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QUALITY OF PIGMENTED GLOSS AND MATTE SURFACE FINISH

Gabriela Slabejová – Mária Šmidriaková

ABSTRACT

The quality of pigmented surface finish intended into interior is presented in the paper. The pigmented surface finish was formed as a system of the basic polyester coating material and the top polyurethane coating material. Two types of top coating materials were tested (gloss and matte). Each type of the surface finish was created in two various coating thicknesses. The coating thicknesses differed in number of coatings of the top coating material. The surface finishes were evaluated according to the film hardness, impact resistance, and resistance to scuffing. Regarding the chemical resistance properties, the surface resistance to cold liquids was determined. Matte surface finishes reached higher film hardness, but lower impact resistance, lower resistance against scuffing, and lower resistance to cold liquids. Neither the film hardness nor the resistance to cold liquids was affected by the number of coatings. On the gloss surface finishes, two layers of the topcoat material resulted in increased impact resistance if compared with the surface with only one top coating layer.

Key words: pigmented finish, hardness, impact, abrasion, cold liquids.

INTRODUCTION

Pigmented surface finish, intended into interior, covers the base material and gives a colourful decorative appearance to the product. At present it is used for kitchen furniture, especially cabinet doors, children's furniture etc. To produce cabinet furniture, particleboards (PB) and medium density fibreboards (MDF) are used. The surface of MDF is usually finished by laminating, veneering or varnishing. All types of surface finish must fulfil the required quality. The quality is assessed according to the properties of the surface finish.

The surface finishes created by coating materials are evaluated according to appearance, physical-mechanical properties and chemical-resistance properties (JAIC, ZIVANOVIC, 1997; TESAŘOVÁ *et al*. 2010; SCRINZI, *et al*. 2010; MODRÁK and MANDULÁK, 2013; BEKHTA *et al*. 2014; SALCA *et al*. 2017; YONG *et al*. 2017). To increase protection of wood and wood-based materials (PB, MDF etc.) is adjust the properties of the coatings (e.g. gloss, hardness, abrasion, impact resistance, and resistance to liquids). The coatings can be modified with nano-technological products (LEE *et al*. 2003; KAYGIN and AKGUN, 2009; KUMAR *et al*. 2015; WETHTHIMUNI *et al*. 2016; CATALDI *et al*. 2017; MIKLEČIĆ *et al*. 2017). PAVLIČ *et al*. (2004) pointed out a basic approach for evaluation of the quality of surface finishing.

Pigmented surface finish is made in a variety of colours and gloss. Gloss is mainly given by chemical composition of the coating material. SAEED and SHABIR (2013) dealt with synthesis of polyurethane and polyacrylic resins, used in water-based coatings, which retain the high gloss even under thermal stress. LEE *et al*. (2003) researched the low gloss of powder coatings, which harden at lower temperatures.

"On coatings, the gloss and colour changes correlate with a slight modification of film-former substance" (SCRINZI *et al*. 2011; MATYAŠOVSKÝ *et al*., 2014). Modification of the coating material does not only affect colour and gloss, but also physical-mechanical properties and chemical-resistance properties.

The aim of this work was to analyse the effect of gloss and number of coatings on the quality of pigmented surface finish. The pigmented surface finish was formed on the surface of veneered MDF board. The quality of the finish was assessed according to the film hardness, impact resistance, resistance against scuffing, and the surface resistance to cold liquids.

MATERIALS AND METHODS

MDF with a thickness of 18 mm was used as the base material (producer Bučina DDD in Zvolen). The MDF was veneered with beech veneer with the thickness of 0.5 mm.

Prior to surface finishing, the veneered MDF was sanded with the sandpaper with grain size number P120. After sanding and cleaning the surface, the surface finishing followed. The coating materials were applied by pneumatic spraying in the amount as recommended by the technical sheet. Curing time of the coating material was 24 hours. After curing, the surface was sanded with sandpaper with grain size number P240. From the surface finished large-scale bodies (300 × 600 × 19 mm), the following test specimens were cut out:

- 300 × 300 × 19 mm (for evaluation of film hardness, impact resistance and resistance to cold liquids),
- 100 × 100 × 19 mm (for evaluation for resistance against scuffing).

