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Influence of the morphological texture on the low wear damage of paint coated sheets

F. Hennebelle [a], D. Najjar [a,*], M. Bigerelle [a,b], A. Iost [a]

[a] *Laboratoire de Métallurgie Physique et Génie des Matériaux, CNRS UMR 8517, Equipe Caractérisation et Propriétés des Périsurfaces, ENSAM, 8 Boulevard Louis XIV, 59046 Lille, France*

[b] *Laboratoire Roberval, FRE 2833/CNRS, Université Technologique de Compiègne, BP20529, 60205 Compiègne, France*

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Abstract

The influence of the morphological texture (flat and structured) of a polyester based paint coating on the low wear damage is characterised by means of roughness and gloss measurements. Using statistical methods, the aim of the investigation is to determine, among about 60 surface roughness parameters, the most relevant of them with regard to the morphological texture and the wear behaviour of polymer coatings. The level of relevance of each roughness is quantitatively assessed through the calculation of a statistical index of performance determined by combining the two-way analysis of variance (ANOVA) and the computer based Bootstrap method (CBBM).

For the experimental conditions related to the present investigation, the fractal dimension and a roughness parameter directly related to the number of inflexion points of the profiles are shown to be the most relevant parameters for discriminating the different morphological textures of studied coatings and for characterising the low wear damage, respectively. Even if the gloss reduction related to the low wear damage is more visually perceptible at a macroscopic scale for the flat products than for the structured ones, the magnitude of this damage is shown to be however very similar at a microscopic scale whatever the morphological texture of the paint coatings.
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1. Introduction

Paint coating is an economic way widely used to protect metallic substrates against aggressive and corrosive environments. However, the improvement of the resistance to mar damage is as much important as the resistance to corrosion for paint coatings used in many applications [1–9]. Indeed, mar damage is known to generate small scratches which affect the aesthetic appearance of automotive, building trade and domestic products. As a consequence, a major industrial concern is to develop paint coatings with morphological textures resistant to mar damage over time.

In a very recent paper [10], we assessed the influence of low wear damage on topography features and gloss reduction of several standard commercial paint coatings having different morphologies and surface hardness. Using a statistical methodology combining the analysis of variance (ANOVA) with the computer based Bootstrap method (CBBM), it was shown that, among a large number of roughness parameters, the fractal dimension and the average curvature radius of peaks were the most relevant roughness parameters for discriminating, respectively, the morphological texture and the magnitude of a low wear damage of the different polymer coatings studied. Besides, from the experimental observations and the statistical analysis results, this low wear damage produced by means of 'the Scotch Brite test' was strongly thought to be the consequence of a ploughing mechanism affecting mainly the topography of asperities at a small scale whatever the initial morphological texture of the polymer coatings studied.

In this paper, the same experimental procedure and statistical methodology were reproduced to assess the influence of morphological texture of improved paint coatings developed to resist wear damage. For these new paint coatings, the aim is to determine which roughness parameters are the most relevant for discriminating the different morphological textures and the magnitude of the low wear damage. Besides, we might also wonder which roughness parameter is the most appropriate to

* Corresponding author. Tel.: +33 320 622 765; fax: +33 320 662 957.
E-mail address: Denis.najjar@lille.ensam.fr (D. Najjar).

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provide an objective ranking of damaged products similar to that subjectively perceived at naked eye.

2. Materials and experimental procedure

2.1. Polymer coatings

The materials under study were pre-painted galvanised steel sheets with different morphological textures which provide different aesthetic appearances to the manufactured products. As aforementioned, the experimental paint coatings considered in this investigation were improved with regard to mar damage in comparison to standard commercial products. From a technological point of view, the formulations of these new experimental paintings were based on that of the more resistant commercial product. After their elaboration, these experimental paint coatings were supplied to us by the firm ARCELOR. These new products were polyester based paint coatings consisting of a primer and topcoat in which different additives were introduced to elaborate flat, grained and structured morphological textures having relatively high surface hardness. Microscopic observations of the morphological textures of these new products are shown in Table 1.

