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GLOSS OF TRANSPARENT COATING ON BEECH WOOD SURFACE

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ABSTRACT

The present article discusses the aesthetic property of transparent coating on beech wood surface. Influence of type of transparent coating, the number of coats, and method for wood surface machining on the gloss of coating on beech wood are monitored. Before finishing, the beech specimens were machined by one of ten different combinations of sanding, milling, and pressing. To form the coating, the representative types of transparent coating (water-based and polyurethane) were used. The coatings were in 2, 3 or 4 coats. The values of gloss G* were measured. Statistical evaluation of gloss showed that the type of coating, the number of coats, and the method for wood surface machining influenced the gloss of surface very much. The gloss of surface with waterborne coating was higher than gloss of surface with polyurethane coating. The gloss was increasing with increasing number of coats of waterborne coating. The highest gloss on two and three coats was achieved on the surfaces gradually sanded with sandpaper from the smallest to the largest fibre size number. Surfaces sanded perpendicular to the wood fibre had reduced gloss in comparison with the surfaces sanded parallel to the wood fibre.

Key words: beech wood, transparent coating, gloss, surface machining.

INTRODUCTION

To protect and increase aesthetic value of wood products, surface finish is used. Gloss of surface belongs to the aesthetic properties of wood finish. To preserve the natural color of wood and just adjust the gloss of wood, we coat the surface with a transparent coating. Lacquers create transparent coating with different values of gloss. Gloss is mainly given by chemical composition of the coating. SAEED 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.* (2003b) researched the low gloss of powder coatings, which harden at lower temperatures.

The gloss is an important surface property concerning many products made from different materials. 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). The purpose of study BEKHTA *et al.* (2014) was to determine the effect of short-term thermo-mechanical (STTM) densification in different wood species (alder (Alnus glutinosa Goertn.), beech (Fagus sylvatica L.), birch (Betula verrucosa Ehrh.), and pine (Pinus sylvestris L.) on their gloss changes. MODRÁK, MANDULÁK (2013) dealt with the impact of technological parameters of injection on the gloss of plastic part of product. In archeology research, VARDI

et al. (2010) described the gloss to be an important characteristic of blade surface; gloss gives information on depreciation of the blade.

The actual chemical composition of coating is not the only factor that affects the gloss. High gloss of the coating can be created by the technology of successive coats and polishing. As the number of coats increases, coating thickness increases, and the surface roughness decreases. "As the surface roughness decreases, the gloss increases. As the number of coats increases, the amount of volatile organic compounds (VOCs) that are volatilized in the environment also increases" (LEE *et al.* 2003a, TESAŘOVÁ *et al.* 2010).

To reduce VOC at surface finish is the important ecological approach in furniture production. From ecological point of view, the service life of the surface finish is also very important. Wood surface and the coating are ageing and slowly degrading. Aging of coatings on wood products is influenced mainly by biotic and abiotic factors. Coatings in interiors are mainly influenced by sun light. SCRINZI *et al.* (2011) measured changes in color and gloss and so they evaluated the service life of water-based and synthetic polyurethane coatings. They evaluated transparent and pigmented coatings. "On transparent coatings, the gloss and color changes correlate with a slight modification of film-former substance" (SCRINZI *et al.* 2011, MATYAŠOVSKÝ *et al.*, 2014). The impact of transparent coating on aesthetic properties of root textures was dealt BY MAMOŇOVÁ (2009). Light stability and structure of acrylic coatings, after a year aging in interior and exterior conditions, were dealt by MAMOŇOVÁ, REINPRECHT (2008).

Research on appearance of wood finishes is focused more on the color of the surface than on the gloss. “But the gloss is not insignificant in appearance surface properties of all materials; and it is perceived visually" (WIEBEL *et al*. 2015). Gloss of the coating can be influenced to some extent even in the process of the coating film creation, as was discussed in the high gloss. In practice, various principles and procedures are established. For economic and environmental reasons, the furniture manufacturers often use different number of coats on different areas of one furniture piece. More exposed surfaces have greater number of coats than other areas. This fact can lead to appearance differences within a single piece of the product, different values of gloss.

The aim of this work was to study the influence of the type of coating, number of coats, and the method for machining of beech wood surface (before coating) on the gloss of coating.