The surface finishes were created as a coating systems with polyester coating material (base coating) and polyurethane coating material (top coating). The gloss and matte surface finishes were created as follows:

- **Gloss/4** – gloss surface finish – 2 coatings of base coating material and 2 coatings of top coating material – representative coating materials: Polybian COV (base coat), LPP2530NC RAL – NCS (top coat),
- **Gloss/3** – gloss surface finish – 2 coatings of base coating material and 1 coating of top coating material – representative coating materials: Polybian COV (base coat), LPP2530NC RAL – NCS (top coat),
- **Matte/4** – matte surface finish – 2 coatings of base coating material and 2 coatings of top coating material – representative coating materials: Polybian COV (base coat), OPP530NI/ GTA RAL – NCS (top coat),
- **Matte/3** – matte surface finish – 2 coatings of base coating material and 1 coating of top coating material – representative coating materials: Polybian COV (base coat), OPP530NI/ GTA RAL – NCS (top coat).

The coating materials from the Sirca company were used:

- Polybian COV: white polyester-base coat with no styrol and no aromatic diluents,
- LPP2530NC/ RAL – NCS: pigmented white gloss polyurethane top coat, characterised by an excellent spreadability, excellent coverage, and high gloss,

- OPP530NI/ GTA RAL – NCS: white matte polyurethane top coat, characterised by an excellent curing speed, excellent coverage, surface smoothness, and film hardness.

The film hardness was determined by the pencil test according to the standard STN EN ISO 15184 (2012). The results of the test were evaluated according the pencil that scratched the surface. The test started with the softest pencil – number 1.

The impact resistance of the surface finishes was determined according to the standard STN EN ISO 6272-2 (2011). The intrusion (diameter of the intrusion) was measured and the surface finish was evaluated subjectively according to Table 1.

Tab. 1 Impact resistance: degree of change and evaluation.

Degree	Visual evaluation
1	No visible changes
2	No cracks on the surface and the intrusion was only slightly visible
3	Visible light cracks on the surface, typically one to two circular cracks around the intrusion
4	Visible large cracks at the intrusion
5	Visible cracks were also off-site of intrusion, peeling of the coating

Evaluation of the surface finish resistance against scuffing was determined according to the standard STN EN ISO 7784-3 (2006). The coefficient of the resistance against scuffing K_T was calculated according to the formula:

$$K_T = (m_1 - m_2)/F \qquad (1)$$

Where: m_1 – specimen weight before sanding (g),
m_2 – specimen weight after sanding (g),
F – correction coefficient of the used pair of abrasive papers (F = 1.052).

Surface resistance to cold liquids was determined according to the standard STN EN 12720 (2014). Tab. 2 shows the selected cold liquids and exposure time. After exposure to a cold liquid, the surface was evaluated and graded according to Tab. 3.

Tab. 2 Cold liquids.

Cold liquid	Test duration (hours)
Acetic acid 10% aqueous solution	24
Citric acid 10% aqueous solution	24
Ethanol (p.a.) 96%	24
Sodium carbonate 10% aqueous solution	24
Sodium chloride 15% aqueous solution	24
Cleaner SAVO	24
Wine	24
Coffee	24
Olive oil	24
Ink	24

Tab. 3 Surface resistance to cold liquids.

Grade	Description of quality
5	No visible changes (no damage)
4	Slight change in gloss – visible only in reflection of light source
3	Slight traces of damage (gloss) – visible from different directions
2	Strong traces of damage usually without changing the structure of varnish
1	Strong damage with change in varnish structure

The results of film hardness and the resistance against scuffing were compared with the technical requirements for the quality of surface finish for wood furniture given by the standard STN 91 0102.

Technical requirements according to the STN 91 0102:

- **Surface hardness of the coating film evaluated by the pencil test**
  - Worktops – grade 8
  - Other worktops – grade 8
  - Furniture doors – grade 6
  - Seating furniture — grade 6
  - External surfaces of cabinet bodies – grade 6
  - Inner surfaces of cabinet bodies – grade 5
- **Surface finish resistance against scuffing (K_T)**
  - Worktops – loss of the surface finish max. to 0.12 g/100 rev. (furniture in public areas), max. to 0.15 g/100 rev. (household furniture)
  - Other worktops – loss of the surface finish max. to 0.15 g/100 rev. (furniture in public areas), max. to 0.20 g/100 rev. (household furniture)
  - Other surfaces are not evaluated

RESULTS AND DISCUSSION

Film hardness

The measured values of the film hardness are shown in Tab. 4. From the results can be seen that no of the tested surface finishes met the requirements for the film hardness for worktops for furniture in public areas and household furniture. The matte surface finishes met the requirement for furniture doors, seating furniture, and external surfaces of cabinet bodies. Gloss surface finishes met only the requirements for inner surfaces of cabinet bodies.

