Development of Speciality Paper is an Art: Overlay Paper from Indigenous Raw Material: *Acacia Tortalis* Part- XVI

Dhram Dutt, Tyagi C H, Upadhyaya J. S. and Swarnima

Indian pulp and paper industries are facing multifarious problems in which raw materials shortage is one of them. Paper technocrats are manufacturing only traditional grades of paper in which profit margin is limited due to tough competition. Paper mills have their own manufacturing standards due to variation in availability of raw materials and they keep their standards secret. Keeping this in view, a study was undertaken to explore the possibility of manufacturing of highly specialized paper i.e., overlay paper from locally available *Acacia tortalis*. The top layer of decorative laminates is made up of overlay paper and provides protection to decorative laminates against abrasion layer. The most important properties for overlay paper are water klemn, wet strength, and castor oil penetration. The special requirement for overlay paper is highly uniform porosity, a reasonably good formation, cleanliness, and light resistance. This paper does not require addition of filler because the paper should become transparent after impregnation with melamine formaldehyde and letting the appearance of the decorative laminate paper come through. However, it requires particularly high resistance to abrasion; hence an extremely hard crystallized alumna is added.

Key Words: *Acacia tortalis,* Overlay paper, Water klemn, COP, Melamine formaldehyde, Corundum, Wear resistance, Decorative laminates.

INTRODUCTION

Indian pulp and paper industries are facing multifarious problems, like tough competition from imports, obsolete technology, soaring environmental costs, depreciation of money and inadequate supply of low-cost fiber to survive in the globally competitive market. This combination has compelled the Indian pulp and paper industry to spend heavily on imported long wood fibers each year. If India cannot overcome its lack of domestic wood fiber as well as revamp and improve its end products to match imports, then the Indian pulp and paper industry will be stagnant and will decline. Keeping this in view, an indigenously available hitherto unexploited source of lignocarbohydrates biomass from A. *tortalis* was tried to develop high value added speciality paper i.e., overlay paper.

Overlay paper is highly specialized and used for making decorative laminates. This paper is a 20-25 g/m^2 sheet made up of pure cellulose. This paper after impregnation with synthetic resins molded as the top layer of decorative laminate. The treated overlay becomes substantially transparent during the molding procedure and gives added protection to the underlying layers.

Department of Paper Technology,
Indian Institute of Technology,
Saharanpur Campus, Sharanpur-247 001

A decorative laminate consists of multiple layers, each having its own function. It is impregnated by resin, mostly melamine, which is cured to form an inert, hard composite with the fiber structure of the paper. The highly visible use of the laminates, as working tables, cupboard fronts, or floor sets very high demand on the appearance of the laminate, which must be clean, have the correct light-resistant shade and surface structure, and be resistant to wear and scratching. The laminate is generally built on a body of absorbent kraft having 4-5 layers.

The unbleached kraft absorbent papers are first applied on each other to make a base of decorative laminate[1]. Prior to lamination the base sheet is saturated with a resin such as melamine formaldehyde or urea formaldehyde in an amount of 32 per cent based on the weight of the finished sheet. Then 4 to 5 layers of barrier paper, which is highly loaded with TiO_2 filler, are applied on the base of decorative laminate[2]. A penultimate layer of ivory base paper then follows it, which is highly opaque and highly loaded with TiO_2 to give high opacity[3]. Finally, overlay paper is being used as top layer in order to give wear resistance to the decorative laminate. The laminate is built so that the plies are impregnated with resin, after which they are cut into sheets and pressed together in a high-density press, with separating plates between the laminate boards. Now a very high-pressure about 3000 lb/in^2 between 150 to 250 ^{0}C is applied on decorative laminate, which is cushioned on both sides by padding paper[4]. The pressure and temperature is enough for pressing out any gases contained in the laminate, which thus becomes a solid, pore less structure.

The most significant properties for overlay paper are as follows:

- The Special requirements for overlay paper are highly uniform porosity, reasonably good formation, and cleanliness and light resistance. Therefore, it should be made up from well-delignified pulp. Porosity is the function of COP and water klemn and a specified value of porosity should be in the range of 600-800 mL/min.

- This paper does not require being loaded with any filler materials because it should be transparent after impregnation with melamine formaldehyde and letting the appearance of the fancy pattern printed on the penultimate layer of ivory base paper of the decorative laminate come through. Decorative laminates, which are used for flooring, require particularly high resistance to abrasion. Therefore, a hard

Table1 Cooking conditions and results of *Acacia tortalis*.

Sl No	Particulars	$Cook_1$	$Cook_2$	Average
1	Moisture, per cent		36.64	
2	Chips classification			
	+ 30 mm		22.00	
	—30 mm + 19 mm		33.70	
	—19 mm + 10 mm		28.30	
	—10 mm + 3 mm		14.40	
	— 3 mm		1.60	
3	Residual alkali, g/L (as Na_2O)	8.68	8.68	8.68
4	Screen rejects, per cent	0.96	0.20	0.58
5	Screened pulp yield, per cent	52.06	53.07	52.06
6	Total unbleached pulp yield, per cent	53.02	53.27	53.20
7	K number	19.20	18.30	18.80
8	Brightness, ^{0}PV (per cent)	30.80	32.30	31.60

Cooking conditions: Active alkali, per cent (as Na_2O) =15, sulphidity, per cent =20, steaming time, min =120, Time from ambient temp to 135 ^{0}C =60 and time from 135 to 162 ^{0}C = 30 min.

