İleri Teknoloji Bilimleri Dergisi

Journal of Advanced Technology Sciences

ISSN:2147-345

TENSILE STRESS OF COATING FILMS

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Abstract- The aim of this contribution is the investigation the influence of the coating formulation on physical – mechanical properties especially on the hardness of finished surfaces, the adhesion of films of lacquers to wooden substrates, the resistance of finished surface to impact, the resistance of finished surfaces to mechanical demage - the impact tests. Tensile tests on free films have been messurend tensile stress. There were ivestigated transparent nitrocellulose, polyuretanne and UV curing high solid acrylic lacquers.The results showed confirmed the raltion between elastic modulus and strain at break on physical-mechanical properties of finished surfaces.

Key words- Tensile stress,Coating Fılms

1.INTRODUCTION

Wood, as a natural construction material in use, needs the protection of by coating films to keep its beauty, colour and integrity. Wood movements due to swelling and shrinking induce stress to the surface coating. Results of this stress, between the wood surfaces and coating films, are the decreasing quality of physical–mechanical properties. The aim of the study is based on the hypothesis that this is caused by the relationship between the physical-mechanical properties and the tensile properties of lacquer films.

In this contribution there are presented the results of the investigation of the influence of influence of coating formulations and layers coats numbers on the physical-mechanical properties of furniture finished surfaces. Improving the physical-mechanical and durability of finished furniture surfaces is essential for the prolonging the life of the furniture [1,2]. The conclusions of this study could have great influence, not only on the coating performance but also on the quality of wooden-based products. The tensile properties of coating films have not been assessed yet in correlation with physical-mechanical properties

The aim of this study was to identify the relationship between influence of tensile strength during the tensile stress at break of the tested lacquer coating films, and the quality of mechanical-physical properties of the finished surfaces coated with the tested lacquers and in dependence of number of cold - warm cycles and number of tested coats.

Bu makale, 4. Uluslararası Mobilya ve Dekorasyon Kongresi'nde sunulmuş ve İleri Teknoloji Bilimleri Dergisi'nde yayınlanmak üzere seçilmiştir.

2.MATERIAL, METHODS, EQUIPMENT

Five different lacquers were tested for the evaluation of the influence of different test parameters; this means that five different resins have been investigated.

1. nitrocellulose lacquer,
2. top solvent polyurethane lacquer
3. basic solvent polyurethane lacquer
4. acrylic water borne lacquer
5. UV curing high solids acrylic lacquer
6. Polyurethane lacquer one or two layers

Preparing the samples:

Each one of the tested coating materials was applied to a sample of chipboard veneered with pine veneer. The amount of coating lacquer varied from 40g/m^2 (UV curing high solids acrylic lacquer) to 300 g/m^2 (solvent polyurethane, basic solvent polyurethane lacquer, water borne lacquer and nitrocellulose lacquer).

Each one of the tested coatings was applied to on polyterephtalate foil by using the laboratory film applicator. The coatings were removed from the foil, in controlled environmental conditions immediately after drying/curing took place. The tested films were carefully detached by hand and cut size (using a scalpel). The size of the films was 10 mm x 50 mm. The specimens were oriented longitudinally.

Test methods and standards used

- Adhesion Paints and varnishes cross-cut standard ČSN EN ISO 2409
- ČSN 910277 Furniture. Testing the furniture surface coating. Method of determining the surface impact resistance
- BS 3962 part 6 The resistance of finished surfaces to mechanical damage - the impact tests
- ČSN EN ISO 2815 Buchholz indentation tests
- Tensile tests were performed using a test device by of the company Instron 3365 Machine Serial Number Locator with measurement software Blue hills
- ČSN EN ISO 527-3 Determination of tensile properties Part 3 The conditions for films and foils
- ČSN EN ISO 527-1 Determination of tensile properties Part 1 General principles

Polyurethane lacquer was tested for the evaluation of the influence of number of cold –warm cycles on the mechanical-physical properties. During one cycle there is changing temperature. One cycle consists from three steps:
1. Step - The samples are put into 50 °C for one hour.
2. Step - The samples are taken out from 50 °C and they are put into -30°C for one hour
3. Step - The samples after them taking out from – 30°C the sample must stay for 15 minutes in the room temperature 23°C.
After the third step the next cycle immediately continues.

3.RESULTS AND DISCUSSION

On the figure numbers 1, 2, 3, 4, 5 and 9 we can observe the physical-mechanical properties of the tested finished surfaces of the chipboard samples veneered with pine veneer. In figure numbers 6, 7, 8, 10, 11 and 12 are the results of measuring the tensile stress at break, force at break and elongation of tested lacquer films. The mean values and standard deviations of assessed properties were determinate and calculated for elongation of the sample of the lacquer film in maximum force (F_{max}). The charts have shown the behaviour of the coating films during the tensile tests. Great differences in behaviour during testing have appeared especially among the water borne lacquer films and UV coating films. The stress curves of tested each one tested coating materials were very different in dependence of used resin.