Tab. 4 Film hardness of the surface finishes.

Pencil hardness	3B	2B	B	HB	**F**	H	**3H**	4H	5H	6H	7H	8H	9H
Pencil number	1	2	3	4	**5**	6	**7**	8	9	10	11	12	13
Samples													
Gloss/4	*	*	*	*	**X**	*	*	*	*	*	*	*	*
Gloss/3	*	*	*	*	**X**	*	*	*	*	*	*	*	*
Matte/4	*	*	*	*	*	*	**X**	*	*	*	*	*	*
Matte/3	*	*	*	*	*	*	**X**	*	*	*	*	*	*

By comparing the gloss surface with the matte one, it is seen that the gloss surface was less resistant against scratching. On the gloss surface finishes, the scratch visible to the naked eye was done by the pencil no. 5. On the matte surface finishes, the visible scratches were made by the pencil no. 7. The film hardness is determined mainly by the film-forming component, in our case polyurethane. The gloss and matte surface finishes were made with the same of base coating material and white gloss or matte polyurethane top coat. The matte appearance of the surface finish is provided by additives (matte materials) added to the coating material directly during manufacture. The additives affected not only the gloss, but also the film hardness of the coating.

The gloss contributes to the quality of the product; this was confirmed by BEKHTA *et al*. (2014), MODRÁK, MANDULÁK (2013) and VARDI *et al*. (2010). Our results have confirmed this statement; the film hardness of the tested surface finishes, and hence the quality, was influenced by the degree of gloss.

Impact resistance

Diameters of intrusions in the tested surface finishes and the degrees of damage are given in Tab. 5.

Tab. 5 Impact resistance of the surface finishes.

Sample	Drop height					
	10 mm	25 mm	50 mm	100 mm	200 mm	400 mm
Gloss/4 Degree of change	2	3	4	4	4	4
Gloss/4 Ø mm	1	2	3	4	4	4
Gloss/3 Degree of change	2	3	4	4	4	4
Gloss/3 Ø mm	1	2	3	4	5	6
Matte/4 Degree of change	1	3	3	4	4	4
Matte/4 Ø mm	1	3	3	4	5	5
Matte/3 Degree of change	1	3	3	4	4	5
Matte/3 Ø mm	1	2	3	4	5	5

Tab. 5 shows that the gloss surface finish Gloss/4 reached better impact resistance at the highest drop height than the Gloss/3. The diameter of intrusion at the drop height of 400 mm on the Gloss/4 was 4 mm and on the Gloss/ 3 even 6 mm. The greatest degree of surface damage was of grade 4 (visible large cracks at the intrusion).

