

REVIEW - INFLUENCE OF PANEL MOISTURE CONTENT ON POWDER COATING OF MEDIUM DENSITY FIBREBOARD (MDF)

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Abstract:

Powder coating medium density fibreboards (MDF) is an emerging environmentally sustainable coating technology that is used today mainly in the furniture industry. Generally the powder coating process can be divided into following steps: First, the MDF panels have to be conditioned. After that the surface is sanded, the work piece is hung on hangers and cleaned by pressurized air. Then the MDF is IR-preheated to improve the following electrostatic powder application. Finally, the powder is melted and cured in the curing oven. After powder primer curing the process starts again for the top coat application. This work summarises the results of different research works on the influence of panel moisture content on powder coating of MDF: Firstly, the electrostatic powder application is influenced by the moisture content due to the increase of electrical resistance with decreasing panel moisture content. If the MDF panel is too dry (high electrical resistance) the required transport of electric charges during electrostatic powder application is not at all or only insufficiently provided, leading to an insufficient film formation and low coating thickness. Additionally, the results indicate a distinct tendency towards the development of cracks (edge cracking during the melting and curing process in the oven) increasing with panel moisture content.

Key words: powder coating; MDF; moisture content; medium density fibreboard.

INTRODUCTION

Powder coating medium density fibreboards (MDF) is an emerging technology that - although already commercially successfully done today - is still in a continuous improvement and further development stage. It is used today mainly in the furniture industry (office, kitchen, ready-to-assemble furniture etc.), for shelving and PoP displays (Fig. 1).



Fig. 1

Powder coated MDF applications (left) and design opportunities (right).

Due to the European Solvent Emission Directive and increasing ecological awareness of customers and producers the usage of ecological and economical coatings is becoming increasingly popular (Barbu and Schmidt 2009, Prieto and Kiene 2007). Coatings with a high solvent content like nitrocellulose lacquers, acid catalyzed lacquers or 2 component polyurethane lacquers are replaced by other systems. In context with coating MDF, powder coatings, water-based finishes and UV-curing finishes are potential alternatives and will compete in future (Barbu and Schmidt 2009). Compared to solvent-based coatings and waterborne paints, waterborne UV curable coatings and powder coatings have much lower environmental impact (Verlaak and Morris 2011, Ramseier Woocoat AG 2011).

Powder coatings have replaced solvent-based coating applications in the metal industry, and there is also a potential in the engineered wood furniture industry allowing powder coatings gaining market share with the same arguments of environmentally friendly, robust and cost efficient surfaces.

Fig. 1 (right) shows powder coated MDF applications. In addition to the variety of design possibilities (wide colour range, seamless all around coatings, 3D - design variations) the inkjet and electrophotographic print on powder coated MDF creates a new freedom of design (Schmidt and Jocham 2009, Kempter 2012, Jocham *et al.* 2013b). Intensive research and development efforts over the last years have led to commercial production lines where durable high quality powder coatings can be applied to MDF products.

Generally the powder coating process can be divided into following steps.

First, the MDF panels have to be conditioned in a climate chamber or in a factory hall with controlled relative humidity. After that the surface is sanded, the work piece is hung on hangers and cleaned by

pressurized air. Then the MDF is IR-preheated to improve the following electrostatic powder application (Jocham *et al.* 2011, Jocham *et al.* 2013b). Finally, the powder is melted and cured in the curing oven – usually also IR ovens. After powder primer curing the process starts again for the top coat application (Fig. 2).