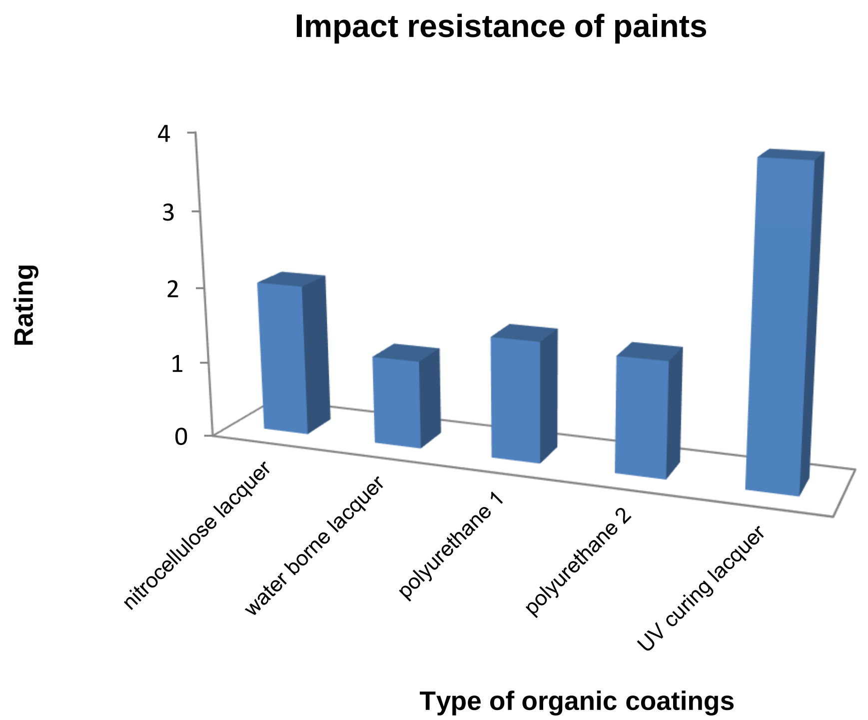

Figure 1. Impact resistance of paints

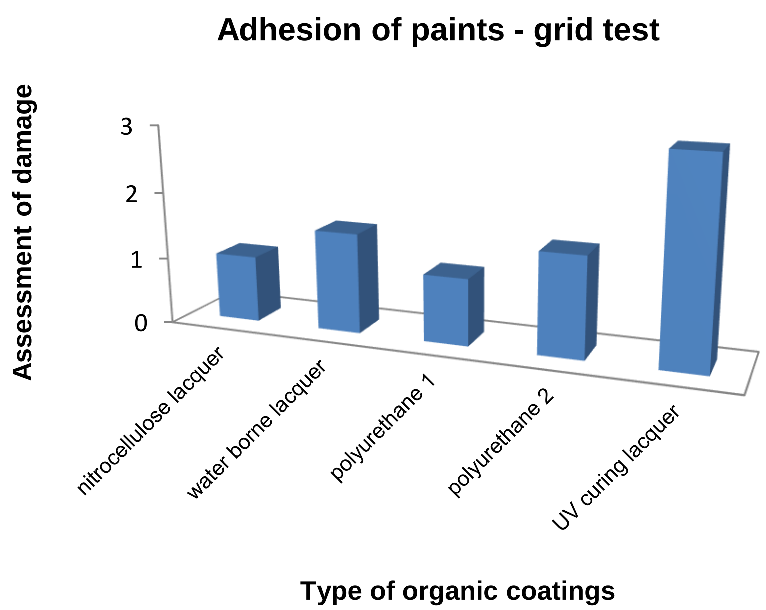

Figure 2. Adhesion of paints – grid test

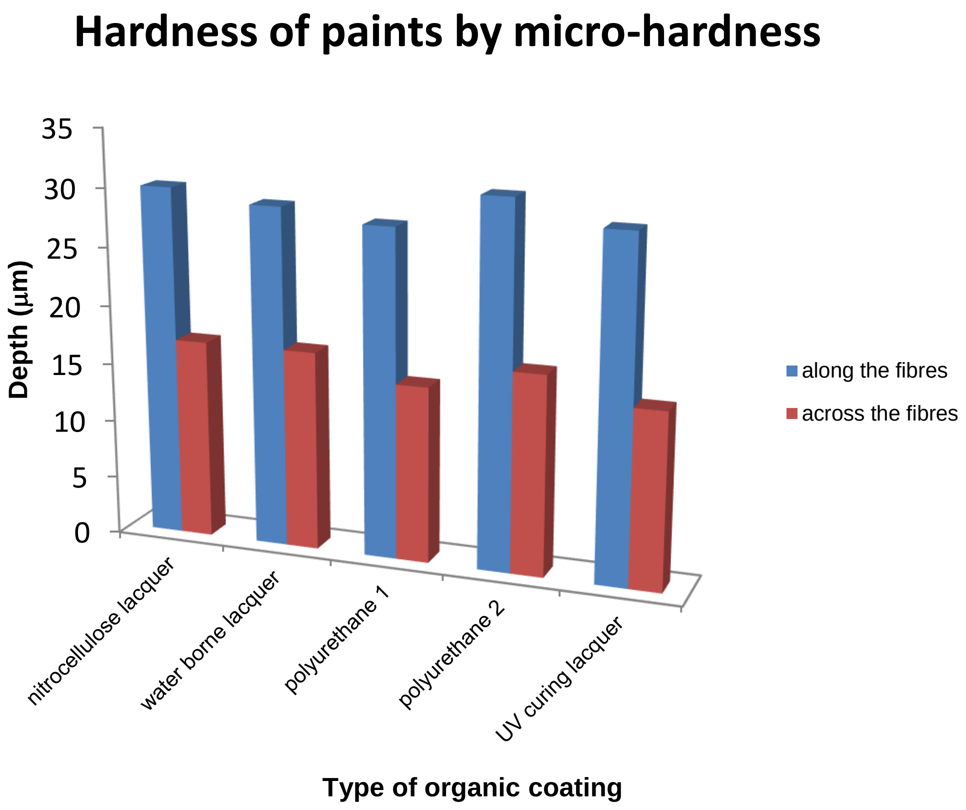

Figure 3. Hardness of paints – micro-hardness

