International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

Lamination Properties of Particleboard from Rubberwood (*Hevea brasiliensis*) and Wood Wastes

Wan Mohd Nazri Wan Abdul Rahman, Wan Nurul Amira Shah Fika Wan Zakaria, Nur Sakinah Mohamed Tamat, Nor Yuziah Mohd Yunus

Abstract: ***The lamination properties on surfaces of laminates board by using different types of decorative papers was evaluated for particleboards manufactured using urea formaldehyde (UF). The different paper need to be checked for suitability especially in protection of performance of laminated particleboard. Failure of product will be costly for both user and supplier. Lamination was done on the top and bottom surfaces of particleboard. These papers are decorative paper S (Stipples), decorative paper T (Texture) and decorative paper WE (Wood grain). Effects of different types of decorative paper used on laminated board for resistance to acid, resistance to scratch, resistance to abrasion and resistance to graphite were investigated. The results showed that significant variation for scratch test but not significant for the other tests. Overall, decorative papers used in this study meet the requirement for the standard BS EN 14322:2004.***

Index Terms: ***Lamination, Particleboard, Rubberwood, Wood Wastes***

I. INTRODUCTION

Lamination is a technique in producing materials in multiple layers so as to increase the strength, stability, appearance and various other performances of the laminated product. The technique is often performed on panel products which are wood based composites such as particleboard, plywood, oriented strand board and medium density fiberboards. The enhancement of panel properties depends on the use of different materials onto the surfaces. This is because different used of materials to cover or coat the surfaces will produce the different result in properties of the panel products. The lamination can be effective even when low density panels were used as base [1]. According to [2], lamination creates surface smoothness, thickness tolerance and uniform density which preserve the surface of panels.

According to [3], typically particleboard used overlay materials in form of vinyl films, laminates, resin-saturated papers, wood veneers, decorative papers and hot transfer films. Particleboard is a suitable lamination based due to its flat shape, uniform surface and panel stability. This encourages ease in laminating and coating process [4]. The surfacing materials used in particleboard can protect the surfaces of the materials during the utilization of these particleboards either for interior fixture or in furniture manufacturers. At the same time, it acts as décor or design for differentiation which enhance the commercial value of particleboard made furniture.

There are many benefits of lamination to panel products. The primary function is increase in mechanical properties, dimensional stability and durability of surface which allows the panel to withstand frequent use. The surface performance of panel product will improve in the resistance to the abrasion, scratch and chemicals [2]. A study by [3] found that thermal conductivity increased while combustion resistance decreased as the panel products coated with different types of overlying material. The resistance against staining and cigarette burns on the particleboard also underwent significant changes as a result of impregnation process of the overlay placed on the surface of the particleboard [4].

Particleboard that have been coated can be used for the various application such as in construction of cabinets, paneling, work surfaces in offices, furniture, laboratories, kitchen worktops, educational establishments and others industrial product applications [5]. The performance of the coated particleboard depends on the quality of the coating materials used, their resistance to abrasion and scratch, and also types of the wood-based panels. The wood-based panel properties are governed parameters including the density and species [3], [4].

This study looks at three types of decorative papers. The objective is to evaluate the surface performance lamination papers when laminated onto particleboard.

Manuscript published on November 30, 2019.
*Correspondence Author
Wan Mohd Nazri Wan Abdul Rahman*, Faculty of Applied Sciences, Universiti Teknologi MARA, Pahang, Malaysia. Email: wmdnazri@uitm.edu.my
Wan Nurul Amira Shah Fika Wan Zakaria, Faculty of Applied Sciences, Universiti Teknologi MARA, Pahang, Malaysia. Email: nuramira642@gmail.com
Nur Sakinah Mohamed Tamat, Faculty of Applied Sciences, Universiti Teknologi MARA, Pahang, Malaysia. Email: sakinah292@yahoo.com
Nor Yuziah Mohd Yunus*, Faculty of Applied Sciences, Universiti Teknologi MARA, Pahang, Malaysia. Email: noryuziah@uitm.edu.my

II. MATERIALS AND METHODS

A. Preparation of sawmill wastes and rubberwood particles

Sawmill wastes and rubberwood materials were obtained from Mieco Manufacturing Sdn. Bhd. Gebeng, Pahang, Malaysia. Logs were debarked and then cut into target size for the chipping process. Chips were flaked into smaller particles before dried in a shaded area. The particles were then screened into 0.5mm, 1.0mm and 2.0mm particle sizes. The screened particles were further oven dried at 80˚C to reduce the moisture content to less than 5%.

