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FreiLacke

Technical article:

Reflection-optimised powder coatings for the lighting industry

Light plays a key role in people's lives, as we largely perceive the world around us using our eyes. When little or no light is available, the environment as perceived by our eyes becomes blurred, if it can still be perceived at all. It is for this reason that man has used artificial lighting ever since the advent of fire to be able to see in the dark as well.

Nowadays, we can no longer imagine our daily lives without artificial lighting, as it is a necessary or desired feature in all areas of life and work. However, visual tasks differ according to activity. For example, different types of lighting are required for reading, driving and microscopic analyses. Lighting must therefore be adjusted to suit each visual task. This lighting quality is influenced by the following factors: visual comfort, visual performance and visual ambiance. In turn, these are influenced by other factors such as colour rendering, brightness distribution, lighting level, glare reduction, shading, light direction and light colour.

Fig. 1: ONDARIA light fitting from Zumtobel, www.zumtobel.com, coated with the reflection-optimised powder coating PP6001DF2004 from FreiLacke

Due to this complexity, lighting quality has been standardised for different areas, e.g. workplaces, sports halls, event venues and streets. The aim of this is to ensure consistent lighting quality in these areas.

Part of this standardisation concerns the photometric properties of light fittings, which include luminous intensity distribution, luminance distribution and luminaire efficiency. These will be discussed in greater detail here. These values are specified by lighting manufacturers to make it possible for architects to design lighting systems.

A graphic representation of the luminous intensity distribution of each light fitting is produced, mainly in the form of a polar diagram, in order to assess the spatial distribution of luminous intensity. The value is given in cd/klm (candela per kilolumen) and is usually based on 1000 lm (lumen) to ease comparison between light fittings.
A luminous intensity distribution curve indicates how much light is emitted in the lower and upper half of the light fitting. For example, the indirect lighting from a light fitting that is reflected off a ceiling is used to create diffused light.

Our sense of sight is mainly affected by luminance distribution, as this measures brightness in luminous intensity per unit area (cd/m^2) This value is therefore a very important planning factor for exterior lighting, e.g. to minimise differences in the brightness of street lighting as much as possible.

Luminaire efficiency provides information on the energy efficiency of a light fitting. Measuring luminaire efficiency involves measuring the ratio of the luminous flux emitted by the light fitting to the luminous flux of its lamps (incandescent light bulb, fluorescent lamp, etc.). The higher this value, the higher the efficiency of the light fitting and the better the ratio of the light fitting's luminous flux to energy consumed.

The "inner workings" of light fittings have a particular effect on their luminaire efficiency, as conventional lamps such as incandescent light bulbs and fluorescent lamps emit diffused light. Thus, it is important that the inner workings of a light fitting reflect light back towards the exposed part of the light fitting so that luminaire efficiency is increased. Besides the geometry of the light fitting and reflectors, this is where the reflective properties of the materials used (mirrors, coatings, plastic covers, etc.) come into play.

Against this background, various lighting manufacturers approached FreiLacke regarding the development of a powder coating with exceptional reflective properties to achieve the best possible luminaire efficiency. In addition, the following requirements had to be met:

- Discolouration-resistant binder
- Gloss level of 25 GU at a 60° angle
- Excellent running properties
- Uniform appearance

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- Excellent application properties owing to the geometric complexity of the objects being coated, particularly in corners
- Good overbake stability when baking the powder coating for 30 minutes at 200 °C, colour shade deviation dE <1

Due to these predefined characteristics, polyester was chosen as the binder. Due to the low gloss level target, matting had to be achieved using a dry-blend powder coating.

Dry-blend powder coatings consist of two separately produced powder coatings that are subsequently blended together when dry, i.e. without repeated extrusion. Following the application of the powder coating to the workpieces, these are baked for 10 minutes at 180 °C in a convection oven. During the baking process, the two powder coatings melt and start to react with the curing agents. The two powder coatings react at different rates, which lead to the formation of a microstructure on the surface (cf. Fig. 2). This microstructure reflects incidental light diffusely and gives the surface a matt appearance.

