Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 106, 2019: 67-71
(Ann. WULS–SGGW, For. and Wood Technol. 106, 2019)

Quality of surface finishes for beech stairs

GABRIELA SLABEJOVÁ, MÁRIA ŠMIDRIAKOVÁ, JURAJ KADLEČÍK
Department of Furniture and Wood Products, Faculty of Wood Sciences and Technology, Technical University in Zvolen

Abstract: *Quality of surface finishes for beech stairs.* The article deals with quality of oil varnish surface finish when compared with a standard polyurethane finish. The manufacturer recommends both surface finishes to be used for stairs. The tested surface finishes were created on beech wood according to producer recommendations. The quality comparison was based on three mechanical properties of the surface finishes: the surface hardness, impact resistance, and resistance to abrasion. The selected properties gave a good indication for suitability of the tested coating materials for stairs. Both surface finishes achieved the same surface hardness – grade of 11, as measured by the pencil scratch test. The impact resistance measured at low drop height (50 and 100 mm) was better for the oil varnish surface than for polyurethane one. At higher drop heights, the impact resistance of both surfaces was the same. The resistance to abrasion of the oil varnish was better than the resistance of the polyurethane one.

Keywords: stairs; beech; coating material; film hardness; impact resistance; resistance to abrasion

INTRODUCTION

Wood constructions, stairs, parquetry, furniture and decorative materials such as cladding and decking are finished with coating materials mainly. To ensure the long term durability, wood is usually coated with various decorative and protective finishes such as opaque paints and semi-transparent stains as well as penetrating finishes or film-forming clear varnishes (Kalendová and Kalenda 2004). Currently, there is a trend to coat solid wood surface intended to interior and to apply varnishes or glazes to keep the wood structure visible. The quality and the level of protection of wood surface can be determined on the base of evaluation of visual, mechanical, physical and resistance properties of the of surface finishes. For each wood product, there are different requirements. Staircases require good resistance to abrasion, impact resistance, and good surface hardness. The properties of individual types of coating films are discussed by Tesařová et al. (2018), Slabejová et al. (2018), Slabejová and Šmidriaková (2018), Tesařová et al. (2017), Salca et al. (2017), Yong et al. (2017), Scrinzi, et al. 2011, and Tesařová et al. (2010).

The aim of the work was to compare the quality of surface finishes for staircases. Oil varnish surface finish and polyurethane varnish surface finish were evaluated according to the mechanical properties (resistance to abrasion, impact resistance, and surface hardness).

MATERIALS AND METHODS

In the experiment, beech test specimens (*Fagus sylvatica* L.) were used. The dimensions of test specimens were 100 mm × 100 mm × 20 mm (abrasion resistance test), and 200 mm × 400 mm × 20 mm (impact resistance – falling-weight test, surface hardness – pencil test). The test specimens were made from tangential or tangential-radial beech boards with moisture content of 10 % ± 2 %. Before the coating materials were applied, all test specimens were grinded and cleaned from dust and other impurities. The last sanding was done with sandpaper grit of P180. The coating materials were applied pneumatically according to the manufacturer's recommendations given in the technical sheets. The following surface finishes were created:

- PUR – representative coating material **JA – 5.4000-30 Acryl varnish** (two-component polyurethane varnish based on acrylic-resins) – 2 coats

- OIL – representative coating material **ODVE723NN02 Oil Indoor** (hard oil based varnish for interior use) – 2 coats

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 to the pencil that scratched the surface (Table 1). The test started with the softest pencil – number 1.

Table 1. Degrees of film hardness.

Pencil Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Pencil Hardness	**3B**	**2B**	**B**	**HB**	**F**	**H**	**3H**	**4H**	**5H**	**6H**	**7H**	**8H**	**9H**

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

Table 2. Impact resistance: degree 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 resistance to abrasion was determined according to the standard STN EN ISO 7784-3 (2016). The coefficient of the resistance to abrasion K_T was calculated according to the formula:

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

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).

The results of film hardness and resistance to abrasion were compared with the technical requirements according to the standard STN 91 0102.

When choosing a surface finish for staircases, it is important to take into account the resistance to abrasion, impact resistance and the surface hardness. Technical requirements for surface finishing of wooden furniture were used as a minimal requirement for quality of surface finish used for staircases.