B. Particleboard Making

Three-layered particleboards with the thickness of 18mm were fabricated at density of 650 kg/m^3. Particle size of 0.5 mm was used for surface layer, while 2.0 mm for core layer. Particles were blended with urea formaldehyde resin before mat forming. The resulting mat was cold pressed before being hot pressed to the required thickness. All particleboards were kept in a conditioning room for 24 hours prior to testing.

C. Lamination Process

Lamination papers were placed on top of the particleboards before being pressed. Then, laminated particleboards were cut into the required sizes for property evaluation as required by [6]. Fig. 1 shows the flowchart of lamination process.

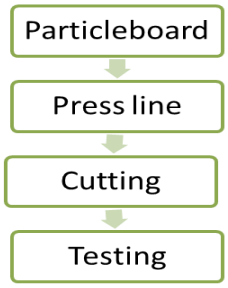

Fig. 1: Lamination process on particleboard

D. Lamination Testing

Laminated particleboards were cut into 10 cm × 10 cm for testing of scratch test, abrasion test, acid test and graphite test according to [6]. All tests were done in duplicate and were evaluated by observation. Results of evaluation were recorded based on specification in Table I.

Table I: Lamination specification

Rating	(5)	(4)	(3)	(2)	(1)
Remarks	No visible change	Slight change of gloss/ brown stain	Moderate change of gloss color/ brown stain	Severe change of gloss/ change of color/ brown mark/	Blistering/ delamination/ surface distortion

The acid test shows the resistance of test surface against the corrosive nature of acid. The acid (0.2N HCl) was placed at the center of sample and the area was covered using a watch glass for 24 hours (Fig. 2). The tested area was then washed with water and wiped with dry cloth before being examined (Fig. 3).

Fig. 2: Before acid test **Fig. 3. After acid test**

For scratch test, sample was placed on the scratch tester with the surface facing upward and 10 N load was applied (Fig. 4). A gap of 3 mm was set between line to line on top of the surface. Scratch appearance was determined based on the rating in Table I.

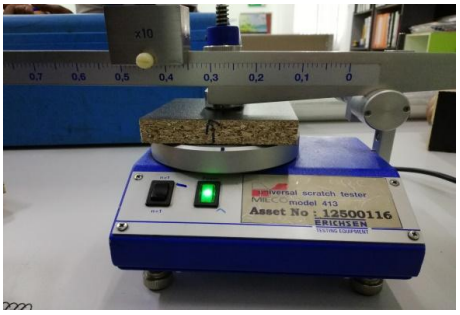

Fig. 4: Scratch tester

For abrasion test, a hole was drilled at the center of the sample prior to its being weighed. Sample was then loaded on the taber scratch test instrument set-up. Self-adhesive sand paper strip was placed onto each roller on the test instrument. The roller was placed on the surface of the samples and then taber-wear test instrument was switched on (Fig. 5). The test was set at 100 rpm (revolutions per minute) and sample was reweighed after the revolution has been completed (Fig. 6). This testing measures the ability of surface sample to resist abrasive wear-through.

Fig. 5: Taber wear machine **Fig. 6: After abrasion test**

Pencil 2B was used to mark the center on the sample surface in graphite test (Fig. 7). Later, the tested area was erased by using an eraser and then wiped with dry cloth. Lastly, the tested area was observed and rated according to Table I.