EXPERIMENTAL PART

In experimental testing, beech wood specimens (*Fagus sylvatica* L.) with dimensions 100 × 60 × 15 mm, moisture content of 8 ± 2%, and average density of 676 $kg \cdot m^{-3}$ (at moisture content of 0 %) were used. Before testing, the test specimens were conditioned at room temperature 20 ± 2 °C and relative humidity 60 ± 5% for 30 days. Then the surface of the test pieces was machined by methods listed in Tab. 1.

After machining, the specimens were coated. The coating material was sprayed pneumatically (Tab. 2). The representative types of transparent coating materials for interior were used, as following:

- transparent water-based coating material, based on polyurethane-acrylate dispersion (semi-dull) – ADLER Aqua-Step Professional 30153 ff (This type of coating material can be used as a single component material or if a hardener is added as two-component material. As hardener, the solution of aliphatic polyisocyanate is used.)
- transparent polyurethane coating material (semi-dull) – ADLER PUR-Strong 26303 ff (The film-forming component of the coating material are polyacrylate resin or

cellulose acetate-butyrate. The advantage of the coating material is that it contains no aromatic solvents.)

Coating film thickness increased with the number of coats – it was measured with Thickness Gauge (type PosiTector 200) working on the ultrasonic principle. Coating film thicknesses are given in Tab. 3.

Tab. 1 Methods for surface treatment of test specimens.

Method for surface treatment		**Operation**	**Machinery**
MILLING		Leveling	Graders milling
		Thicknessing	Thicknesser milling machine
		Parameter	**Machinery**
PRESSING		Compression Height [mm]	Press with two heated plates
		1	
		Temperature [°C]	
		120	
		Time [min]	
		5	
		Fibre size and direction of machining	**Machinery**
SANDING	simple	60 r	Belt sander
		60 k	
		80 r	
		80 k	
		120 r	
		120 k	
	double combination	60 k 120 r	
		80 k 150 r	
		120 k 180 r	
	triple combination	80 k 120 r 180 r	

Note: 60 r - sandpapering with grit number P60 in direction parallel to wood fibers, 60 k - sandpapering with grit number P60 in direction perpendicular to wood fibers. If sandpapering in triple combination, the last sandpapering 180 r, i.e. with P180 grit number, was done in opposite direction as sanding 120 r.

Tab. 2 Parameters of pneumatic spraying.

Parameter [units]	**Value**
Air pressure [MPa]	0.4–0.5
Diameter of nozzle of spray gun [mm]	1.5
Distance when spraying [cm]	cca 25
incidence angle of coating material to surface	cca 90°
Ambient temperature [°C]	18 ± 2

Tab. 3 Average thickness of coating film.

Average coating film thickness [µm]			
coating material	after 2nd coat	after 3rd coat	after 4th coat
water-based	53.3	73.8	99.8
polyurethane	54.8	71.4	95

On test specimens, having different number of coats, the gloss of surface was measured perpendicular to wood fibers by STN EN 13722 Furniture – Assessment of the surface gloss. To measure the gloss, the spectrophotometer, type of BYK-Gardner GmbH, was used. This type of spectrophotometer is used to measure the gloss at the angle of 60 °. This device is equipped with an improved technical specification for an angle of 60 ° also in the degree of gloss matt (0–10).

On each test specimen, three measurements of gloss G* **[**GU**]** were done in direction perpendicular to the fibers.

RESULTS AND DISCUSSION

The effect of the monitored factors (and also their interactions) on the gloss of coating is shown in Tab. 4.

Tab. 4 Analysis of variance for gloss.

	Sum of squares	**Degrees of freedom**	**Deviation**	**F-test**	**Level of significance p**
Absolute member	375348.6	1	375348.6	184145.4	0.000
Number of coats (NC)	104719.3	3	34906.4	17125.0	0.000
Surface machining method (SMM)	5853.9	11	532.2	261.1	0.000
Type of coating (TC)	10578.2	1	10578.2	5189.7	0.000
NC*SMM	3094.5	33	93.8	46.0	0.000
NC*TC	3726.9	3	1242.3	609.5	0.000
SMM *TC	1622.6	11	147.5	72.4	0.000
NC *SMM *TC	1539.7	33	46.7	22.9	0.000
Error	2739.5	1344	2.0		

Based on the results (Tab. 4) we can say that the impact of all monitored factors (and their interactions) on the gloss is highly statistically significant. The dependence of the gloss on the method for surface machining and on the number of coats – for particular types of coatings – is graphically shown in Fig. 1–4.