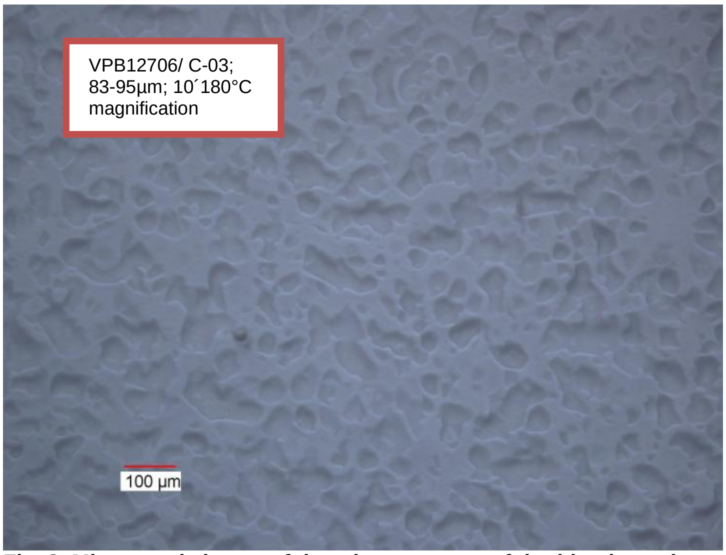

Fig. 2: Microscopic image of the microstructure of dry-blend powder coatings

Depending on the binder components, the use of dry-blend powder coatings can lead to pixellation. This means that the individual powder coatings in the coating film can be seen with the naked eye. This effect is usually not desired, as it means that the powder coating is not uniform in appearance (cf. Fig. 3). By way of illustration, examples of heavy and low pixellation were produced in colour shade RAL 9005, as the difference is most pronounced in this shade.

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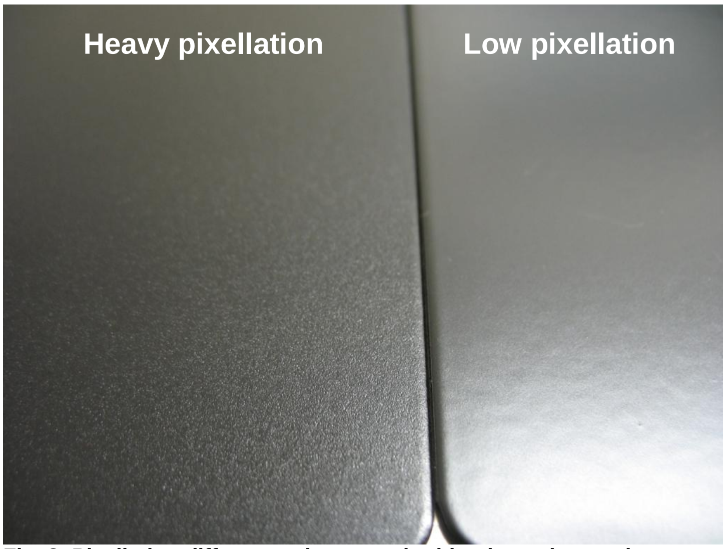

Fig. 3: Pixellation differences between dry-blend powder coatings

After conducting a series of experiments, a combination of binders in each powder coating was found that results in extremely minimal pixellation and therefore produces a surface that is homogeneous in appearance.

Another challenge for lighting manufacturers was to find a dry-blend powder coating with excellent running properties. These are greatly affected by the viscosity of the powder coating during the melting process. The lower the viscosity (thinner), the better the running properties. However, if the viscosity is too low, the powder coating starts to run off the workpieces to form drops on edges and in corners.

Since the powder coating's reflective properties played a major role during the development process, it was necessary to define a suitable measuring method for these. The degree of diffuse reflection (ρdif) was chosen to evaluate the reflective properties of the powder coatings, which takes into account the total luminous flux reflected by surfaces. The measurement is performed using an integrating sphere, a lamp with a constant luminous flux at 25 °C and a calibrated reflectivity standard with a known reflectivity level in accordance with DIN 5036 Part 3.

It was possible to determine two different powder coating attributes.
The standard attribute for these reflection-optimised powder coatings is characterised by excellent reflective and visual properties with a very good price/performance ratio. Running properties are outstanding and pixellation was reduced to such a minimum that only very close inspection reveals the coating to be a dry-blend powder coating. Application properties are also excellent, even in the case of geometrically complex components.
A second powder coating attribute was defined to ensure the highest possible reflectivity. This required a special binder to further increase reflectivity. This also meets high visual

requirements and has excellent application properties. Due to the higher price of the special binder, the powder coating price has also risen. Fig. 4 illustrates the different reflectivity levels (ρ_{dif}) of different powder coatings plus a mirror reflector as used in the lighting industry.

