has been achieved. The first applications using this technology are already in operation in the USA, Canada and Asia, and rising energy prices, in particular, will give the market a further boost to help minimise the cost of operating air-conditioning systems. Since metal roofing for domestic housing is still uncommon in Europe, the emphasis here is more for use in agricultural buildings, enabling better climate control to be obtained.

NEW SURFACE DESIGN

Colour The construction industry and white goods manufacturers have followed the carmakers' trend towards metallic colours for many years. For instance, many façades are designed in 'white aluminium' (RAL 9006) and lighter coloured metallics are now also used for refrigerators. Whereas historically these colours were only available in polyester, polyurethane or polyvinyliden fluoride (PVDF) topcoats, a special formulation process now permits brilliant metallic colours also to be provided for polyvinyl chloride (PVC) plastisols.

In addition to the classic metallic colours, highly iridescent colours produced by the addition of mica and colour change coatings which change from red, through yellow to violet as a function of the angle of view are achieved with the use of interference-generating pigments such as Paliocrom®, are increasingly being used today. An example is shown in *Figure 1*.

Product	Polyceram SR	Standard
Substrate	Aluminium and steel	Aluminium and steel
Primer thickness	5–25µm	5–15µm
Topcoat thickness	18–25µm	18–22µm
PMT	200–250°C	220–250°C
Adhesion(adhesive tape)	T0	T0
T-bend, crack free	0.5–2.0 x T (thickness)	2.0–3.0 x T
Pencil hardness	H-2H	F
Scratch resistance	40N	25N
Dirt resistance	Good	Good
Weathering resistance	Good	Good

Table 1 **Properties of Polyceram SR and standard coat**

Textured surfaces The topography of the coating surface is a significant design element. Roll application of coatings actually results in a smooth surface in the coil coating process, so in the 1980s when the white goods industry began using pre-coated panels in combination with sprayed components there was a miss-match in surface appearance. The coating process was required to look as if it had been painted using spray application including the typical orange peel effect.

The challenge was met by the introduction of special texture primers which are over-coated with a topcoat adapted to the primers. A schematic of the system is shown in *Figure 2*. Enormous efforts were needed initially to achieve a reproducible texture, but the innovation that was launched as a result became established during the following decade and now represents the coil coating standard for the European white goods industry. The ▷

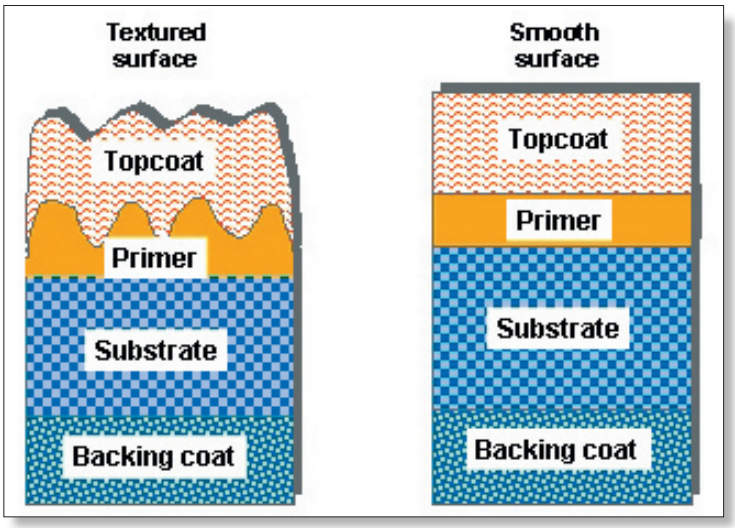

Fig.2 Comparison of smooth and textured surfaces

European steel industry now supplies almost 400,000t/y of pre-coated steel to this sector.

In addition to its design aspects, the textured surface offers advantages in processing. The friction properties in dies are lower than those of a conventional smooth coating. Also, the surface is more robust and is not so easily damaged during the assembly process, and unevenness and flaws are masked by the texture. Ultimately the surface requires less care by the consumer.

The advantages in the processing of textured coil surfaces can also be exploited with textures produced in other ways. Their appearance is different, but they are also easier to process and are more wear resistant than smooth surfaces. For example, polyamide in a fine particle distribution can be incorporated into the colouring topcoat. Roller blind elements very often use a surface of this kind where the flexible polyamide particles ensure enhanced wear resistance for the coating to cope with the frequent opening and closing of the roller blinds.

NEW PROCESSES IN COIL COATING

One of the very costly and energy-intensive stages in the coating process is thermal drying. The metal strip, running at high line speeds of 80–150m/min, is heated to approximately 240°C for 20–30 seconds in 40–50m long continuous curing ovens, so that the solvents evaporate and the paint film cross links. The strip is then cooled down to room temperature. This expensive and environmentally unfriendly process takes place twice during each pass, resulting in coils which, for example, could be 0.75mm thick with two paint films with a combined thickness of 25µm, ie, one-thirtieth of the coil thickness, to provide the necessary corrosion protection and surface design.

Water-based UV-curable primers One approach towards simplifying the drying process is to initiate cross linking using ultraviolet radiation rather than by thermal means. This represents a complete departure from traditional methods as the primers required have to have a new formulation with different raw materials based on a completely new type of binder and cross-linking agents. They have to be sensitive to UV light and curable within seconds. Solvents are no longer necessary for such a primer formulation and viscosity is adjusted by using water. Whereas, traditionally, a dwell time in the oven of approximately 25 seconds is required for drying, when processing a water-dilutable UV primer the time is reduced to about five seconds. First, the water is expelled within three seconds at 80–100°C, followed immediately by irradiation with UV light for two seconds, which provides the necessary cross linking energy for the system. A significant amount of space is saved when compared with a traditional continuous curing oven.

Since no solvents are involved in this process, the thermal oxidation of the oven exhaust gases, which is necessary in the case of solvent-based technology, is no longer required.

The advantages of this system may be summarised as:

- Lower energy consumption
- Reduced environmental pollution
- Smaller plant footprint
- Paint quality is as good as the solvent-based system.

UV curable pre-treatment primers If the primer in the above example can be adjusted such that it is also able to take on the function of pre-treatment product at the same time, there is even more potential for reducing the complexity of the coating process. It will then be possible to operate the coil coating line with even fewer individual stages.

Compared with conventional coil coating, which involves degreasing the metal strip, pre-treatment, post-treatment, drying the surface and finally applying and curing the primer, the use of a UV-curable pre-treatment primer enables a great deal of the complexity to be removed. The process is shorter and lower temperatures are used. It is also possible to build a coating unit of this type downstream of a galvanising line thus the primer can then be applied at this early stage and pre-primed steel sheet can be produced without a separate coil coating line.

A UV primer with pre-treatment function already exists on a pilot-plant scale. Its implementation in an existing or new production process will turn it into an innovation which will be capable of generating huge benefits in terms of cost structures. MS

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