Fig. 7: Graphite test

III. RESULTS AND DISCUSSION

Experimental results for the properties of lamination are summarized in Table II The highest average rating for acid test on top and bottom of the surface was 4.6 and 3.8 which was for decorative paper Texture (T) and the lowest rating was decorative paper Wood grain (WE) for both of the surfaces with values 4.2 for top and 3.6 for bottom. Whereas for scratch test, decorative paper Stipples (S) dominated with rating 3.8 and 3.9 for top and bottom and the least value was for decorative paper WE with rating 2.4 and 2.6 respectively. Then, for abrasion test, decorative paper WE was good in resistance to the abrasion test for top surface as the value was slightly lower (0.045 g) compared to the decorative paper S (0.044 g) and decorative paper T (0.042 g). While for bottom surface, decorative paper S was higher with 0.032 g lost while decorative paper T was 0.042 g and followed by decorative paper WE with 0.043 g. Lastly, decorative paper WE showed the highest rating of 5 in graphite test for both top and bottom surface and then followed by decorative paper S and decorative paper T with same values which were 4.8 for top and bottom.

Table II: Lamination of properties of particleboard

	Acid 0.2N, HCl/24h		Scratch		Abrasion, 100rpm/g		Graphite, 2B/rub	
Paper	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
S	4.0	2.0	3.5	4.0	0.041	0.04	5.0	5.0
S	5.0	4.0	4.5	4.5	0.04	0.039	5.0	5.0
S	5.0	5.0	3.0	3.0	0.035	0.027	5.0	5.0
S	5.0	2.0	3.0	3.0	0.041	0.04	5.0	5.0
S	3.0	3.0	5.0	5.0	0.062	0.012	4.0	4.0
Average	4.4	3.2	3.8	3.9	0.044	0.032	4.8	4.8
T	4.0	3.0	2.5	3.0	0.038	0.035	5.0	5.0
T	5.0	4.0	4.5	4.5	0.04	0.039	5.0	5.0
T	5.0	5.0	3.5	3.5	0.059	0.052	4.0	4.0
T	4.0	2.0	3.5	4.0	0.041	0.04	5.0	5.0
T	5.0	5.0	3.5	3.5	0.049	0.045	5.0	5.0
Average	4.6	3.8	3.5	3.7	0.045	0.042	4.8	4.8
WE	5.0	3.0	2.5	2.5	0.048	0.043	5.0	5.0
WE	3.0	2.0	3.0	3.0	0.046	0.042	5.0	5.0
WE	5.0	5.0	2.0	2.5	0.042	0.043	5.0	5.0
WE	3.0	3.0	2.0	2.0	0.045	0.039	5.0	5.0
WE	5.0	5.0	2.5	3.0	0.037	0.049	5.0	5.0
Average	4.2	3.6	2.4	2.6	0.043	0.043	5.0	5.0

Note: Rating = 1,2,3,4 and 5, Rating 5 = No visible change, Rating 4 = Slight change of gloss/brown stain, Rating 3 = Moderate change of gloss color/brown stain, Rating 2 = Severe change of gloss/change of color/brown mark, Rating 1 = Blistering/delamination/surface distortion.

A. Statistical Significance

The ANOVA for the effects of plates on lamination properties is shown in Table III. Scratch test was found to effect on top and bottom surface of the laminated particleboard significantly while the other tests was not significantly effecting the top and bottom of the laminated particleboard.

Table III: Summary of the ANOVA on Lamination Properties

		Acid 0.2N, HCl/24h		Scratch		Abrasion, 100rpm		Graphite, 2B	
SOV	df	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Decorative paper	2	0.26ns	0.27ns	5.43*	5.65*	0.07ns	2.94ns	0.50ns	0.50ns

Note: SOV = Source of Variance, df = Degree of freedom, *significant at p < 0.05, ns =Not significant at p> 0.05

B. Effects of Acid Test on Decorative Paper

Fig. 8 and Fig. 9 demonstrate the effects of acid test on top and bottom surface of laminated particleboard respectively. The results revealed that both of the surfaces for decorative paper S, decorative paper T and decorative paper WE were not affected by the acid although the ratings for decorative paper S and decorative paper WE were 4 for top surface which was lower than decorative paper T which has rating 5. While for bottom surface, decorative paper T and decorative paper WE had same values which were 4 in rating compared with decorative paper S which was rated 3. From the graph it shows no significant difference showing all types of decorative paper used have good resistant against the acid. The level of resin impregnation in the paper used is similarly controlled, thus leading to the same acid resistance performance. Change in resin impregnation level is known to have an effect on laminated surface performance [7]. Although the rating between each decorative paper were different, they also achieved the required specification, where rating 2 and above is acceptable. Rating 5 means there is no visible changes on the surface of the sample, rating 4 slight changes, rating 3 moderate changes and rating 2 brown stains appear.

