Coatings for agricultural and construction machinery

Powder Coatings instead of Liquid Paints

Manufacturers of construction and agricultural machinery place a wide variety of requirements on the coatings used on their products, including a high-quality appearance, a robust finish and easy application. This article explains the standards that modern powder coatings must meet and how the coatings must be applied.

A number of companies in the agricultural and construction machinery industries are in the process of choosing new coating systems. There are a number of reasons for this, including increases in capacity, modernisation, higher quality standards, environmental considerations and/or financial issues. The crucial issue is to identify the coating system that meets each company's specific requirements.

The choice includes, for example, the latest liquid paints based on ultra-high-solids, water-soluble paints, cathodic e-coats combined with liquid paints or powder coatings and single-component or two-component powder coatings. This article describes the use of powder coatings on agricultural and construction machinery.

Bild: Volvo

Construction and agricultural machinery manufacturers are increasingly using powder coatings.

More than just a coat of paint

Until the 1980s, physical drying or oxidative curing liquid paints were the most common choice, as the majority of users at that time accepted that curing times would be relatively long. The levels of technology were relatively low and the appearance of the coatings was relatively poor. In fact, the paint simply performed the function of a „shop coating" until the machinery was sold.

Increasing demands for the development of brand images and for improvements in the external appearance of the machines and equipment, together with the introduction of leasing contracts in these industries, resulted in a greater emphasis on weather resistance, corrosion protection and mechanical properties. In order to meet these requirements, the conventional single-component paints were replaced by systems consisting of a two-component epoxy base coat and a two-component polyurethane top coat. Existing paint shops could be used to apply these new coatings with relatively little conversion work. Manufacturers with a high throughput used anodic e-coat and later cathodic e-coat systems as primers.

At the same time, powder coatings were being developed for a wide range of other applications, both for the interior and later for the exterior. They proved to be successful, high-quality solutions with excellent potential for automation and a low incidence of faults during processing. Inevitably, the interest in powder coatings among manufacturers in the agricultural and construction machinery industries started to grow

and the process of testing products and putting them into use began.

Special properties required

Many agricultural and construction machinery manufacturers have drawn up specifications on the basis of their existing paints, often as part of the introduction of a quality management system. These include requirements for weather resistance, corrosion protection, mechanical properties and resistance to aggressive substances. These requirements specifications are used to compare the latest coating systems. Some examples include:

- Complex welded structures made of components with a wide variety of wall thicknesses. In extreme cases, these can range from light gauge sheet metal with a thickness of 1 mm to a solid 60 mm shaft.
- The high level of brand recognition among construction and agricultural machinery is based largely on the corporate colours of each manufacturer. In hardly any other industry is there such a strong identification between the brand and the colour. Bright, eye-catching shades of yellow, orange, red and green are often used.
- The relatively low degree of vertical integration means that components coated using different systems have to be supplied and assembled. The colour, gloss and surface texture of the components must be similar. Some manufacturers require a high level of similarity between powder-coated and painted components and SMC components.
- High standards of weather and UV resistance. The results obtained with two-component polyurethane liquid top coats represent a benchmark in this respect.

The specific requirements of these industries alone make significant demands on the product quality and processing characteristics of powder coatings.

Name	Curing component	Area of application
PP Standard polyester powder coating	β-hydroxy-alkylamide	General industrial use, such as post boxes
PT High-quality polyester powder coating	Aromatic glycidyl ester	Higher-quality uses, such as children's bicycles and forklift trucks
PS Super-durable powder coating	β-hydroxy-alkylamide	Highest levels of UV stability

Table 1: Three polyester powder coating systems and their areas of application

Weather and UV resistance

Powder coatings do not stand up well to comparison with two-component polyurethane top coats. This article does not cover highly weather-resistant fluoropolymers and GMA acrylates, because they are not widely used as a result of their other properties and their cost. It may be possible in future to use GMA acrylates in more applications [1]. In addition, TGIC coatings will not be investigated in this article because of the potential physiological problems involved.