Table 2 Oxygen delignification of *Acacia tortalis*.

Sl No	Particulars	Results
1	Unbleached pulp brightness, ^{0}PV (per cent)	31.60
2	K number	19.20
3	Unbleached pulp viscosity, cm^3/g	845
4	NaOH, per cent on o d pulp basis	2.0
5	O_2 pressure, kgf/cm^2	6.0
6	Consistency, per cent	10
7	Retention time, min	60
8	K number	9.60
9	K number reduction, per cent	50.6
10	Viscosity, cm^3/g	778
11	Brightness, (^{0}PV) per cent	44.5
12	Pulp yield, per cent	97.2

Table 3 CEpHH bleaching of oxygen delignified pulp of *A. tortalis*.

Sl No	Particulars	Results
Chlorination stage		
1	Initial K number	9.6
2	Pulp brightness, (^{0}PV)	31.60
3	Pulp viscosity, cm^3/g	845
4	Cl_2 applied as available Cl_2 on pulp basis	2.48
E_p stage		
5	NaOH, per cent on pulp basis	2.0
6	H_2O_2, per cent on pulp basis	0.7
7	Pulp brightness, (^{0}PV)	68.1
8	Pulp viscosity, cm^3/g	485
H_1 stage		
9	$Ca(OCl)_2$ applied as available Cl_2 on pulp basis	1.0
10	Buffer, per cent NaOH of $Ca(OCl)_2$	20
11	Sulphamic acid, per cent	1.0
12	Pulp brightness, (^{0}PV)	83.5
13	Pulp viscosity, cm^3/g	442
H_2 stage		
14	$Ca(OCl)_2$ applied as available Cl_2 on pulp basis	0.5
15	Buffer, per cent NaOH of $Ca(OCl)_2$	20
16	Sulphamic acid, per cent	1.0
17	Pulp brightness, (^{0}PV)	87.6
18	Pulp viscosity, cm^3/g	430

Bleaching conditions

Parameters	C	E_p	H_1	H_2
Consistency, per cent	3.0	10	10	10
Temperature, ^{0}C	35	70	45	45
Retention time, min	30	120	60	60
pH	2.8	11.2	11.6	11.4

pigment like crystallized alumna is added to the overlay paper.

- Water klemn property is related to rise of impregnation of melamine formaldehyde in the capillaries of overlay paper during saturation step. Castor oil penetration property (COP) of overlay paper is related to tendency to retain melamine formaldehyde in it. Both the properties are opposite to each other. An optimum value for COP and water klemn can be obtained by selecting an optimum degree of refining and blending.

- The other important properties related to sun mica manufacturing process are tearing factor, bulk, and pH.

EXPERIMENTAL METHODOLOGY

Raw materials preparation and pulping The logs of A. *tortalis* were collected from U.P. Forest Corporation Department and debarked and chipped in drum chipper. The screened chips were cooked in WEVERK rotary digester of capacity 0.02 m^3 by kraft pulping process as per conditions reported in Table 1. The pulp was evaluated for K. number (T 236 cm-85), screened pulp yield, screening rejects, brightness and residual alkali as per Tappi Standard Test Methods. The results are reported in Table 1. Further, the pulp was treated with O_2 to reduce the K. number at conditions given in Table 2. The results of O_2 delignification of A. *tortalis* reported in Table 2.

Pulp Bleaching-The pulp was bleached by CE_pHH bleaching sequence and the results are reported in Table 3.

Pulp Beating, Blending, Stock Preparation and Sheet Making The bleached A. *tortalis and imported softwood pulps were beaten separately in WEVERK valley beater at consistency 1.57 per cent at beating levels of 30, 35 and 40 ^{0}SR respectively and were blended in the ratios of 90:10, 80:20 and 70:30 respectively. They are further treated with 1.5 per cent melamine formaldehyde, 2 per cent starch and* $Al_2(SO_4)_3$ 14-18 H_2O (non-ferric) to get pH 6.5. Laboratory hand sheets of 40 g/m^2 were made on British sheet former. The sheets were air-dried, conditioned and tested as per BIS specifications. The results are reported in Table 4.

Collection and Analysis of overlay Paper Samples Samples of overlay paper used by decorative laminates manufacturers were collected with specifications prescribed by them. The samples were analyzed for furnish components by microscopic examinations and surface, strength and other properties were evaluated as per Tappi Standards Test Methods. The results of laboratory made hand-sheets were compared with the specification prescribed by the decorative laminates manufacturers, imported overlay paper and Indian made overlay paper. The results are reported in Table 5.

Table 4 Effect of pulp blending on various properties required for overlay paper.