Technical requirements according to the STN 91 0102:

- Surface hardness of the coating film evaluated by the pencil test
  - Worktops – grade 8
- Surface resistance to abrasion (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

The film hardness according to the pencil test is listed in Table 3. The pencil with the number of 7H scratched both surface finishes – polyurethane and oil; which correspond to the film hardness of 11. Both surface finishes showed very good surface hardness and they are suitable for stressed furniture surfaces as well as for floors and staircases. They met the technical requirements for furniture in public areas.

The measured film hardness was comparable with the hardness of UV-hardened coating films reported by Tesařová et al. (2010), but it was significantly higher than the film hardness of polyester-polyurethane surface finish reported by Slabejová and Šmidriaková (2018).

Table 3. Impact resistance, resistance to abrasion, and film hardness.

Surface Finish	Drop Height (mm)						K_T	Hardness
	10	25	50	100	200	400		
PUR	1	2	3	4	4	5	0.127	11
OIL	1	2	2	3	4	5	0.086	11

The impact resistance of surface finishes is summarised in Table 3. The impact resistance from the highest drop height of 400 mm was low and the surface damage of both surface finishes was graded as 5 (Visible cracks were also off-site of intrusion, peeling of the coating). The differences were recorded at drop heights of 50 mm and 100 mm; the oil surface finish was more resistant.

Slabejová and Šmidriaková (2018) tested the pigmented matt polyester-polyurethane surface finish; the impact resistance at drop height of 400 mm was graded as 5. Slabejová et al. (2018) evaluated silicone coatings by naked eye and with magnifying glass (at magnification 35×); the surface damage evaluated by naked eye was graded as 3 or 4, but at magnification there were visible cracks also off-site of the intrusion and the coating was peeling (degree 5).

When the impact resistance is tested, the intrusion or cracking depends on properties of the coating film. Tesařová et al. (2017) comparing their results confirmed their hypothesis about the relationship between the physical-mechanical properties of lacquer surface finishes and the ultimate tensile stress of free coating films.

The surface resistance to abrasion is listed in Table 3. The oil varnish reached higher resistance to abrasion in comparison with the polyurethane varnish. When the results were compared with the technical requirements (STN 91 0102), it was found that polyurethane surface finish met the requirements for household furniture only. It is interesting that the two-component polyurethane varnish which is a standard among the surface finishes used for staircases did not meet the stricter requirements. After abrasion testing, the traces were visible on both surface finishes (Fig. 1).

When comparing the polyurethane varnish with the oil one, the oil surface finish reached better results. The same film hardness of both coating films does not guarantee the same impact resistance at all drop heights.

The resistance to abrasion is very specific and influenced by various components present in the coating material (Slabejová and Šmidriaková 2018). Tesařová et al. (2017) recorded that the polyurethane top varnish showed the best physical and mechanical properties when compared to nitrocelulose, waterborne acrylate, UV hardened acrylate, and base polurethane varnishes.

Our experimental results showed that the oil varnish may be a good choice to finish beech staircases.

PUR OIL

Figure 1. Traces on surface finish after resistance to abrasion testing.

CONCLUSIONS

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

- The film hardness of both oil and polyurethane surface finishes was the same, very good, graded as 11.
- The impact resistance at lowerr drop heights (50 mm and 100 mm) was better on the oil surface finish than on the polyurethane one. At drop heights of 200 mm and 400 mm, the impact resistance was the same for both the surface finishes.
- The resistance to abrasion of oil surface finish was better than the resistance of the polyurethane surface finish.

Acknowledgements: This work was supported by the Slovak Research and Development Agency under the contract No. APVV-16-0177 and by VEGA grant No. 1/0822/17.