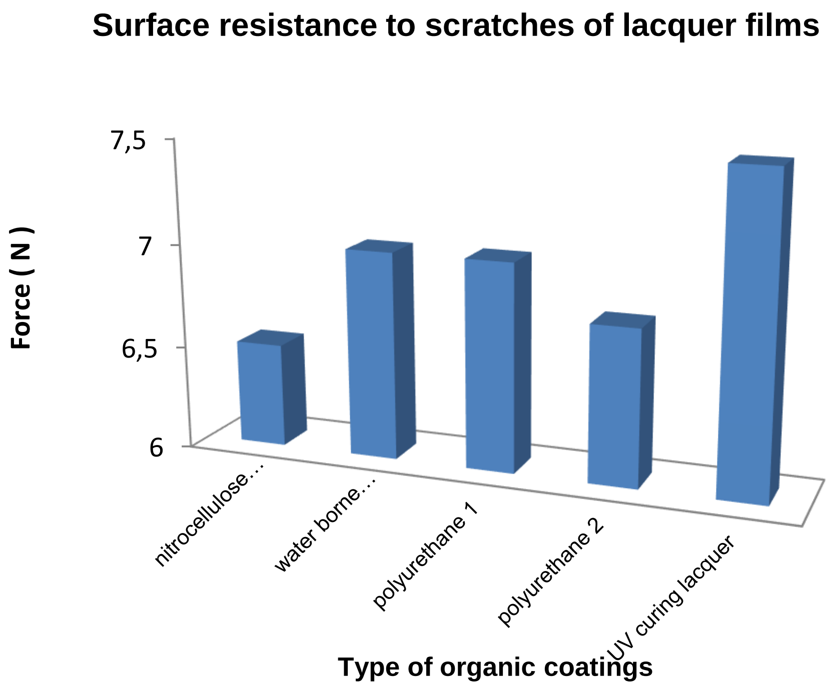

Figure 4. Surface resistance to scratches of paints

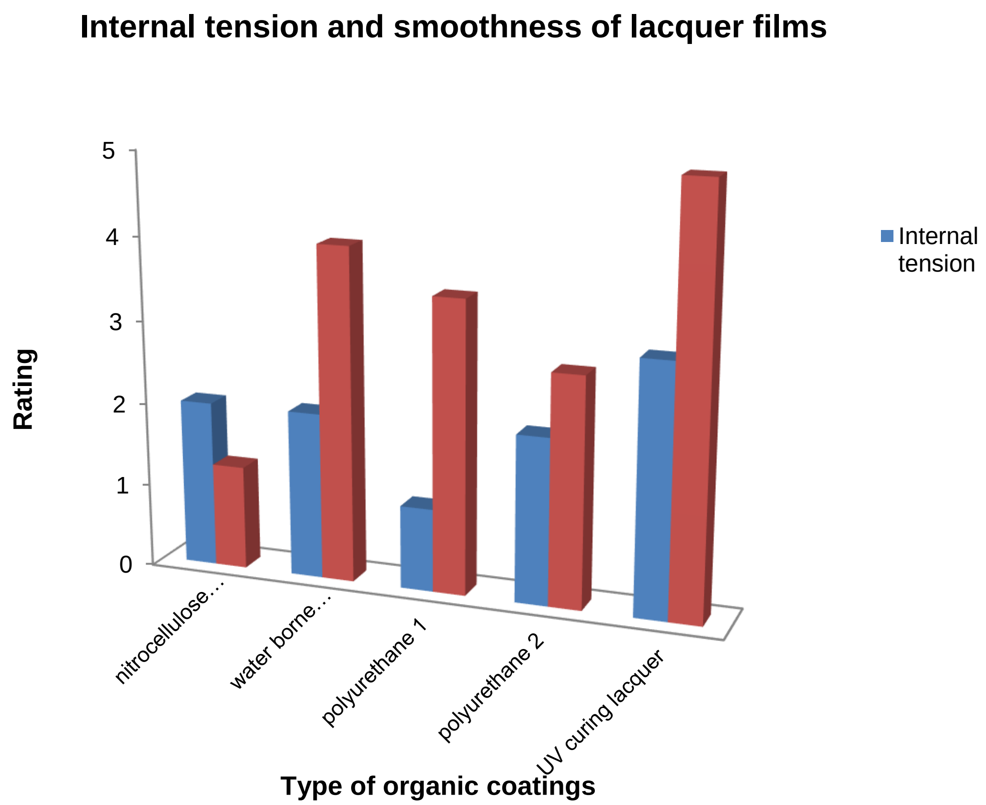

Figure 5. Internal tension and smoothness of lacquer films

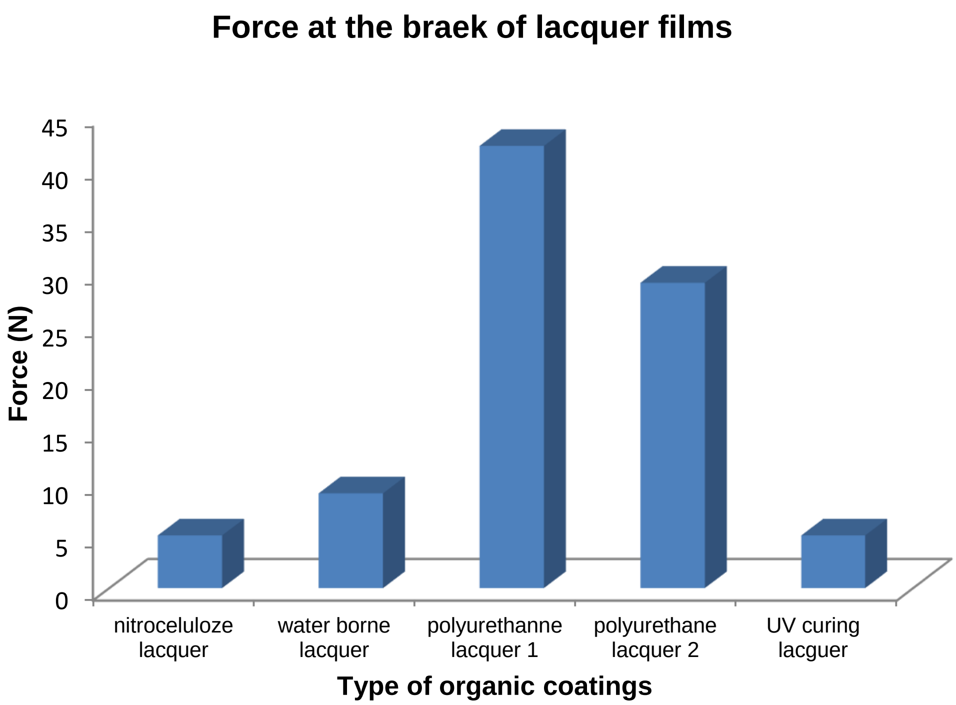