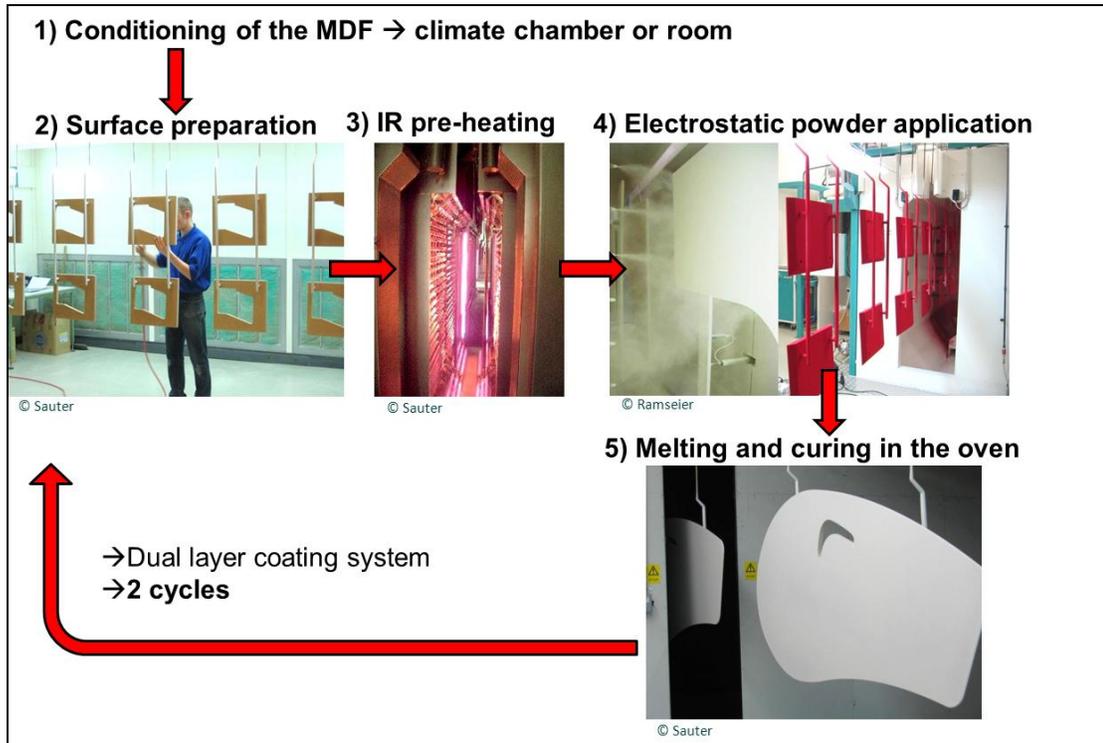


Fig. 2
MDF powder coating process.

INFLUENCE OF PANEL MOISTURE CONTENT ON POWDER COATING OF MEDIUM DENSITY FIBREBOARD (MDF)

Several works (Schmidt and Jocham 2009, Jocham 2009, Jocham *et al.* 2010, Jocham *et al.* 2013a, Jocham *et al.* 2013b, Jocham *et al.* 2013c) over the last years have shown that the moisture content of the MDF panel prior powder coating has a significant influence on the MDF powder coating results.

Influence of panel moisture content on the electrostatic properties and electrostatic powder application

One of the main challenges of powder coating MDF is the electrostatic application of the powder which requires an electrical conductive substrate. However, the conductivity does not need to be as high as with metal substrates and newly developed “conductive” MDF boards (MDF containing electroconductive additives = powder coating grade) are well suitable for the process.

Generally, it is defined that the surface electrical resistance of the MDF should be lower than 10^{11} Ohm to provide sufficient electrostatic powder application (Barbu and Schmidt 2009).

Understanding the electrical resistance of MDF panels on the surface and in the core of the material and the relationship to the panel moisture content is of utmost importance for the design of a well-controlled production process. Fig. 3 shows the equilibrium moisture content (EMC) distribution across panel thickness of a 25mm thick MDF. At equilibrium the moisture content of the core layer of the MDF panel is higher than the moisture content of the surface layer (Jocham 2009). A similar effect has been reported by other researchers (Kehr and Grabitzki 1965, Wu and Xiong 2001). It can be assumed that the observed behaviour is caused by the higher thermal impact of temperature pre-treatment on the surface layers during MDF production (hot pressing).

The bottom part of Fig. 3 shows the electrical resistance distribution across the panel thickness of the same 25mm thick MDF. It can clearly be seen that areas of higher moisture content show lower electrical resistance and therefore increased conductivity.

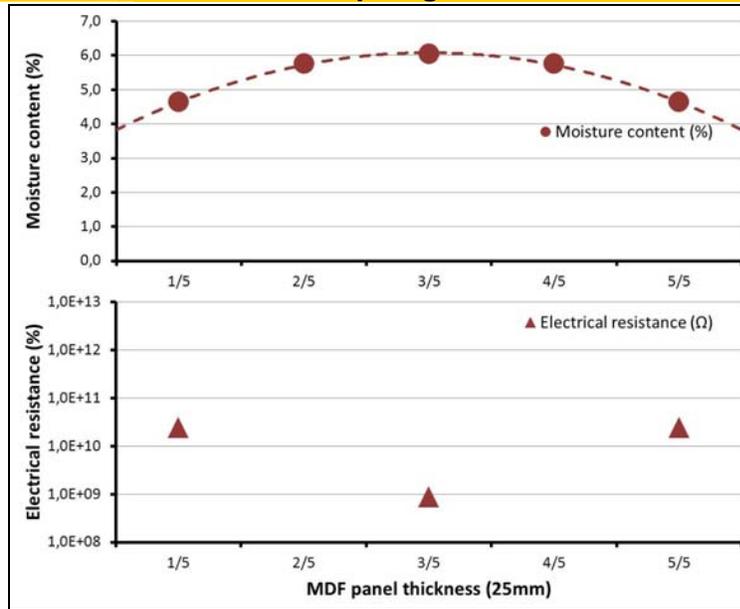


Fig. 3

Equilibrium moisture content (EMC) (top) and electrical resistance distribution (bottom) across panel thickness of a 25mm thick MDF (adapted from Jocham 2009, Schmidt and Jocham 2009).

