TATA STEEL

Premium paint appearance

Serica®: hot-dip galvanised surface finish for exposed automotive panels

Introduction

When it comes to car design, the trend is very much towards sharp lines and concave or convex forms as well as exceptionally smooth paint finishes. At the same time, components also have to be as lightweight and as easy to process as possible in order to keep overall costs as low as possible for the manufacturer. Fulfilling these requirements calls for exposed body panels that are easy to form and that present a premium appearance after painting.

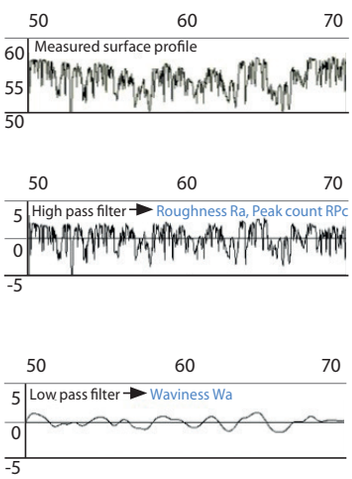
Against this background Tata Steel evaluated exactly how the surface properties of the steel substrate influence the final paint appearance. Through specific modifications to the manufacturing process, the steel manufacturer collaborated with a European vehicle manufacturer to develop a premium surface finish for hot-dip galvanised steels designed specifically for an excellent paint result that can be processed on existing equipment.

Steel surface properties

When considering the properties of the steel surface, there are two competing requirements. On the one hand, a certain roughness is necessary for it to react appropriately in the press shop. The various steps involved in the forming process, such as deep drawing, call for good lubrication, whereby the oil collects in the valleys of the surface profile. On the other hand, the steel surface must appear as smooth as possible, so that the structure profile is not visible in the paint coat, thus detracting from the finish.

The exact properties of the steel surface are determined with the aid of a BMT roughness scanner. This mechanical measuring device runs along the surface with a probe tip and calculates the microscopic surface profile (image 1). A high-pass filter is then applied to these results to identify the roughness (Ra) – defined as the average depth of the measured surface profile, known as mean roughness parameter – as well as the peak count (RPc). RPc expresses the number of peaks per centimetre in the surface profile. A low-pass filter permits determination of waviness (Wa), which is defined as the average value of the waves measured and is perceived by the human eye as long-wave surface topography (a waviness profile of Wsa(1-5) has established itself as the industry standard, as this correlates strongly with paint waviness).
It is also possible to calculate the Wa0.8 figure – wave surface arithmetic value – using an adjusted profile filter. Wa0.8 shows an equally strong correlation with paint waviness as Wsa(1-5).

Image 1: Measurement of the surface topography



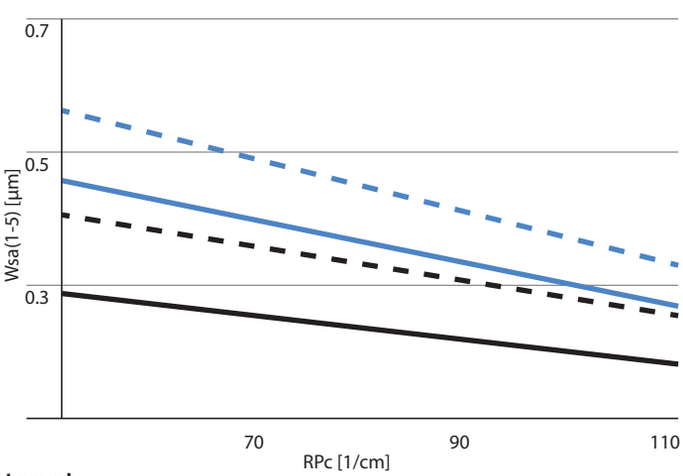
The microscopic surface structure as measured by the Dual Wavescan device

High pass filter gives roughness and peak count (EN 10094)
- Roughness Ra – average distance to zero of roughness profile
- Peak Count RPc – number of roughness peaks per cm

Low pass filter gives waviness (SEP1941)
- Waviness Wa – average distance to zero of waviness profile
- Different filters give different waviness levels

- Wsa(1-5) ➔ cut-off points 1.0 / 5.0 mm
- Wa0.8 ➔ cut-off points 0.8 / 10.0 mm

Image 2: Dependence of the three parameters of surface topography



Legend

— Ra = 0.9 µm - - Ra = 0.9 µm after forming
— Ra = 1.4 µm - - Ra = 1.4 µm after forming

Surface impact on the paint appearance

When considering paint appearance, the three parameters of surface topography – Ra, RPc and Wsa – are highly dependent on one another (image 2). High roughness usually results in high waviness and thus leads to a blurry appearance. A high peak count, in contrast, leads to low waviness and thus to a paint appearance with an exceptionally smooth reflection. For an excellent paint appearance with low waviness (Wa) paired with good processing characteristics, the roughness (Ra) and peak count (RPc) must be specifically adapted to one another.