REFERENCES

1. KALENDOVÁ, A., KALENDA, P. 2004. Technologie nátěrových hmot I. Pojiva, rozpouštědla a aditiva pro výrobu nátěrových hmot. Univerzita Pardubice 2004. 328 s. ISBN 80-7194-691-5
2. SALCA, E. A., KRYSTOFIAK, T., LIS, B. 2017. Evaluation of Selected Properties of Alder Wood as Functions of Sanding and Coating. In COATINGS. ISSN 2079-6412. 2017, vol. 7, no. 10, art. no. 176.
3. SCRINZI, E., ROSSI, S., DEFLORIAN, F., ZANELLA, C. 2011. Evaluation of aesthetic durability of waterborne polyurethane coatings applied on wood for interior applications. In Progress in Organic Coatings [online], 2011, 72(1–2): 81–87. [online] www.sciencedirect.com.
4. SLABEJOVÁ, G., ŠMIDRIAKOVÁ, M., PÁNIS, D. 2018. Quality of silicone coating on the veneer surfaces. In BioResources. 2018, (13)1: 776–788. URL: https://bioresources.cnr.ncsu.edu
5. SLABEJOVÁ, G., ŠMIDRIAKOVÁ, M.2018. Quality of Pigmented Gloss and Matte Surface Finish. Acta Facultatis Xylologiae Zvolen, 60(2): 1–9.
6. STN EN ISO 7784-3: 2016, Determination of paint resistance against abrasion by abrasive paper in "Taber-Abraser" apparatus.
7. STN EN ISO 15184: 2012, Paints and varnishes. Determination of film hardness by pencil test.
8. STN EN ISO 6272-2: 2011, Paints and varnishes. Rapid-deformation (impact resistance) tests. Part 2: Falling-weight test, small-area indenter.

9. STN 91 0102: 1991, Furniture. Surface finishing of wooden furniture. Technical requirements.
10. TESAŘOVÁ, D., CHLADIL, J., ČECH, P., TOBIÁŠOVÁ, K. 2010. Ekologické povrchové úpravy. Monografia. Brno. 2010. 126 p.
11. TESAŘOVÁ, D., ČECH, P., HLAVATÝ, J. 2017. Influence of coating formulation on physical-mechanical properties. Wood Science and Engineering in the Third Millenium: Proceedings of the International Conference (ICWSE 2017). Brasov: Universitatea Transilvania din Brasov, 486–493. ISSN 1843-2689. URL: http://www.unitbv.ro/il/Conferinte/ICWSE2017.aspx
12. TESAŘOVÁ, D., ČECH, P., JEŘÁBKOVÁ, E., KRONTORÁD, K. 2018. Influence of wooden outdoor furniture finished surfaces water absorption on and the properties of coating films. International forest products congress. Trabzon: Karadeniz Technical University, 664–671. URL: http://www.ktu.edu.tr/orenko2018
13. YONG, Q.W., NIAN, F.W., LIAO, B., GUO, Y., HUANG, L.P., WANG, L., PANG, H. 2017. Synthesis and surface analysis of self-mattee coating based on waterborne polyurethane resin and study on the mattee mechanism. In Polymer Bulletin 74(4): 1061–1076. DOI: 10.1007/s00289-016-1763-7.

Streszczenie: *Jakość wykończenia powierzchni schodów bukowych.* W ramach badań porównano jakości wykończenia powierzchni drewna utwardzonym olejem do standardowego wykończenia lakierem poliuretanowym. Obydwa wyroby przeznaczone są do wykańczania powierzchni schodów. Badane powłoki wytworzono na drewnie bukowym zgodnie z zaleceniami producenta. Dla wytworzonych powłok porównano: twardości powierzchni, odporności na uderzenia i odporności na ścieranie. Uzyskane wyniki potwierdziły możliwość wykorzystania obydwu środków do wykańczania powierzchni elementów schdów. Obie badane powierzchnie charakteryzowały się tym samym poziomem twardości powierzchni - stopień 11 (metoda zarysowania ołówkiem). Powierzchnia wykończona utwardzonym olejem charakteryzowała się wyższą odpornością na uderzenia przy niskiej wysokości rzutu (50 i 100 mm) w porównaniu do powierzchni z powłoką poliuretanową. Przy wyższych wysokościach rzutu odporność na uderzenia obu powierzchni była taka sama. Powierzchnia wykończona utwardzonym olejem charakteryzowała się również wyższą odpornością na ścieranie.

Corresponding author:

Gabriela Slabejová
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

ORCID ID:

Slabejová Gabriela 0000-0002-9209-0386