Figure 6. Force at the braek of lacquer films

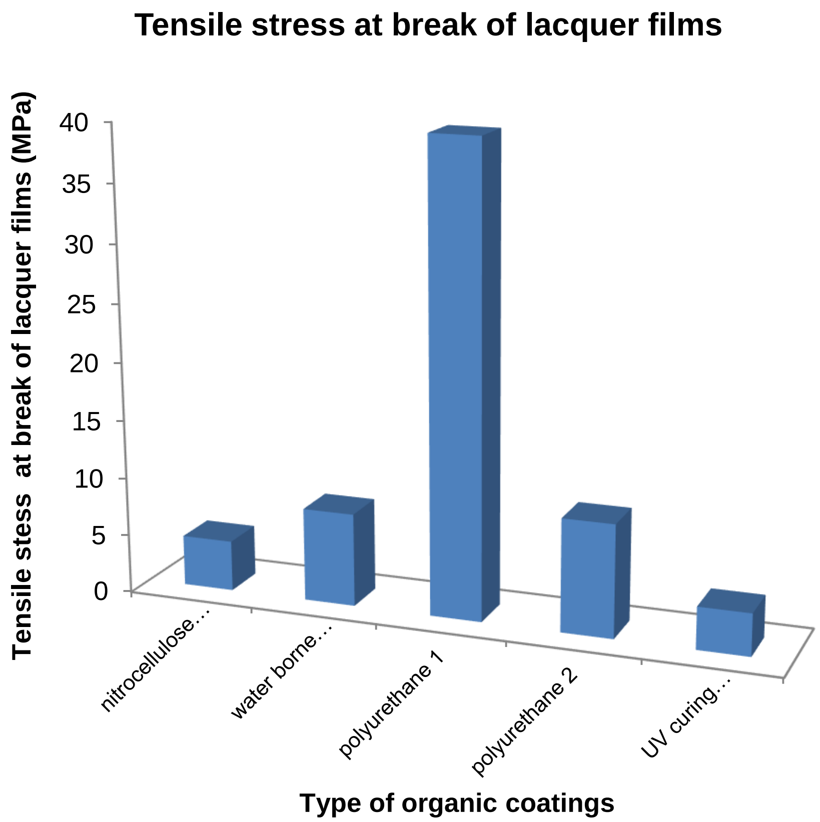

Figure 7. Tensile stress at the break of lacquer films

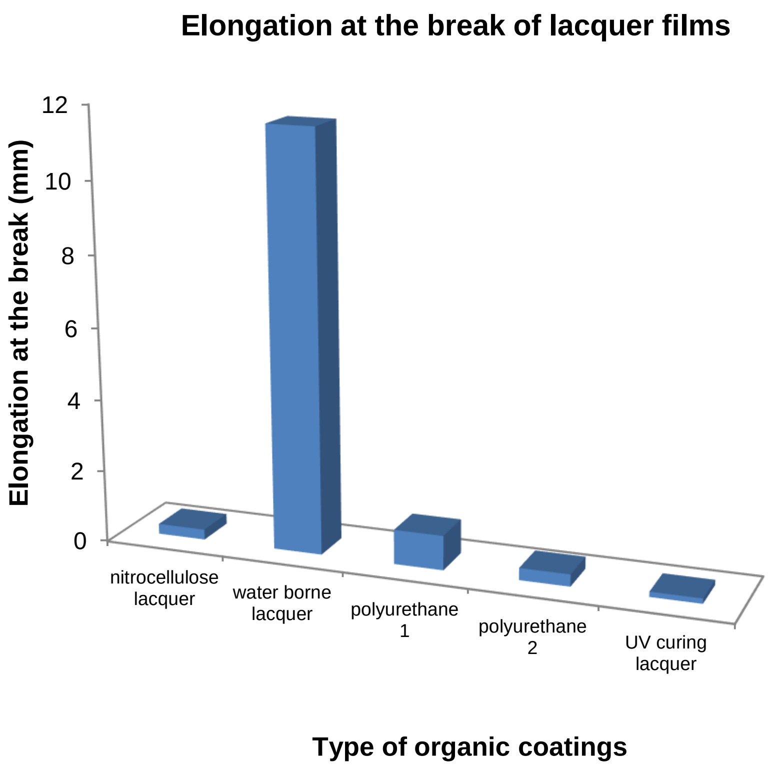

Figure 8. The elongation at the break of lacquer films