Fig. 1 shows that the gloss is increasing with increasing number of coats. Higher gloss was achieved on the specimens with water-based coating in 2, 3, and also 4 coats (Fig. 2, 3, 4). The highest value of gloss (G * = 25.2 GU) was achieved on the surface with 2 coats of water-based coating, previously sanded by 3-combination (Fig. 2). If sanded by 2-combination (120k 180r), the values of gloss G* were from 15.5 GU to 25.1 GU. The specimens sanded simply (the last sanding perpendicular to the wood fibers) achieved the lowest gloss: on 2 coats, the gloss G * was from 5.3 GU to 10.5 GU. If simple parallel sanding and 2 coats, the gloss G * had the values from 10.6 GU to 15.7 GU. Milled specimens showed the gloss G = 15.2 GU and pressed specimens the value G * = 20.4 GU.

In practice, the coating it often created just with two coats. The graphs (Fig. 1–4) shows the effect of sanding of wood surface on the gloss of coating. Sanding is the most common method for wood surface machining before finish. Sanding ensures the sufficient smoothness before application of coating material if we comply with the established work procedure. The highest value of gloss (32 GU) was measured on the surfaces sanded gradually with sandpaper grit number from the smallest to the largest number required. Higher surface gloss (by 20 GU) was achieved on surfaces which were sanded parallel to the wood fibers in comparison with surfaces sanded across wood fibers.

The gloss on specimens with polyurethane coating was lower. We assumed that the polyurethane coating material with increasing number of coats will be raising gloss more than water-based coating material. Experimental tests but showed that with increasing number of coats gloss was raising more in water-based coating material. On simply sanded or milled surfaces, the difference between the gloss of water-based and polyurethane coatings was lower (when compared with other surfaces). Sanded surfaces with 2 coats

achieved the values of gloss G * from 5.5 GU to 15.0 GU. Milled surfaces with 2 coats reached the value of gloss G * = 10.3 GU; and pressed surfaces G * = 10.6 GU (Fig. 2). The differences between gloss of water-based and polyurethane coatings were increasing with increasing number of coats. The biggest differences were on most surfaces (variously machined) with three coats (Fig. 3).

From Fig. 1–4, we can conclude that the gloss more increases with increasing number of coats water-based than polyurethane coatings. The increasing gloss, created by increasing number of coats, is barely perceptible with the naked eye. Gloss of coatings (water-based or polyurethane) with 2, 3 or 4 coats was ranked to the degree of gloss "semi-dull" (8 – 40 GU). Difference in degree of gloss may occur in the case, if the surface with two coats reaches upper limit of degree of gloss. By increasing the number of coats we reach higher degree of gloss. Experimental tests have shown that increasing the number of water-based coating material from 2 to 4 coats of paint we can increase the gloss by 5-20 GU. In practice, the trend is not to increase the number of coats on all surfaces of one furniture piece.As reported by LEE *et al*. (2003), TESAŘOVÁ *et al*. (2010), increasing the number of coats, VOC in the atmosphere are increasing; and the price of furniture is increased. Therefore, higher number of coats is applied only onto the surfaces which are mechanically stressed. These areas may be glossier than the other areas of the same furniture piece.