The panel moisture content is of great importance for electrostatic powder application since the moisture distribution in the panel governs the electrical resistance of the panel (Jocham *et al.* 2011). The relationship between surface electrical resistance and the panel moisture content can be seen in Fig. 4. With increasing panel moisture content the surface electrical resistance is decreasing. Additionally, the electrical resistance of the MDF is influenced by the MDF panel type. Standard grade MDF panels (without electroconductive additives) have a higher electrical resistance than powder coating grade MDF panels (with electroconductive additives); both types having the same moisture content level (Jocham *et al.* 2013a).

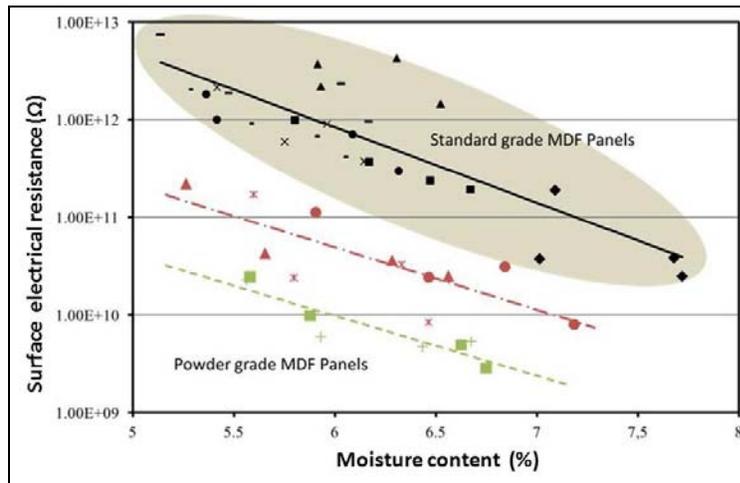


Fig. 4

Surface electrical resistance in dependence of panel moisture content and panel type. The shaded ellipse represents all tested standard grade MDF panels. The symbols outside the shaded ellipse represent two types of powder coating grade MDF panels (adapted from Jocham *et al.* 2013a).

If the MDF panel is too dry (high electrical resistance) the required transport of electric charges during electrostatic powder application is not at all or only insufficiently provided, leading to an insufficient film formation and low coating thickness (Jocham *et al.* 2013a).

The influence of the electrical resistance of MDF panels on coating thickness at the edges is shown in Fig. 5. It is evident that with increasing electrical resistance the coating thickness decreases steadily. At surface electrical resistance values > 10¹¹ Ohm, the coatings formed were too thin and the MDF substrate

occasionally was visible through the coating leading to an unsatisfactory coating quality (see picture in Fig. 5; right). While the plain surfaces were acceptable in many cases even at such critical values for surface electrical resistance, the edges often remained uncoated. Hence, a surface electrical resistance value of $< 10^{11}$ Ohm can be regarded as a critical limit required for sufficient electrostatic powder application (Jocham *et al.* 2013a, Jocham *et al.* 2013b, compare picture in Fig. 5 left).

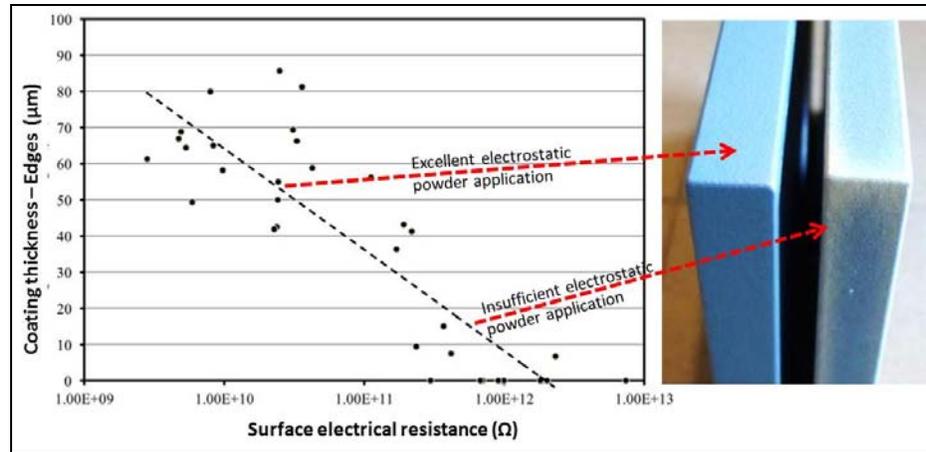


Fig. 5

Thickness of cured powder coating at the edges in dependence of the surface electrical resistance (adapted from Jocham *et al.* 2013a → left) and picture of the powder coating results → right.