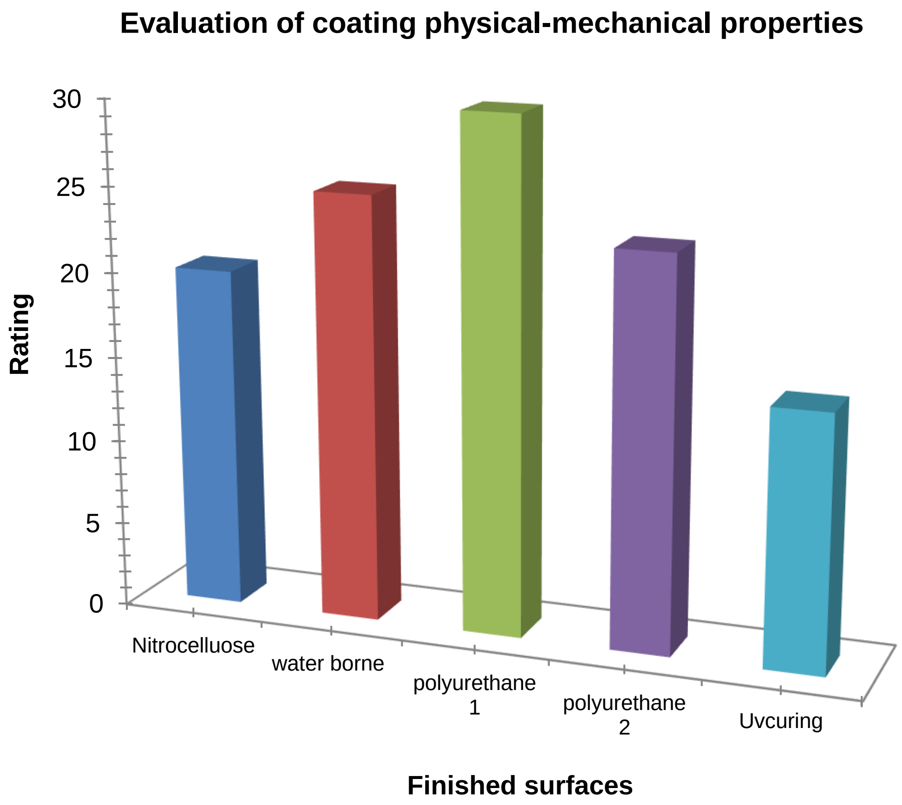

Figure 9. Evaluation of finished surfaces physical-mechanical properties

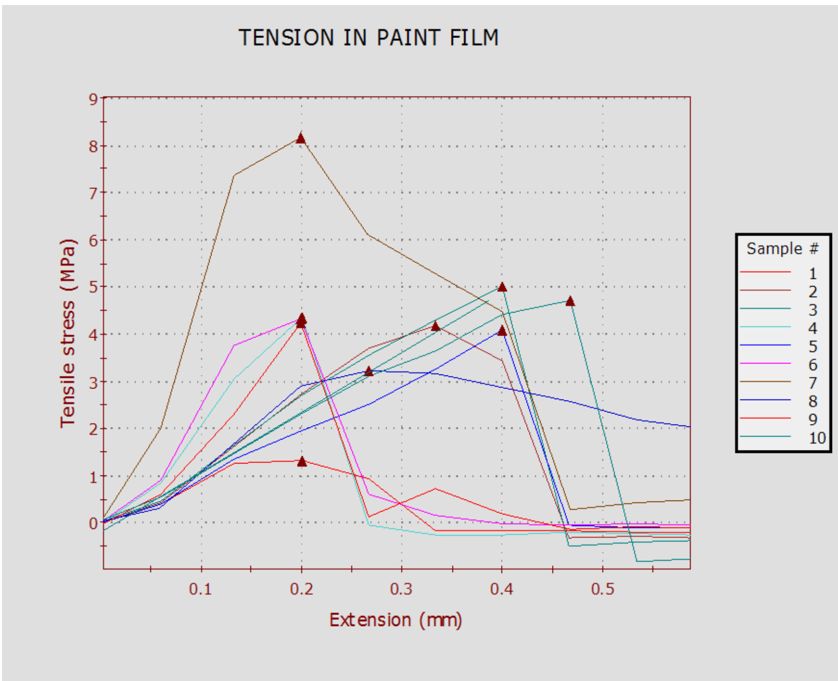

Figure 10. Tensile tension in samples of lacquer films nitrocellulose