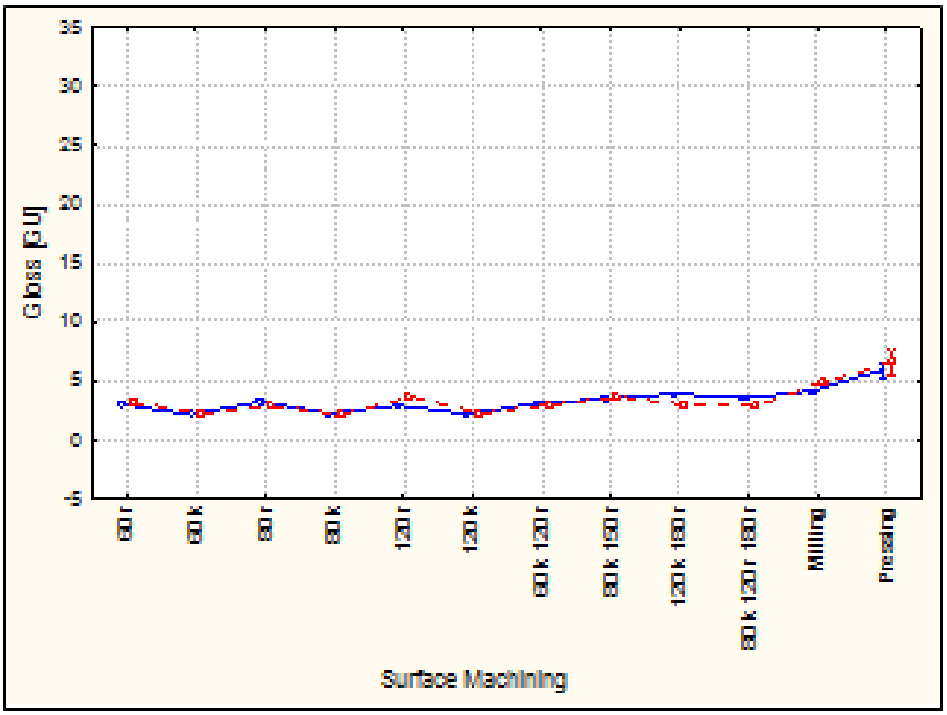

Fig. 1 Impact of method for surface machining and number of coats on gloss of water-based and polyurethane coatings: water-based coating, polyurethane coating; Unpainted.

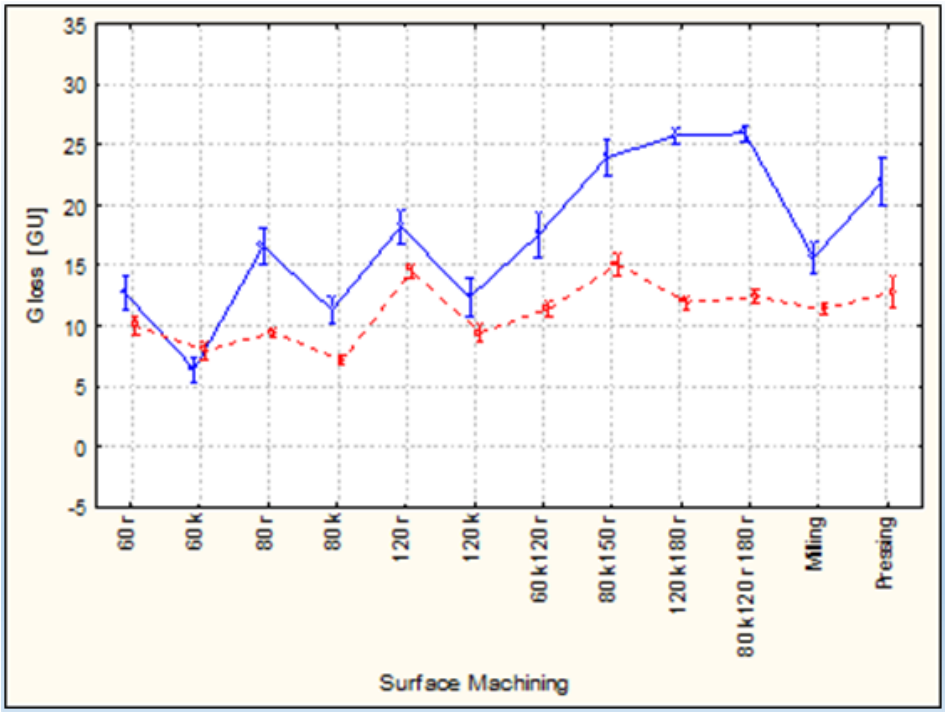

Fig. 2 Impact of method for surface machining and number of coats on gloss of water-based and polyurethane coatings: water-based coating, polyurethane coating; Two Coats.