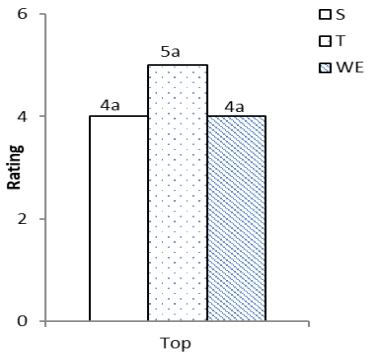

Fig. 8: Effects of acid test on top surface. Single letter a indicate values in cluster have no significant difference at p < 0.05

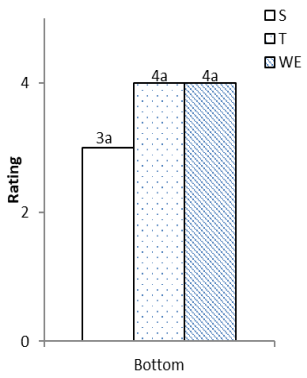

Fig. 9: Effects of acid test on bottom surface. Single letter a indicate values in cluster have no significant difference at $p < 0.05$

C. Effects of Scratch Test on Decorative Paper

The results on the effects of scratch test on top and bottom surfaces of laminated board are illustrated in Fig. 10 and Fig. 11. The rating for the top and bottom surfaces of both decorative papers S and T were same (rating 4) while decorative paper WE had lower rating especially for top surface with rating 2 and rating 3 for bottom surface. This result proved that there was significantly difference between decorative papers WE with decorative papers S and T. The press factor of the lamination plays a role in performance of the laminated surface as the resin cure state will control the strength of the surface [8]. Despite lower rating, decorative paper WE still comply as having good resistance to scratch since it achieved the targeted specification between 2 to 5 (Table I).

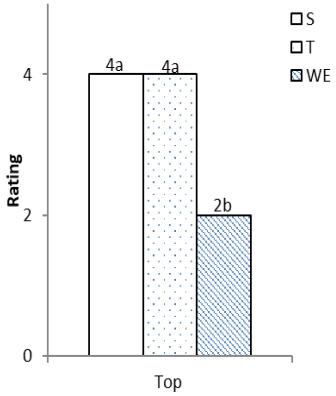

Fig. 10: Effects of scratch test on top surface. Letters a and b indicate values in cluster to be significantly different at $p < 0.05$

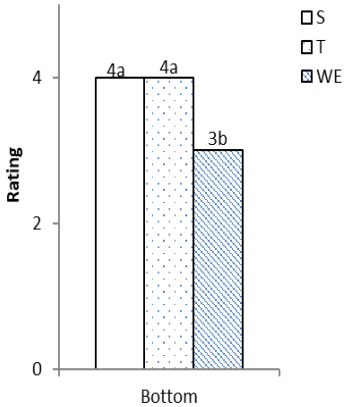

Fig. 11: Effects of scratch test on bottom surface. Letters a and b indicate values in cluster to be significantly different at $p < 0.05$

D. Effects of Abrasion Test on Decorative Paper

The effects of the abrasion test on laminated particleboard for decorative paper S, T and WE are shown in Fig. 12 and Fig. 13. From the graph, it showed that there was no significant difference between decorative papers for both surfaces. The graph showed that decorative paper T is more resistance to abrasion for both of the surfaces compared to decorative papers of S and WE. For top surface, value of decorative paper T is 0.05 g while bottom surface is 0.04 g followed by decorative paper WE (0.04 g) which is higher value at the bottom as compared to the decorative paper S (0.03 g). While for top surface, both decorative papers had same values of 0.04 g. The specification state the acceptable weight loss for abrasion test at maximum of 0.08 g. All the decorative papers for top and bottom surfaces registered weight loss lower than 0.08 g and achieved the standard. The abrasion test is used to determine the resistance of material surfaces to abrasive stress. The use of correct resin amount and proper technique of impregnation in laminate paper will be observed in the good performance of the abrasion test. [9][10].