Influence of panel moisture content on development of cracks on the edges during the melting and curing processes in the oven

A challenge in powder coating MDF can be the development of cracks on the edges during the melting and curing processes in the oven (see picture in Fig. 6). Generally, this failure is influenced by the strength (internal bond) and density profile of the MDF (Bauch *et al.* 2007). Additional studies showed that this defect could also be closely related to the moisture content of the raw MDF (immediately prior powder coating application). Especially, changes in climate conditions during transport und storage can lead to variation in panel moisture content prior powder coating. This variation can be a cause for this type of coating defect (Jocham *et al.* 2013c).

Fig. 6 shows the dependence of the probability of crack formation (during the melting and curing process in the oven) on the moisture content of MDF. With rising moisture content the probability of crack formation is increasing. At a high moisture content level (e.g. 7%) the typical cracks can be observed after the melting and curing process in the oven. In this case the work pieces has to be rejected or rework is necessary (see picture in Fig. 6; top). On the other hand, if the moisture content level of the same MDF type is lower (e.g. 5%) excellent coating qualities can be achieved (see picture in Fig. 6; bottom).

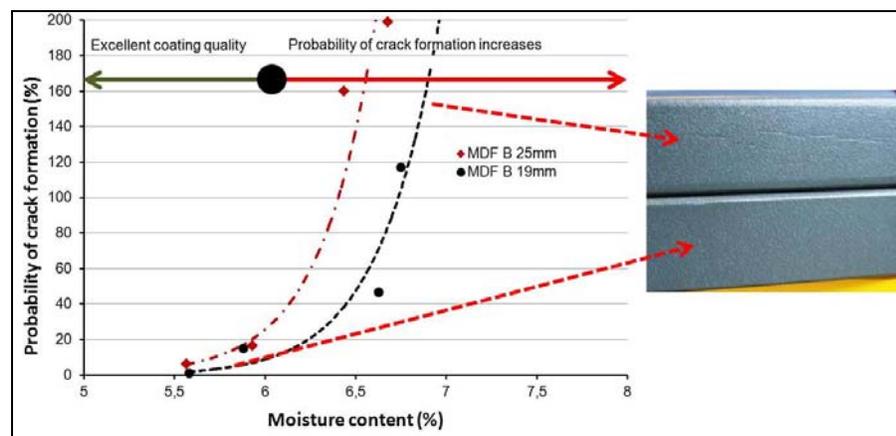


Fig. 6

Dependence of the probability of crack formation on the moisture content of MDF (powder coating grade MDF quality) (adapted from Jocham *et al.* 2013c → left) and picture of the powder coating results → right.

Moisture content and process window

Hence, in order to gain an excellent powder coating result the moisture content of the MDF panel has to be in a specified process window, so that sufficient electrostatic powder application is possible and no cracks during the melting and curing process occur (compare Fig. 7).

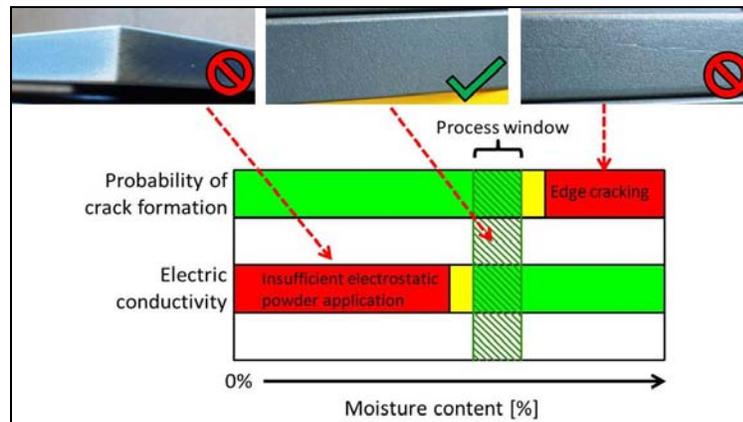


Fig. 7
Process window MDF (adapted from Jocham et al. 2013c).

CONCLUSION

The results of several works in the last years have shown that there is a distinct tendency towards the development of cracks (edge cracking during the melting and curing process in the oven) increasing with panel moisture content. Additionally, the electrostatic powder application is influenced by the moisture content due to the increase of electrical resistance with decreasing panel moisture content. Therefore the MDF panel moisture content should be within a defined process window, which might be achieved by conditioning the substrate immediately prior powder coating. Future works will focus on defining the accurate process window and developing solutions for reducing the required conditioning time.

ANNOTATION

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