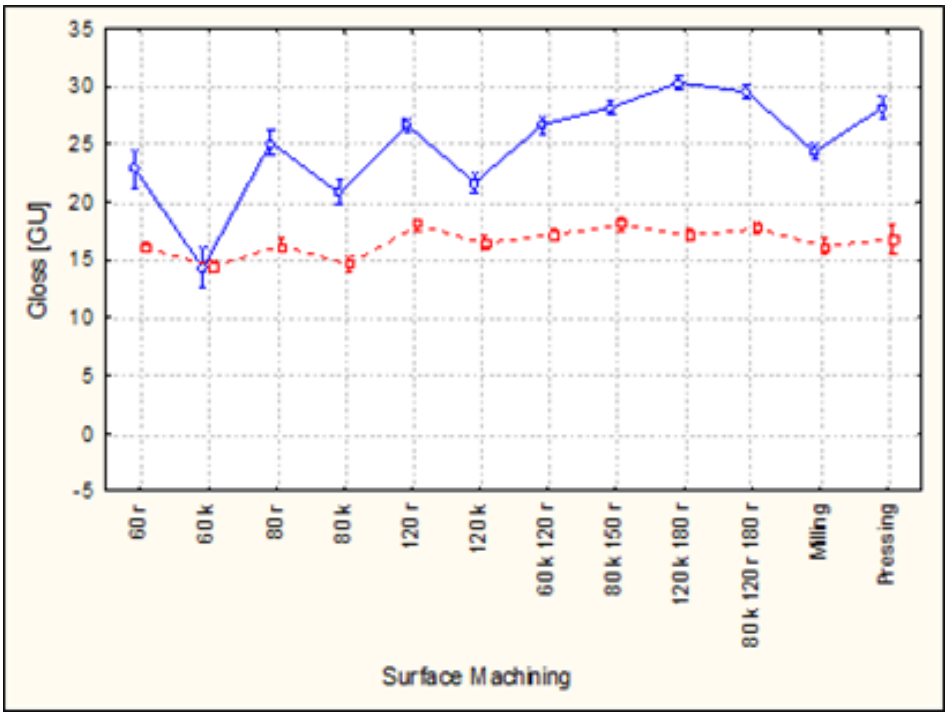

Fig. 3 Impact of method for surface machining and number of coats on gloss of water-based and polyurethane coatings: water-based coating, polyurethane coating; Three Coats.

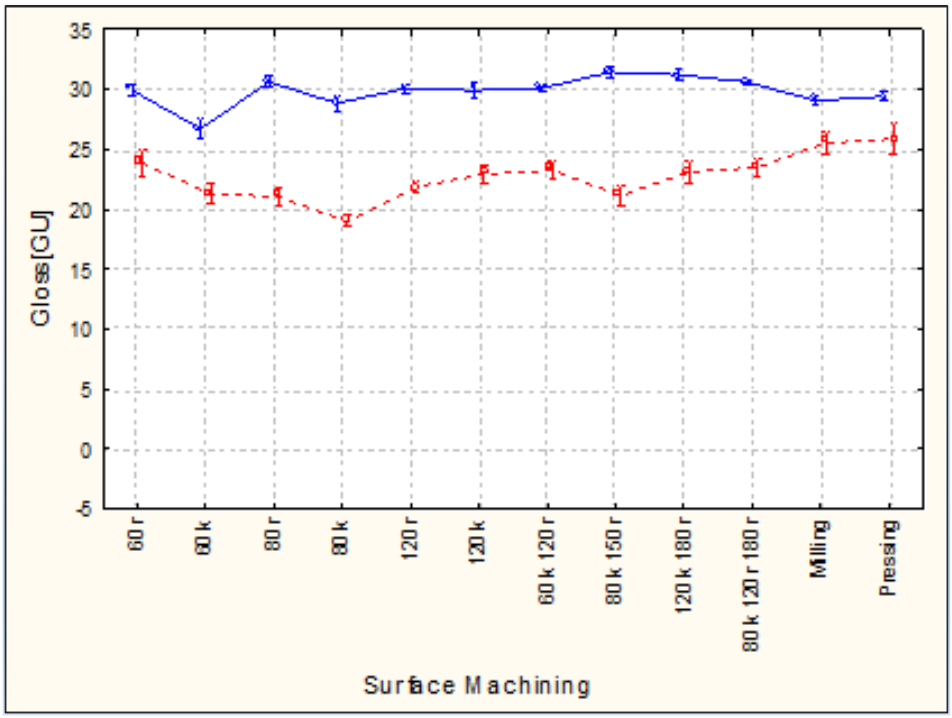

Fig. 4 Impact of method for surface machining and number of coats on gloss of water-based and polyurethane coatings: water-based coating, polyurethane coating; Four Coats.