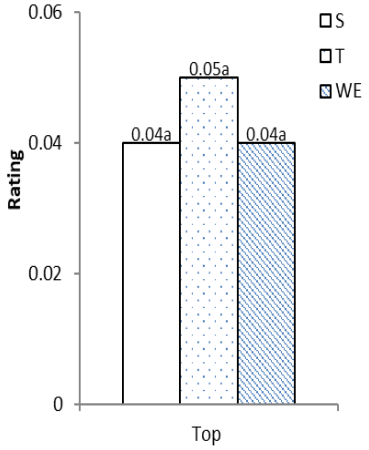

Fig. 12: Effects of abrasion test on to surface. Single letter a indicate values in cluster have no significant difference at $p < 0.05$

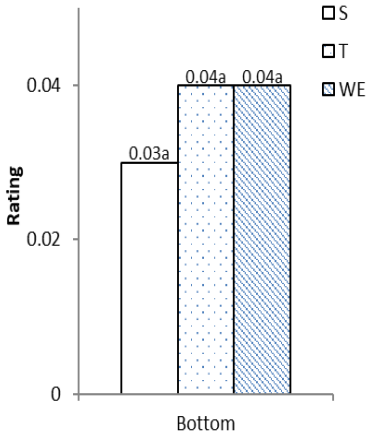

Fig. 13: Effects of abrasion test on bottom surface. Single letter a indicate values in cluster have no significant difference at $p < 0.05$

E. Effects of Graphite Test on Decorative Paper

Fig. 14 and Fig. 15 show the results on top and bottom surfaces of the graphite test. Through these results, it showed no significant different between the decorative papers used for the top and bottom, it showed the same rating which was 5 for both surfaces respectively. The rating needed in graphite test is 5, which is no visible change should occur. Decorative papers T, S and WE achieved the rating and this proved that all the decorative papers were of good quality as no changes occurred in graphite test.

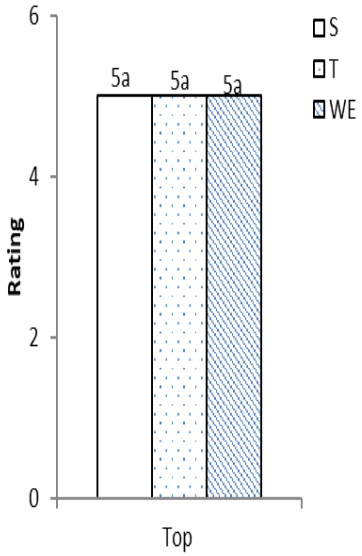

Fig. 14: Effects of graphite test on top surface. Single letter a indicate values in cluster have no significant difference at p < 0.05

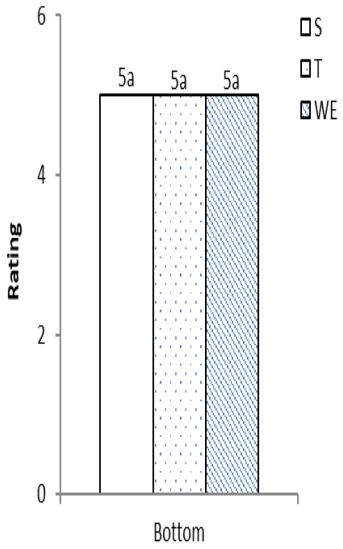

Fig. 15: Effects of graphite test on bottom surface. Single letter a indicate values in cluster have no significant difference at p < 0.05

The high resistance to graphite test makes the laminated particleboard suitable for furniture applications such as tabletop and kitchen cabinet as it can prevent surfaces from getting graphite stain.

IV. CONCLUSION

Lamination surface for the different types of decorative paper used was shown not to be significantly affected by the acid test, abrasion test and graphite test conducted. Only scratch test showed significant difference between the decorative papers with decorative papers WE showing lower performance. All the decorative papers achieved the specification required.