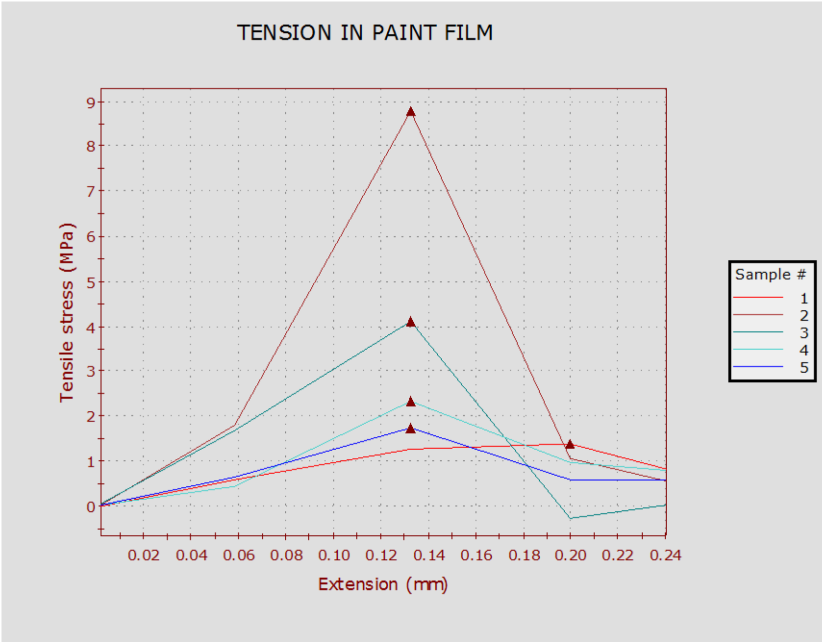

Figure 11. Tensile tension in samples of lacquer films UV curing lacquers

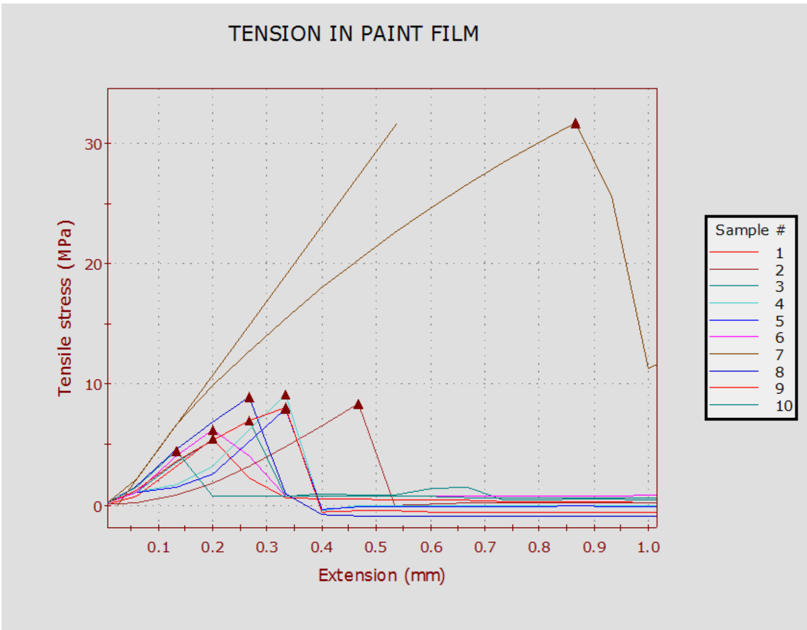

Figure 12. Tensile tension in samples of lacquer films lacquer films polyurethane-2K