CONCLUSION

Analyzing the results, the following conclusions can be drawn:

- The gloss of coating on beech wood surface is greatly influenced by the type of coating, the number of coats, and the method for wood surface machining.
- The gloss of coating on beech wood is increasing with increasing number of coats.
- Higher gloss and also higher increase in gloss with increasing number of coats was achieved by water-based coating when compared with polyurethane coating.
- The highest gloss of coating in two or three coats was reached on the surfaces gradually sanded with sandpaper with grit number from the lowest to the highest required.
- Higher gloss of coating (by 20 GU) on beech wood surface is reached on the surfaces which, were finally machined by sanding parallel to the wood fibers, when compared with those sanded perpendicular to the fiber.

REFERENCES

BEKHTA, P., PROSZYK, S., LIS, B., KRYSTOFIAK, T. 2014. Gloss of thermally densified alder (Alnus glutinosa Goertn.), beech (Fagus sylvatica L.), birch (Betula verrucosa Ehrh.), and pine (Pinus sylvestris L.) wood veneers. European Journal of Wood and Wood Products, 2014, 72(6): 799–808.
LEE, S-CH., KWOK, N-H., GUO, H., HUNG, W-T. 2003a. The effect of wet film thickness on VOC emissions from a finishing varnish. Science of The Total Environment [online], 2003, 302(1–3): 75–84. Dostupné na internete: www.sciencedirect.com.

LEE, S. S., KOO, J. H., LEE, S. S., CHAI, S. G., LIM, J. CH. 2003b. Gloss reduction in low temperature curable hybrid powder coatings. Progress in Organic Coatings [online], 2003, 46(4): 266–272. Dostupné na internete: http://thirdworld.nl/gloss-reduction-in-low-temperature-curable-hybrid-powder-coatings.
MAMOŇOVÁ (MASARYKOVÁ), M. 2009. Voľba vhodného náterového systému pre textúry koreníc. Acta facultatis xylologiae Zvolen. Zvolen : Technická univerzita vo Zvolene. 2009, 51(2) 39–48. ISSN 1336-3824.
MAMOŇOVÁ, M., REINPRECHT, L. 2008. Štruktúra a farba akrylátových náterov po ročnej expozícii v exteriéri a interiéri. In Interaction of wood with various forms of energy. Zvolen : Technical University in Zvolen, 2008, 91–97. ISBN 978-80-228-1927-5.
MATYAŠOVSKÝ, J., SEDLIAČIK, .J, MATYAŠOVSKÝ, J. JR, JURKOVIČ, P., DUCHOVIČ, P. 2014. Collagen and keratin colloid systems with a multifunctional effect for cosmetic and technical applications. Journal of the American Leather Chemists Association, 2014, 109 (9): 284–295.
MODRÁK, V., MANDULÁK, J. 2013: Exploration of Impact of Technological Parameters on Surface Gloss of Plastic Parts. Eighth CIRP Conference on Intelligent Computation in Manufacturing Engineering [online], 2013, 12: 504–509. Dostupné na internete: http://www.sciencedirect.com/science/article/pii/S2212827113007270
SAEED, A., SHABIR, G. 2013. Synthesis of thermally stable high gloss water dispersible polyurethane/polyacrylate resins. In Progress in Organic Coatings [online], 2013, 76(9): 1135–1143. Dostupné na internete: http://www.sciencedirect.com/science/article/pii/S0300944013000635.
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. Dostupné na internete: www.sciencedirect.com.
TESAŘOVÁ, D., CHLADIL, J., ČECH, P., TOBIÁŠOVÁ, K. 2010. Ekologické povrchové úpravy. Monografia. Brno. 2010. 126 p.
VARDI, J., GOLAN, A., LEVY, D., GILEAD, I. 2010. Tracing sickle blade levels of wear and discard patterns: a new sickle gloss quantification method. Journal of Archaeological Science [online], 2010, 37(7): 1716–1724.
Dostupné na internete: http://www.sciencedirect.com/science/article/pii/S0305440310000361.
WIEBEL, CH. B., TOSCANI, M., GEGENFURTNER, K. R. 2015. Statistical correlates of perceived gloss in natural images. Vision Research [online], 2015, 115B: 175–187.
Dostupné na internete: http://www.sciencedirect.com/science/article/pii/S0042698915001595.

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