ACKNOWLEDGEMENT

The authors gratefully acknowledged Mieco Chipboard Bhd. at Gebeng, Pahang, Malaysia for providing raw materials, necessary facilities and much guidance for the experimental work.

REFERENCES

1. N. Ayrilmis. “Enhancement of dimensional stability and mechanical properties of light MDF by adding melamine resin impregnated paper waste”. Int. J. of Adhesion and Adhesives, 33: 2012, 45-49.
2. G. Nemli, S. Yildiz and E. D. Gezer. “Effects of melamine raw paper weight, varnish type and the structure of continuous pressed laminate (CPL) on the physical , mechanical properties and decay resistance of particleboard,” Biodeterioration & Biodegradation, 2005, pp. 166–172.
3. G. Nemli and H. Kalaycioğlu, “The resistances of several types of overlaying materials against cigarette burn, scratch, and abrasion,” Building and Environment 41, 2006, pp. 640–645.
4. G. Nemli and G. Çolakoğlu, “The influence of lamination technique on the properties of particleboard,” Building and Environment 40, 2005, pp. 83–87.
5. G. Nemli, Y. Örs and H. Kalaycioğlu, “The choosing of suitable decorative surface coating material types for interior end use applications of particleboard,” Construction and Building Materials 19, 2005, pp. 307–312.
6. European Standard (EN) 14322, “Wood-based panels – Melamine faced boards for interior uses. Definition, requirements and classification”, 2004.
7. M. Çiçekler, A. Tutus and F. Ozdemir. “Resin impregnation of decor papers and comparison of physical properties”. 2nd International Furniture Congress, at Muğla/Turkey, 13-15 October 2016.
8. G. Nemli and S. Hiziroğlu. “Effect of press parameters on scratch and abrasion resistance of overlaid particleboard panels,” Journal of Composite Materials 43(13), 2009, pp. 1413-1420.
9. I. Abdullah, A. Deniz and A. Soner, “The effect of décor paper and resin type on the physical, mechanical, and surface quality properties of particleboards coated with impregnated décor papers,” BioResources 5, 2010, pp. 1074-1083.
10. U. Büyüksari. “Surface characteristics and hardness of MDF panels laminated with thermally compressed veneer”. Composites: Part B Engineering, 44(1): 2013, pp. 675-678.

AUTHORS PROFILE

Wan Mohd Nazri Wan Abdul Rahman is an associate professor at the Department of Wood Industry, Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), Jengka Campus, Pahang, Malaysia. He started teaching at UiTM since 2000. He obtained his Bachelor of Science (Forestry) Degree in 1998 and Master Degree of Science (Wood Utilization) in 2000 at Universiti Putra Malaysia (UPM). He holds a Philosophy Degree in 2009 from UiTM. His research fields in forest plantation, biomass and wood composite.

Wan Nurul Amira Shah Fika Wan Zakaria obtained her Degree in Science (Furniture Technology) in 2018 from Universiti Teknologi MARA (UiTM). Her thesis involved evaluation on lamination properties of 16mm particleboard made from rubberwood (*Hevea brasiliensis*) and sawmill waste.

Nur Sakinah Mohamed Tamat obtained her Degree in Science (Furniture Technology) in 2010 from Universiti Teknologi MARA (UiTM). Her PhD in Wood Science and Technology was done also in UiTM. Her thesis involved evaluation on the effects of particle size, board density, resin content, hot press temperature and alkaline concentration on properties of Kelempayan (*Neolamarckia cadamba*) particleboard. She published her work in Scopus-Index Journals, Open-Access Journals, Book Chapter and International Conference Proceedings.

Nor Yuziah Mohd Yunus is an associate professor at Department of Wood Industry, Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), Jengka Campus, Pahang. She started at UiTM since 2014. Before joining academic profession, she was R&D manager and Director for Malayan Adhesives & Chemicals Sdn. Bhd for 26 years. She is a chemist by profession and her research fields in adhesive and wood composite and also holds an MBA. Her Philosophy Degree in 2005 from Universiti Putra Malaysia is in the field of wood plastic composite – conventional versus radiation treatment.