2.2. Wear testing

Because the affected area would be too small in comparison with the heterogeneity of the morphological texture of some polymer coatings under consideration in this study, the simple 'Scotch Brite test' has been preferred to usual scratch tests or micro-hardness tests [3,4,7,9,21]. While affecting a larger area during testing, the 'Scotch Brite test' is also more representative of damage encountered in real applications since it simulates a low wear mar damage (occurring for example during automatic car washing [3,4]). More precisely, the mar damage is due to a wear mechanism generating scratches of less than 1 μm depth [3,4,7,9,21] that may affect the surface topography and the aspect.

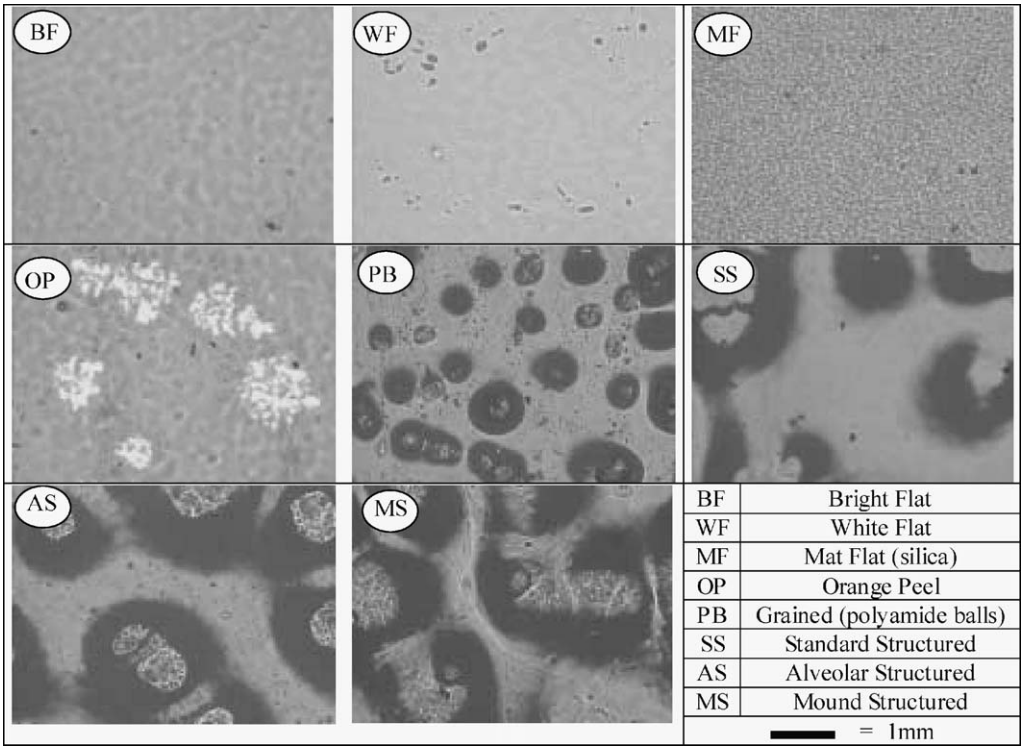
Even if the 'Scotch Brite test' is a normalised test (BS EN ISO 11998 Standard), it was shown in our previous investigation [10] that the application of the normalised conditions was not adapted for the standard commercial paints. As a consequence, these normalised conditions were lightly modified and it was found that applying a 15 N load during 10 cycles allowed to obtain visually homogenous and reproducible wear damage. For each sample tested, the worn area was 4 cm large and 12 cm long. The same experimental conditions were retained for the new experimental hard paint coatings tested in this investigation.

It must be mentioned that the 'Scotch Brite test' provides only subjective information that depends in particular on the physiological perception of the practitioner since the magnitude of wear damage is visually assessed (high density of scratches, low density of scratches, no scratches). In this investigation, the mar damage has been quantitatively assessed by means of roughness and gloss measurements.

2.3. Roughness measurements

Preliminary measurements have been performed by means of a three-dimensional (3D) tactile roughness profilometer KLA

Table 1
Microscopic observations of the morphological textures of the different paint coatings under study



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