Analysis of the adhesive application to the strands for manufacture LSL element from underutilized wood species

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GOAL

The main goal of this project was expansion of knowledge in bonding wood-based composites from underutilized wood species. Project was aimed to the properties of bondline in wood-based composite materials. This project evaluated differences between four group of samples. These samples were made from four different wood species (beech, pine, poplar, spruce). Project evaluated lap shear strength and surface coverage of resin droplets.

MATERIAL & METHODS

Veneer sheets of four types of wood species (beech, pine, poplar, spruce) were cut to the specimens with dimension 25 × 60 mm. The adhesive was applicated in laboratory rotary blender, as the resin application technology was used spinning disc atomizer with 14 000 rpm. Two different types of adhesive were used PMDI and MUF. Application time was established to 20 seconds. Bonding area was defined by aluminum template with square holes 25 × 25 mm. Bonding specimens was manufactured on universal testing machine Zwick Z050 (Zwick Roell, Ulm, Deutschland). The machine was equipped with two aluminum heating plates. Pressing parameters were pressure 1 MPa, temperature 120 °C and for the duration 120 seconds. These specimens were tested on the universal testing machine (Tinius Olsen 10ST, Redhill, UK) with 10 kN load cell. Results of this project will be comparison of adhesives droplet size and lap shear strength. The same adhesives with 2-3 % of black pigment were used for the evaluation of the percentage coverage of surface. These specimens were dried after resin application in 103 °C. This type of specimens were photographed by microscope and evaluated by ImageJ software.

Fig. 1: Adhesive application to the specimens in rotary blender with spinning disc atomizer.

Fig. 2: Pressing specimens by universal testing machine Zwick Z050 (Zwick Roell, Ulm, Deutschland)

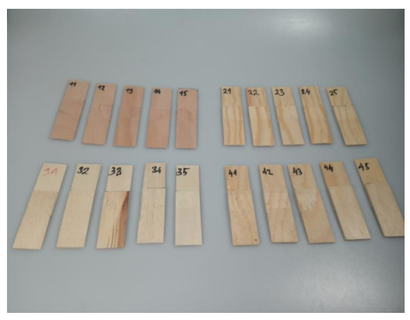

Fig. 3: Lap shear specimens with PMDI adhesive

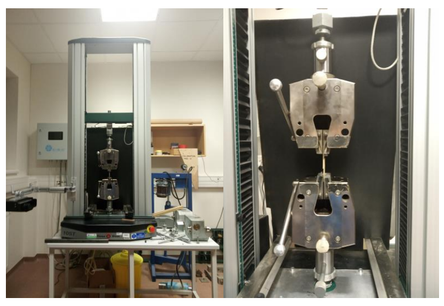

Fig. 4: Testing specimens by Tinius Olsen 10ST (Redhill, UK)

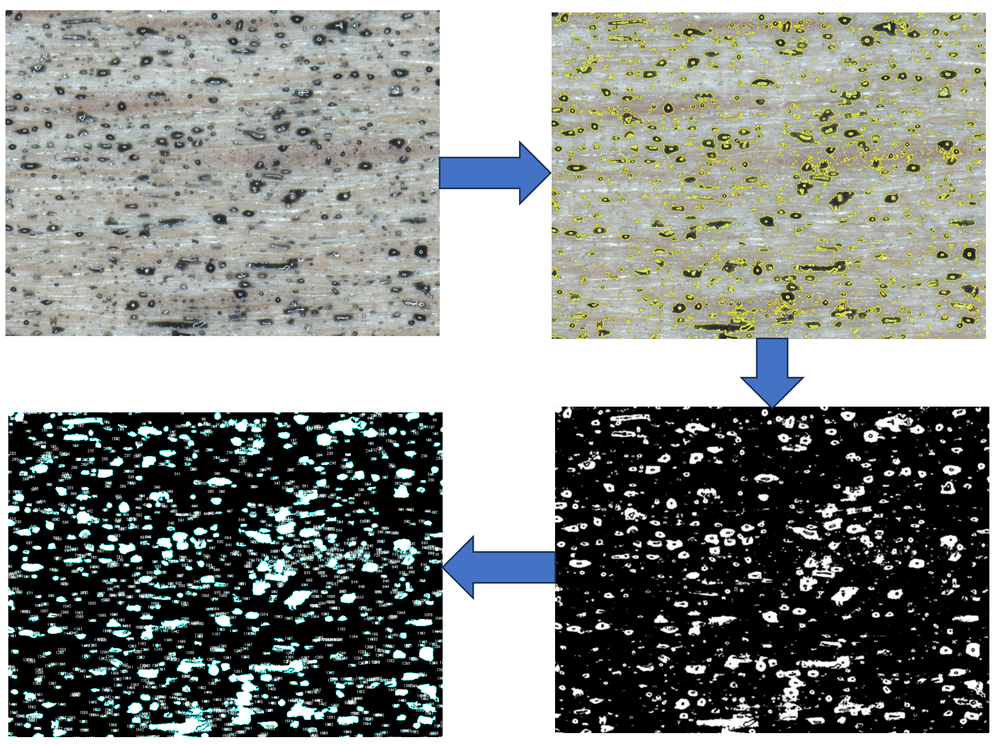

Fig. 5: Scheme of evaluation surface coverage by software ImageJ.