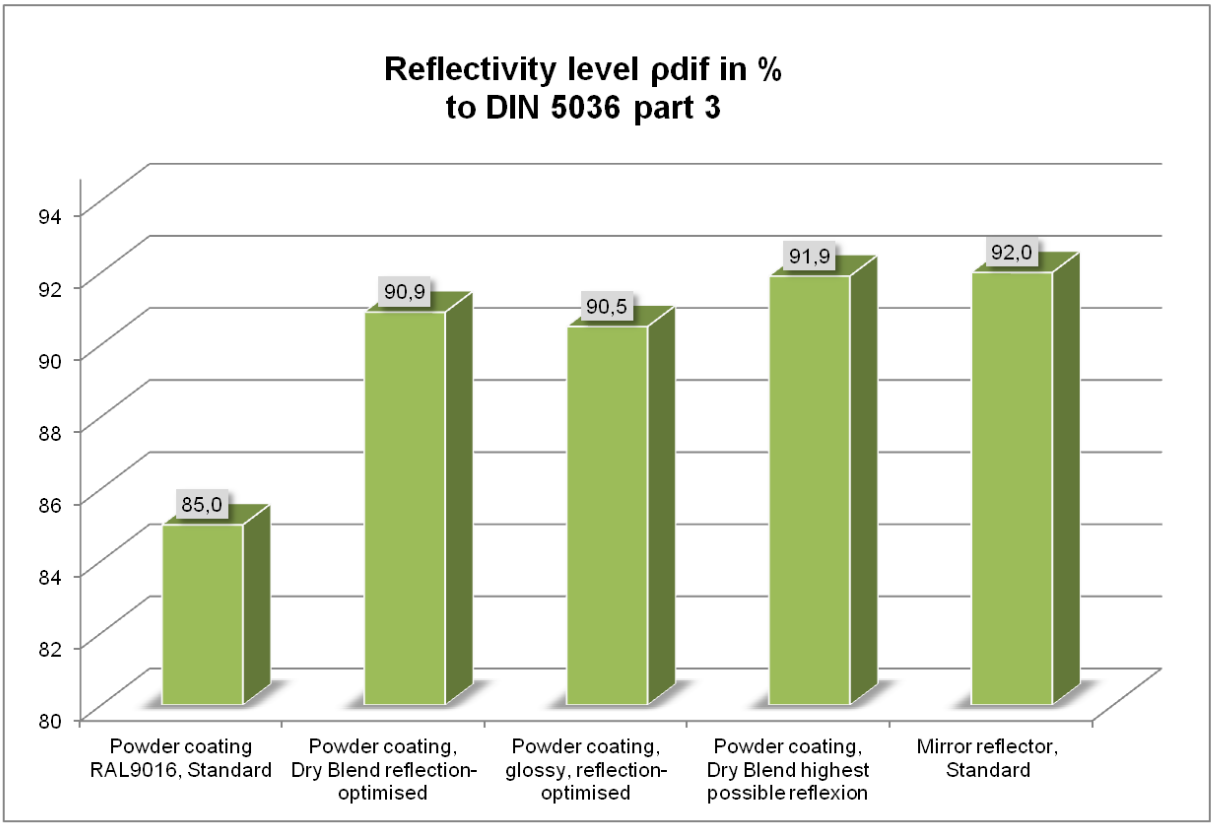

Fig. 4: Different reflectivity levels of powder coatings

Reflection-optimised powder coatings are particularly suited for use with light fittings for which high luminaire efficiency is required. Other possible areas of application for reflection-optimised powder coatings include ceiling tiles and metal walls, which can be used to either create brighter rooms or reduce the number of light fittings in an area while maintaining a consistent level of brightness.

The powder coatings of the future will not only be available in low-gloss and dry-blend versions, as it has already been possible to apply development results to high-gloss powder coatings. However, it is necessary to stick to white when using reflection-optimised powder coatings, as other colour shades absorb certain wavelengths of light.

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