The most common polyester powder coatings are those that are cured using ß-hydroxyalkylamide (Primid XL 552) or aromatic glycidyl ester (Araldite PT 910). The fundamental properties are determined by the polyester resin. For clarification purposes, we will make a distinction in this article between three different kinds of polyester powder coatings: standard (PP), high-quality (PT) and super-durable powder coatings (PS), Table 1.

In terms of gloss retention, super-durable powder coatings produce the best results in xenon arc weathering tests, Figure 1, but they do not stand up

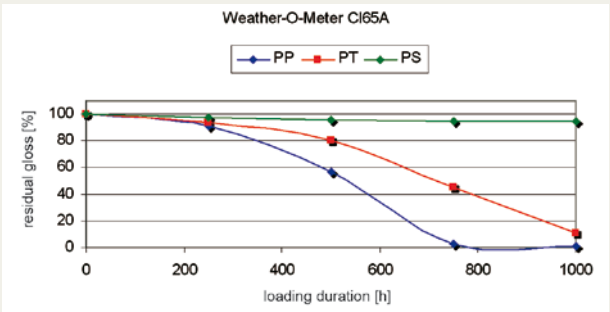

Figure 1: Comparison of different polyester powder coatings under xenon arc light.

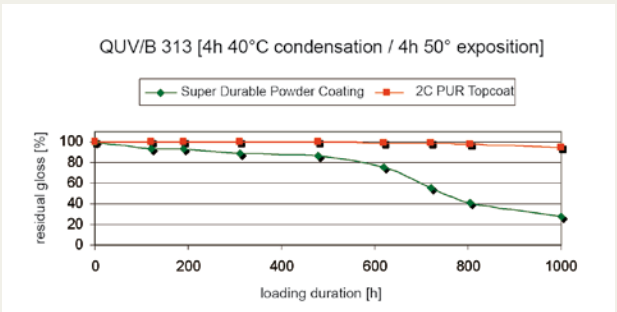

Figure 2: Super-durable powder coatings produce poorer results in the xenon arc weathering test than two-component polyurethane top coats.

>> well to comparison with a conventional, commercially available two-component polyurethane top coat, Figure 2. In the context of the construction and agricultural machinery industry, this means that high-quality powder coatings do not meet the existing specifications, or at least only to a limited degree. Therefore, if powder coatings are to be used, the specifications must be evaluated and, if necessary, modified.

The problem becomes more serious when powder-coated and painted components are combined on one machine. After several years of use, differences in the gloss levels and the colour that will give the machine a patchy appearance may develop. Whether this is acceptable will ultimately depend on the tolerance limits of the manufacturer and its end customers. One solution in this case may be to reduce the UV resistance of the liquid paint slightly in order to ensure that the components fade and weather evenly, resulting in a more uniform appearance in the long term.

It goes without saying that stable pigments must be used to formulate the colours of both the powder coating and the paint.

Edge coverage depends on the colour

As already mentioned, construction and agricultural machinery is often painted in bright colours. Large quantities of high-quality pigments are used to formulate the powder coating, in order to guarantee coverage of 60 to 80 µm and upwards, depending on the colour. Together with the necessary large amounts of binder, this has an impact on the price and also on the rheological properties, with the result that the edge coverage is comparatively poor and therefore more susceptible to corrosion.

It is generally true that the clearer and brighter the colour, the more critical this factor becomes. It has frequently been demonstrated in practice that a small modification to the colour results in a significant reduction in edge corrosion.

Complex parts with different wall thicknesses

Because of the complex parts used in the machines, it is almost inevitable that a manual coating process will be needed in addition to the automated one. This manual coating area should be ergonomically designed so that no acrobatics are required from the operator. An even coating can only be guaranteed when the automatic application process is complemented by a manual operator. This makes it possible to ensure that all the corners, edges and cavities are correctly coated and meet the corrosion protection requirements, in particular in the case of one-coat systems.

The coating must be applied as evenly as possible to achieve the minimum layer thickness required for critical colours and to ensure a uniform appearance. It is also important to avoid applying the coating too thickly in order to prevent pinholes. These can occur in polyester powder coatings that are cured with ß-hydroxyalkylamide above a specific thickness threshold and are caused by the water molecules released during the curing process. This threshold can be raised by careful formulation of the powder coating.