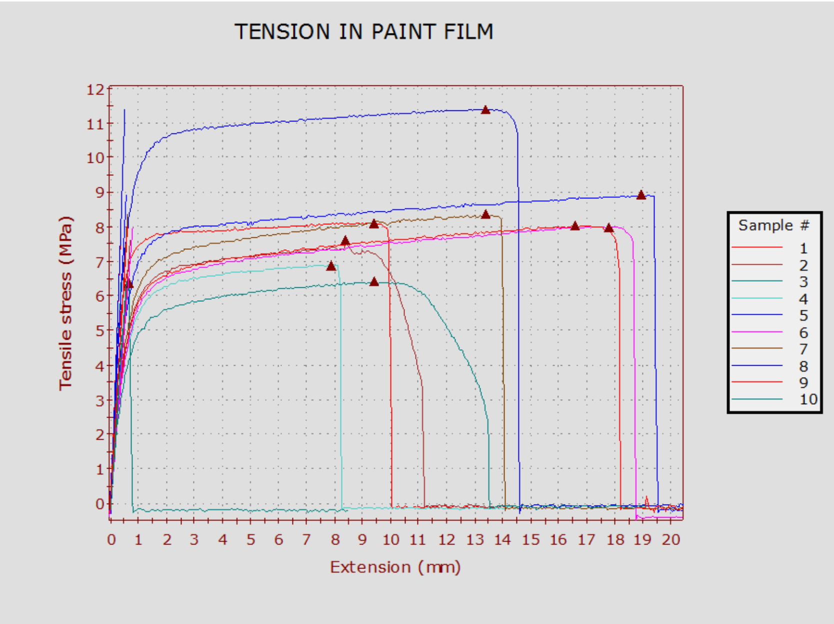

Figure 13. Tensile tension in samples of water borne lacquer

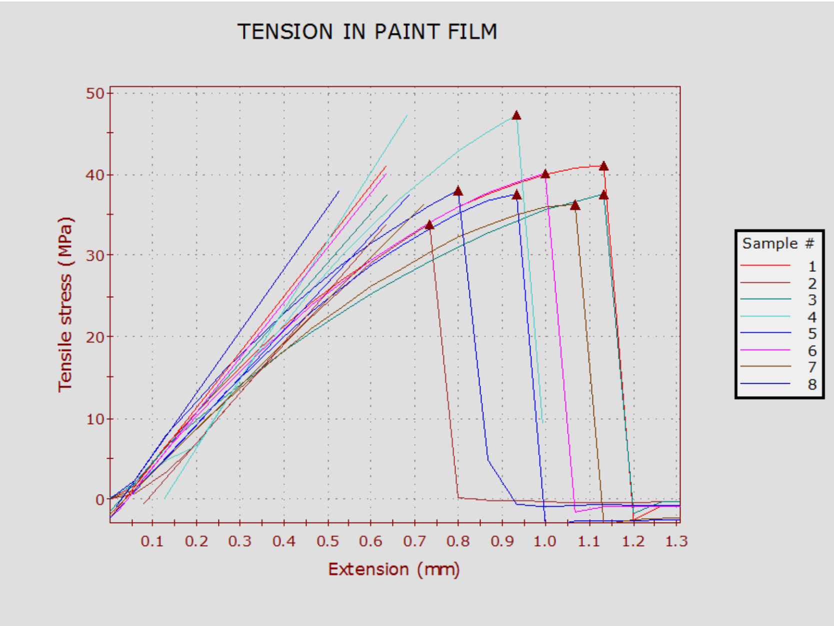

Figure 14. Tensile tension in samples of lacquer films of polyurethane-1K

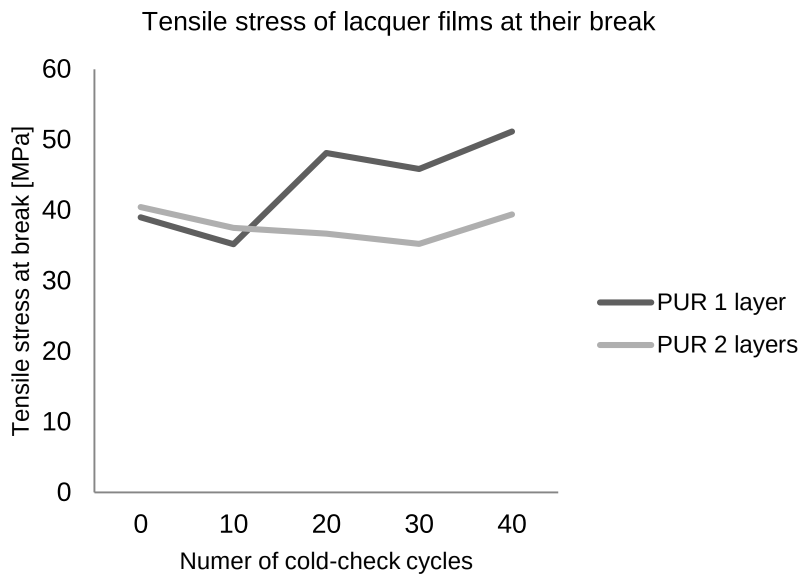

Figure 15. Tensile stress of lacquer films at their break.