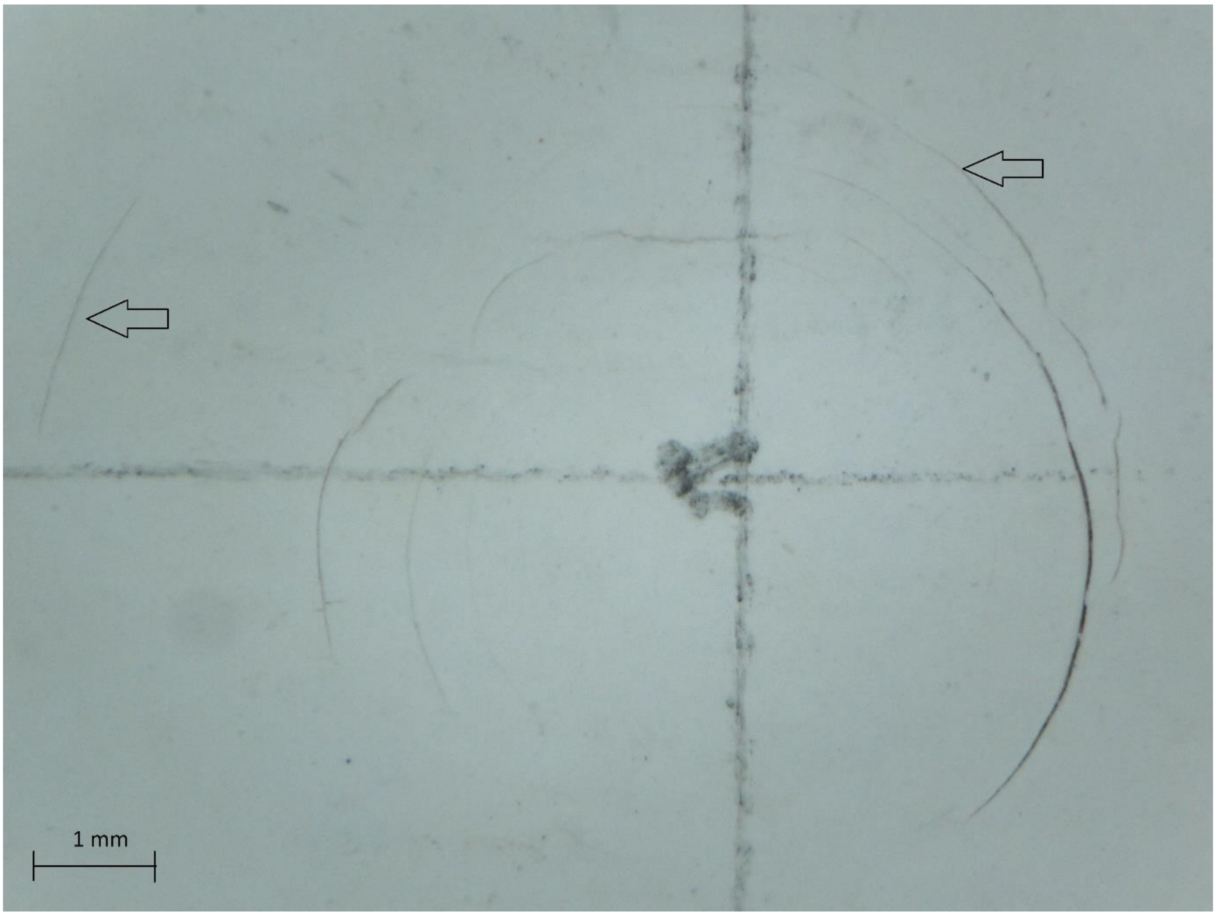

Fig. 1 Cracking visible on the surfaces with pigmented surface finish (Matte/4) after impact resistance testing at the drop height of 400 mm (visible at magnification 17×).

The surface finish Matte/4 reached the same value of the impact resistance as the surface Matte/3. Both matte finishes, at the drop height of 400 mm, showed the same 5 mm diameter of intrusions (Fig. 1).

Impact resistance of the coating increases with increasing thickness of the coating to some extent (SLABEJOVÁ 2012; SLABEJOVÁ *et al*. 2018). This claim was confirmed in the gloss surface finish, but no in the matte one. The other factor is the degree of the surface damage. The degree of damage at the drop height of 400 mm evaluated by the naked eye was of 4 on both the gloss surface finishes and on the Matte/4. At magnification 17×, on the Matte/4, the cracking was visible also outside the imprints (Fig. 1); at magnification 17× the degree of damage can be stated of grade 5.

Surface finish resistance against scuffing

When assessing the resistance against scuffing, the weight loss from the surface finish after abrasion and the coefficient of resistance against scuffing K_T were determined (Fig. 2). It is seen from the graph that the gloss surface finishes were more resistant against scuffing than the matte surface finishes. The difference between the resistance against scuffing of the four-layer coating and the three-layer coating is negligible both for the gloss surface finishes and the matte ones.

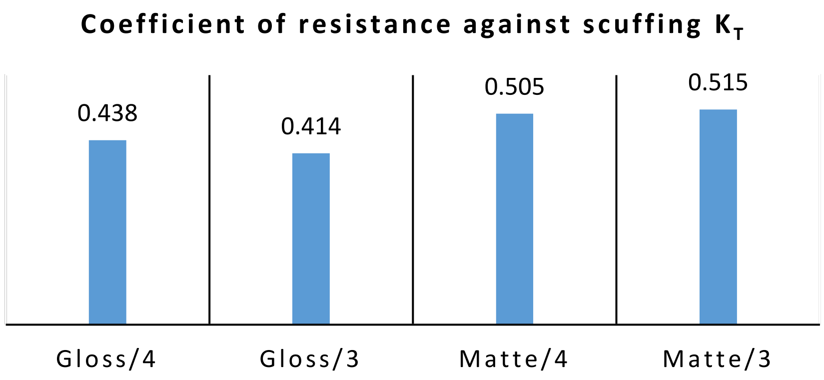

Fig. 2 Coefficient of resistance against scuffing K_T.