In the case of highly complex parts, triboelectric application systems may be preferable to corona systems, but a decision must be made in each individual case. The differing thicknesses of the component walls present the greatest challenge for the manufacturers of the dryer and the coating. It is essential that the coating on parts with thick walls is crosslinked effectively and that thin-walled areas are not overbaked.

The range of parts must be carefully assessed during the process of designing the coating plant. Tests can be used to determine the best size for the dryer. In order to ensure that all the technological properties of the coating are fully exploited, the parts should be heated as quickly as possible and allowed to cure evenly at a lower peak temperature for a suitable dwell time.

A slightly longer dryer is recommended to allow for an adequate dwell time and to restrict the temperature of the circulating air to a maximum of 210 °C. Medium-wave infrared heaters can be used to advantage during the heating phase, depending on the complexity of

Figure 3: UV resistance of a super-durable powder coating (left) and a standard polyester powder coating (right). QUV/B 313, exposure time 430 hours.

	Standard polyester powder coating	Super-durable powder coating	Hydro two-coat	High-solids two-coat	High-solids single-coat	Standard two-coat paint
Relative price comparison per m² (material costs)*	1.0	1.2	2.8	2.1	1.85	2.1
Total coating thickness [µm]	80	80	130	130	80	130
Drying/curing conditions	10 min./ 180 °C	10 min./ 180 °C	Base coat: 20 min./ RT Top coat: 30 min./ 70°C	Base coat: 20 min./ RT Top coat: 30 min./ 70°C	30 min./ 70 °C	Base coat: 20 min./ RT Top coat: 30 min./ 70°C
Solvent percentage [%]	0	0	8	22	15	47
* strongly dependent on the colour used						

Table 2: Comparison of the properties of different powder coatings and liquid paints

the parts. A carefully designed curing oven can be complemented by the ideal powder formulation in order to achieve a reasonable process window.

The optimum powder coating

Coating manufacturer FreiLacke recommends the use of highly flexible, super-durable powder coatings. The requirement for high levels of weather resistance and the high standards set by the liquid paint systems preclude the use of lower quality systems.

Super-durable powder coatings have the following properties:

- Excellent weather resistance
- Very good flexibility
- No labelling required and no heavy metals used
- Good chemical resistance
- Long curing window
- Can be applied using corona and triboelectric charge systems

Advantages of powder coatings over liquid paints

Although powder coatings are not yet technologically in a position to replace paints completely, they do offer some advantages:

- High levels of material usage
- Variable coating thicknesses
- Fully automatic coating processes using modern plants
- Rapid assembly of parts
- Environmentally friendly
- Low health risks during manufacturing and application

Cooperation during the design phase

In order to ensure that every aspect of the conversion of an existing plant or the design of a new one is taken into account, it is essential for the plant operator, the plant manufacturer, the supplier of the pretreatment system and the coating manufacturer to work closely together from the start.

Only by taking a structured approach and producing a carefully thought-out test plan will it be possible to identify the appropriate coating, the correct pretreatment method and the best possible plant design, which can be incorporated into an efficient and reliable production process.

Exceeding the weather resistance of liquid paints

For agricultural machinery and, in particular, for tractors and self-propelled machines, a combination of a cathodic e-coat and a powder top coat is often used. In contrast, single-layer coatings are generally found on the associated equipment.

In the construction machinery industry, there is a trend towards single-layer powder coatings. This presents the development departments of coating manufacturers with the challenge of developing a comprehensive product portfolio. More and more often, the classic, gloss corporate colour is combined with a complementary shade of matt grey or black.

Coatings with different gloss levels but with the same high levels of weather resistance are currently under development. The main objective in the area of weather resistance is to match or even exceed the properties of liquid paints.

Source:

[1] Rembert, Axel, John Deere Werke Bruchsal, Landmaschinen in Automobilqualität (Agricultural machinery with the same quality standards as cars), EPS 2006

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