However, the decisive parameter for the final appearance is not the surface properties of the still unformed sheet, but the waviness of the steel after it has been formed into the finished part. So-called pattern defects can arise through the forming process – such as lines perpendicular to the direction of rolling (image 3) – thus increasing waviness.

Study under real-life conditions

Based on these findings, Tata Steel collaborated with a European vehicle manufacturer to conduct a series of tests under real-life painting conditions that measured the influence of surface waviness on paint waviness. In each case, a comparison was made between the results for flat steel (plate) and formed parts (cup) that had been painted horizontally or vertically and the paint waviness was measured in the rolling direction of the substrate or transverse to it.

In the case of vertically painted parts, such as a side door, the paint process has a great influence on the paint waviness of both plate and cup parts (image 4). In rolling direction, the steel surface structure becomes more clearly visible in the form of paint waviness than in the direction transverse to the rolling direction.
For horizontally painted parts such as a bonnet (angle of less than 5-10 degrees), it was evident that the paint result is strongly influenced by the rolling direction of the substrate and the roughness of the surface structure, and less by the painting process. In the direction of rolling, higher paint waviness occurs on flat steel, rising disproportionately even further in the case of formed parts. Overall, the roughness of the surface structure is significantly more visible in the paint result on painted formed parts than on the flat steel samples.

Serica: low waviness for premium paint appearance

On the basis of the test results, Tata Steel implemented modifications to the steel manufacturing process – e.g. in the chemical composition and specific adaptation of the skin pass rolling – and developed its premium surface finish for hot-dip galvanised steels named Serica.

Serica enables an outstanding paint result through optimised surface properties notable for guaranteed characteristics as presented in the table shown in image 5. The optimised surface properties are defined by low roughness (0.9 to 1.4 µm) paired with a high peak count (≥ 75 cm^{-1}) and low waviness after deformation - thanks to the stability of the substrate during deformation - and are thus ideally suited to achieving a premium paint appearance on exposed automotive panels such as bonnets, doors, fenders and body sides.

Serica is available at different guaranteed waviness levels, allowing paint engineers to choose the required waviness for (adjacent) parts with different paint appearance requirements. This enables not only an optimized paint appearance of individual parts but also to achieve a perfect harmony in the overall paint appearance of the vehicle.

The quality of the paint appearance of Serica 32 can be compared to traditional Full Finish qualities in image 6. It is clearly evident here that the light reflections on the other two surfaces is are more irregular and diffuse, leading to a blurred image. By comparison, the Serica 32 surface displays far sharper reflections and a more premium appearance. This means that vehicle manufacturers can improve the quality of exposed