Matte surface finish reached smaller resistance against scuffing which can be caused by the additives that provide a matte appearance. The additives are mainly in powder form insoluble but dispersed in the coating material. The powder can increase the surface hardness, but at the same time it can weaken the polymer linkages in the coating film (KALENDOVÁ and KALENDA 2004) and so reduce the resistance against scuffing.

Matte and gloss white polyurethane finish reached smaller resistance against scuffing than UV water-soluble polyurethane coatings, that dealt with by TESAŘOVÁ *et al*. (2010).

If compare surface finish resistance against scuffing (K_T) with the technical requirements by the standard STN 91 0102, none of four surface finishes fulfil the requirements of resistance against scuffing for worktops and other worktops.

Surface resistance to cold liquids

The resistance of the surface finishes to cold liquids is evaluated in Tab. 6.

The biggest changes (grade 3) on the surface of all four surface finishes were caused by coffee. The gloss surfaces exposed to coffee were slightly yellowing and became matte. On the matte surface, the colour changed to yellow. For other cold liquids, the gloss surface finishes showed excellent resistance and were graded of 5.

The matte surface finishes showed lower resistance to acetic acid and ethanol (grade 3). The resistance of grade 4 was reached after exposure to cleaner SAVO, wine, and ink.

The matt surface finishes exposed to detergent SAVO and wine turned white if compared to the reference surface. Ink left the small traces of dye.

The resistance to cold liquids on the polyurethane matt surface finish was low (3) for acetic acid, ethanol and coffee if compared to that of commonly used coatings. On the polyurethan gloss surface finish was low (3) for coffee. KAYGIN and AKGUN (2009) and PAVLIČ *et al*. (2004) have stated that the resistance to selected cold liquids on the surfaces with UV acrylate or UV polyester coatings reach the highest grade (5). Polyester, polyurethane, nitrocellulose, and water-soluble coatings reach the grade 3 or more. Good resistance to cold liquids of UV water-soluble coatings was reported by TESAŘOVÁ *et al*. (2010).

Tab. 6 Surface resistance to cold liquids.

Cold liquid	Surface finish			
	Gloss/4	**Gloss/3**	**Matte/4**	**Matte/3**
Acetic acid10%	5	5	3	3
Citric acid10%	5	5	5	5
Ethanol 96%	5	5	3	3
Sodium carbonate10%	5	5	5	5
Sodium chloride15%	5	5	5	5
SAVO cleaner 10%	5	5	4	4
Wine	5	5	4	4
Coffee	3	3	3	3
Olive oil	5	5	5	5
Ink	5	5	4	4

The tested surface finishes were created with a polyester base coating material and a polyurethane top coating material. The resistance to cold liquids was not affected by the number of polyurethane top coats, but by the gloss. The gloss surface finishes were more resistant to selected cold liquids than matte surface finishes. Again it can be claimed that the matte additives significantly affected the chemical resistance of the surface finish.

CONCLUSIONS

Based on the analysis of the results, one can draw the following conclusions:

- The gloss surface finishes, designed as a system with a polyester base coating material (2 coats) and a polyurethane top coating material (2 or 1 coat), showed less film hardness than the matte surface finishes designed as the same system.
- The film hardness was not affected by the number of coatings neither for the gloss nor for the matte surface finishes.
- The gloss surface finish created of four coats (Gloss/4) showed the smallest diameter of intrusion at the highest drop height; the gloss surface finish created of three coats (Gloss/3) showed the largest diameter of intrusion. The impact resistance of the matte surface finishes was not influenced by the number of coats.
- On both gloss surface finishes and Matte/4, degrees of change at the highest drop height evaluated with the naked eye were graded of 4. The Matte/3 showed the grade of 5. At magnification 17× the cracking was visible also outside the imprint and so the Matte/4 could be graded as 5.

- The coefficient of the resistance against scuffing finishes was higher on the matte surface finishes than on the gloss ones.
- Surface resistance to cold liquids on the gloss surface finishes was better when compared with the matte surface finishes.
- The lowest surface resistance to cold liquids was showed both for gloss and matte surface finishes to coffee; slight traces of damage were visible from different directions.

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AUTHORS´ ADDRESS

Gabriela Slabejová
Mária Šmidriaková
Technical University in Zvolen
Faculty of Wood Sciences and Technology
Department of Furniture and Wood Products
T.G. Masaryka 24
960 53 Zvolen
Slovakia
slabejova@tuzvo.sk
smidriakova@tuzvo.sk