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RESULTS

Table 1: The average values of density and equilibrium moisture content of specimens at 20 °C and 65% RH

Type of species	Density kg/m³	Tukey´s test	MC [%]	Tukey´s test
Beech	642 (63)	B	9,11 (0,42)	A
Pine	527 (41)	A	9,68 (0,64)	B
Poplar	342 (57)	C	8,99 (0,40)	A
Spruce	510 31)	A	9,18 (0,42)	A

Means with the same letter in column do not differ statistically by the Tukey´s test (α=0.05). Numbers in parentheses represent standard deviation

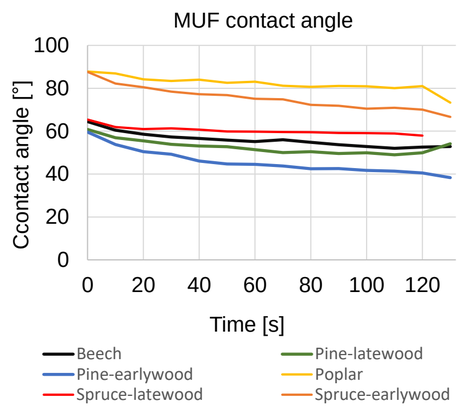

Fig. 6: Results of MUF contact angle measurement

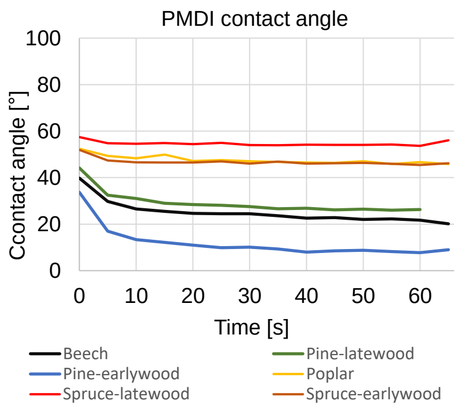

Fig. 7: Results of PMDI contact angle measurement

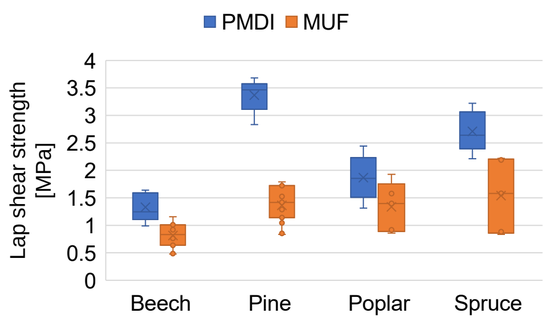

Fig. 8: Lap shear strength of four wood species

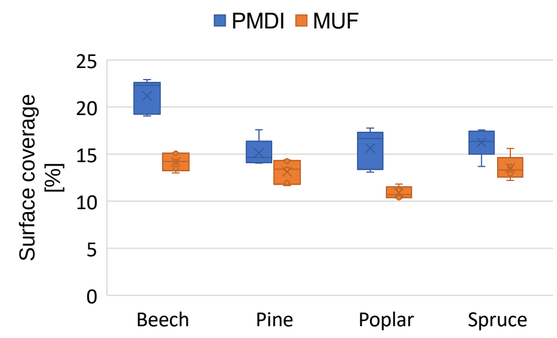

Fig. 9: Surface coverage of four wood species

Table 2: The average values of surface coverage and droplets size.

	PMDI				MUF			
descriptive statistic coverage	Beech	Pine	Poplar	Spruce	Beech	Pine	Poplar	Spruce
Average surface coverage [%]	21,20	15,12	15,61	16,24	14,18	13,13	10,90	13,54
Standard deviation coverage [%]	1,61	1,30	1,87	1,37	0,84	1,14	0,56	1,14
Average droplets size [μm²]	0,19	0,24	0,34	0,30	0,41	0,28	0,36	0,36
Standard deviation droplets size [μm²]	2,19	1,85	2,99	2,59	5,37	2,04	2,06	3,16
Minimum droplet size [μm²]	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Maximum droplet size [μm²]	174,00	122,00	213,00	152,00	421,00	138,00	71,00	197,00

DISCUSION AND CONCLUSION

The significant differences were found in density. This fact was expected because of differences in the density in the used wood species. It was found one significant difference in pine group of samples for moisture content. This fact could affect curing of PMDI adhesive, because the MC is one of the most important parameters for this adhesive. Lap-shear strength for Pine specimens was significantly higher compared to the other groups of specimens. The lowest values of lap shear strength were found on beech specimens. Contact angle on beech specimens were very low in both adhesives, this fact could be a reason why the lap shear strength was so low. Adhesive could penetrate to the bonding substrate so fast and very low amount of adhesive stays in the bondline. The surface coverage was higher in beech specimens in PMDI adhesive. In this case PMDI adhesive penetrate to the wood and droplets were spread over a large area of the specimen's surface. Bonding of beech species could be problematic in wood-based composite materials. Measuring of surface coverage was affected in some specimens by joining droplets together and made some large droplets. It was typical in poplar specimens and pine specimens in earlywood. Lap shear strength had wider variability in pine and spruce specimens. This variability could be caused by different behavior of early and late wood and by ratio on specimens of these two parts of annual ring. Bonding of beech wood could be problematic in wood-based composite materials.

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