Image 3: Pattern defects due to forming

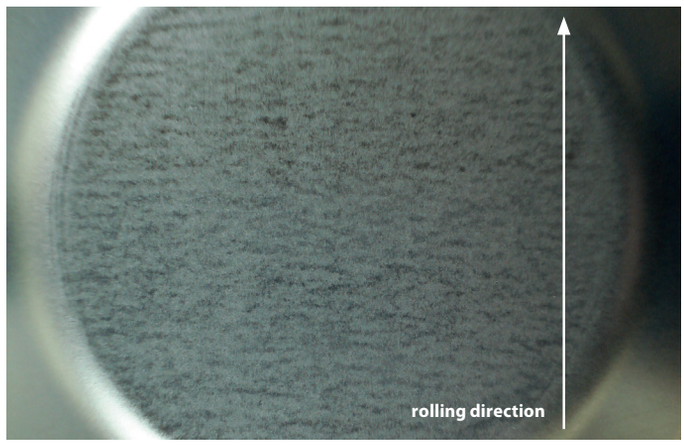
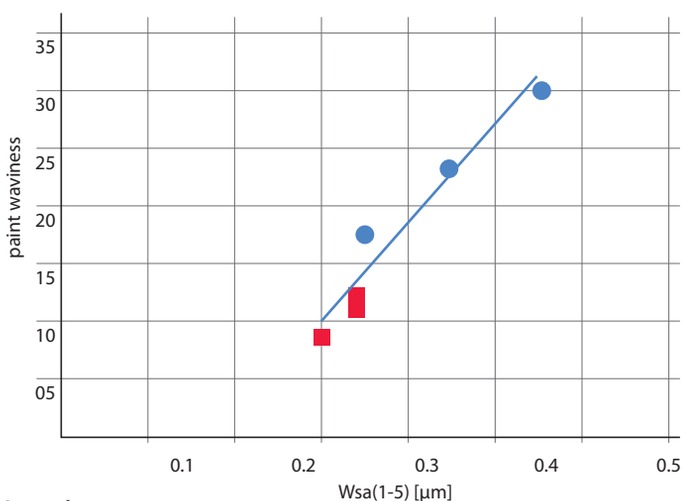


Image 4: Influence of surface waviness for vertically painted parts

Typical correlation between Wsa(1-5) and paint waviness



Legend

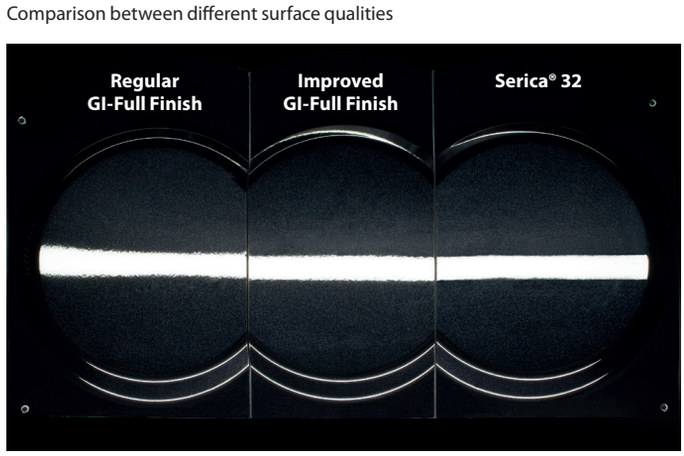
plate (flat steel) cup (formed parts)

Image 5: Product specifications for Serica® family

	Roughness, Ra	Peak count, RPc	Waviness Wsa(1-5)(at 5% strain)
Serica 35	0.9 - 1.4	≥ 75cm^{-1}	≤ 0.35 µm
Serica 32	0.9 - 1.4	≥ 75cm^{-1}	≤ 0.32 µm
Serica 29	0.9 - 1.4	≥ 75cm^{-1}	≤ 0.29 µm

Image 6: Light reflection on a painted steel sample

Comparison between different surface qualities



Surface:
Ra = 1.51 µm;
RPc = 69/cm;
Wsa(1-5) at 5%
= 0.46 µm

Surface:
Ra = 1.36 µm;
RPc = 91/cm;
Wsa(1-5) at 5%
= 0.34 µm

Surface:
Ra = 0.99 µm;
RPc = 99/cm;
Wsa(1-5) at 5%
= 0.28 µm

body panels and reduce costs by using a modern paint system with fewer or thinner layers or by switching from electro-galvanised to hot-dip galvanised steels.
At the same time, its roughness values ensure that Serica 32 provides the necessary grip during the production process. Investigations with a number of different customers have shown that there are no detrimental effects on lubrication within this band of roughness compared to higher values. This means that, in deep drawing processes designed for hot-dipped galvanised steels, no major modifications are required in order to swap existing materials for steels with low roughness.

Summary

With Serica, the new surface optimisation for hot-dip galvanised steels, vehicle manufacturers now have access to steels for exterior body panels that enable them to implement the current trends in vehicle design and improve quality as well as lower their total costs of ownership. The new premium surface facilitates, on the one hand, the use of fewer or thinner paint layers, thus optimising efficiency and material usage in the painting process. On the other hand, cost-effective hot-dip galvanising and minimal modifications to the existing production process also offer potential savings, which can be calculated on an individual basis by the experts at Tata Steel for each application.

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