Table 1. Tensile stress of lacquer film finished by one layer of polyurethane lacquer

	σ_t [MPa]	σ_t [MPa]	σ_t [MPa]	σ_t [MPa]	σ_t [MPa]
Number of cold-check cycles	0	10	20	30	40
Average	39,013	35,19	48,129	45,86	51,188
Maximum	56,959	38,652	56,793	50,766	59,69
Minimální	28,881	28,505	33,343	37,823	40,365
Standard deviation	8,3505	3,2108	6,6693	3,6409	5,934
Median	35,315	36,235	50,519	46,696	52,792

Table 2. Tensile stress of lacquer film finished by two layers of polyurethane lacquer

	σ_t [MPa]	σ_t [MPa]	σ_t [MPa]	σ_t [MPa]	σ_t [MPa]
Number of cold-check cycles	0	10	20	30	40
Average	40,4691	37,4962	36,6965	35,2242	39,4205
Maximum	64,049	42,715	41,471	39,172	42,257
Minimální	27,408	25,658	30,268	29,823	37,507
Standard deviation	9,2322	4,41572	3,51735	2,50394	1,51257
median Medián	39,69	37,924	37,2215	34,8615	39,148

Table 3.Surface hardness - direction of measurement along fibers.

	Hardness [mm] 0 cycle	Hardness [mm] 10 cycles	Hardness [mm] 20 cycles	Hardness [mm] 30 cycles	Hardness [mm] 40 cycles
Average value	-0,010	-0,010	-0,010	-0,012	-0,010
Reference sample	-0,013	-0,013	-0,012	-0,016	-0,015

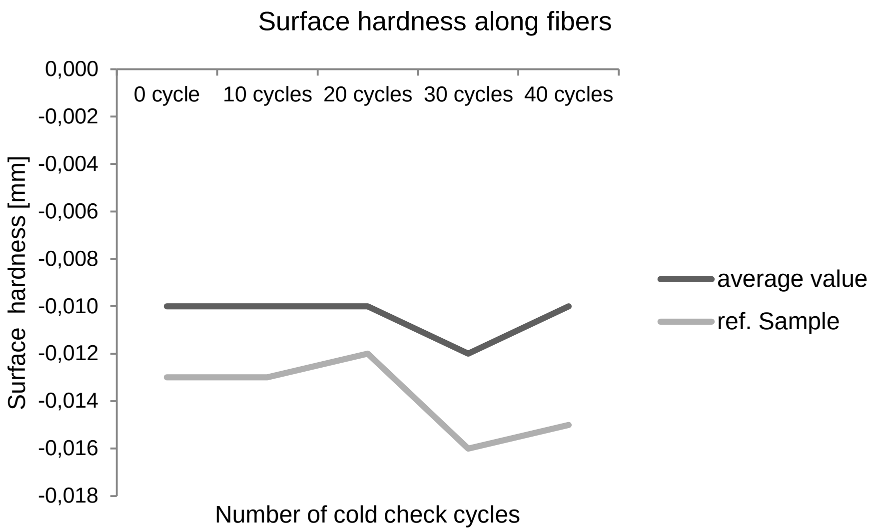

Figure 16. Changes of hardness tested surface - direction of measurement along fibers.

4.CONCLUSION

In this contribution we achieved very important results. When we have compared the results of physical –mechanical properties of finished surfaces and the results of tensile stress at break of lacquer films, we found the relationship between tensile stress stresss and physical-mechanical properties. The results of physical-mechanical properties are summarized in figure 9, the results of the assessment of tensile stress of coating films are expressed in figure 6 and the forces at break of lacquer films are shown in figure 7, and when we put them together we compared all results. These achieved and compared results confirmed our hypothesis about the relationship between the physical-mechanical properties of lacquers films and the ultimate tensile stress of free coating films.
The coating film of the polyurethane lacquer 1K delivered the best results during the investigation of physical-mechanical properties of finished surfaces and kept the highest tensile stress at the break of lacquer films. UV curing lacquer films provided the worst results in both of the testing methods (physical –mechanical). When we compared both of figures 6 and 7 to the results in figure 9, we could see the relationship between the tested physical-mechanical properties of finished surfaces and lacquers films made from the same coating materials. The results of surface hardness are summarized in figure 16 table 3. When all results were put together it was possible to compare them. These achieved and compared results confirmed our hypothesis about the relationship between the physical-mechanical properties of lacquers films and ultimate tensile stress of free coating films. The results of surface hardness especially in direction along the wooden fibres are improving its properties in dependence of number of cycles. The harmonization of the tensile test conditions for free wood coatings is mandatory before talking about threshold values or limits for mechanical properties. This study has shown that it is very important to investigate the tensile stress of free coating films during the development of coating materials.

Acknowledgement This study was kindly supported by Grant Agency pro, the supported project Design and development of unique planar composite elements of wood-based flooring for sports and theatre space TH 02020984

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