Sl N0	Particulars	30 ^{0}SR			35 ^{0}SR			40 ^{0}SR		
1	*A. tortalis* pulp: Softwood pulp	90:10	80:20	70:30	90:10	80:20	70:30	90:10	80:20	70:30
2	Basis weight, g/m^2	40	40	40	40	40	40	40	40	40
3	Thickness, µm	90	95	100	92	98	102	85	90	95
4	Bendtsen porosity, mL/min	730	780	800	650	730	780	500	650	720
5	Water klemn, mm (4min)	18	24	28	15	18	21	13	14	17
6	Oil absorbency, s	26/38	24/36	24/32	55/65	38/45	40/48	58/66	48/52	36/42
7	Wet strength, g/cm	160	196	230	117	23	242	183	215	149
8	Brightness, per cent (ISO)	84	85.2	85.9	84.3	85.6	84.8	84.2	84.6	84.4
9	Alum (non-ferric)	6.5	6.3	6.4	6.5	6.6	6.5	6.4	6.5	6.5
10	MF resin, per cent	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
11	Starch, per cent	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

RESULTS AND DISCUSSION

Table1 shows the cooking conditions and results of *A. tortalis*. *A. tortalis* produces screened pulp yield of 52.06 per cent at K number of 18.80 and at 15 per cent active alkali (as Na_2O), sulphidity 20 per cent and maximum cooking temp 162 ^{0}C for 30 min.

Table 2 shows the results of O_2 delignification of unbleached pulp of *A. tortalis*. The K number reduces by 50.6 per cent and pulp brightness improved 40.82 per cent. The pulp yield after O_2 delignification is found to be 97.2 per cent and pulp viscosity is 778 cm^3/g

Table 3 shows the CE_pHH bleaching results of *A. tortalis*. The CEPHH bleaching sequence produces a pulp of brightness 87.6 per cent (^{0}PV) and viscosity 430 cm^3/g.

Table 4 shows the blending results of *A. tortalis* pulp with softwood pulp in different proportions, i.e., *90:10, 80:20 and 70:30 and freeness levels*, i.e., *30, 35 and 40 ^{0}SR respectively. Set 1, 2 and 3 indicate that on increasing softwood pulp proportion all the properties like, thickness, porosity, water klemn, COP, wet strength of laboratory made paper increases and a pulp blend having A. tortalis pulp and softwood pulp in the ratio of 70:30 at 30 ^{0}SR gives the results comparable to specifications prescribed by* decorative laminates manufacturers. Four per cent crystallized alumna $Al_2(OH)_6$ and two per cent starch for entrapping crystallized alumna was found suitable to mitigate abrasion of decorative laminates. 1.5 per cent MF resin dose was found to develop cross-linking, which is essentially required during saturation step. Non-ferric alum was added to get pH about 6.5 with continuous stirring, which serves to entrap fines, and MF resin. It is important to note that pressing and calendaring is to be avoided to get a porosity of 600-800mL/min at pope reel.

Table 5 shows the comparative test results of imported overlay paper, mill made paper and specifications prescribed by decorative laminates manufactures. Substance of overlay paper resembles with imported and laboratory made overlay paper. However, the substance of mill made paper is 45 g/m2, but this paper may be manufactured in the basis weight range of 20-45 g/m^2 based on its end use. Decorative laminate manufacturers have not prescribed thickness, burst factor and tear factor of overlay paper, and these properties were tested keeping in view the customer's complaints. Laboratory made hand sheets resemble with mill made paper with respect to above-mentioned properties. Wet strength of imported overlay paper and laboratory-made hand-sheets are found to be on higher side than the prescribed specifications. It exhibits better cross-linking in paper, which is beneficial during saturation step. Oil absorbency of laboratory-made hand-sheet closely resembles the specification, whereas in imported overlay paper; it is slightly lower than the specified value. However the water klemn value of laboratory made paper and mill made overlay paper resembles with each other but water klemn of imported overlay paper is approximately 17 per cent higher than the prescribed specification. Porosity of laboratory made paper and imported overlay paper resemble with specifications, while porosity of overlay paper of mill made is slightly higher than the specified value.

CONCLUSIONS

1. A. tortalis produces screened pulp yield of 52.06 per cent at K number of 18.80 and at 15 per cent active alkali (as Na_2O), sulphidity 20 per cent and maximum cooking temp 162 ^{0}C for 30 min. Further, O_2 delignification reduces K number by 50.6 per cent and pulp brightness improves by 40.82 per cent. The CEPHH bleaching sequence produces a pulp of brightness 87.6 per cent (^{0}PV) and viscosity 430 cm^3/g. Pulps furnish having *A. tortalis* and imported softwood pulp in the ratio of 70:30 at beating level of 30 ^{0}SR is found suitable for manufacturing of overlay paper.

2. One per cent MF resin for cross linking, four per cent crystallized alumna $Al_2(OH)_6$ as abrasion resistance and two per cent starch to entrap $Al_2(OH)_6$ were found suitable for the development of overlay paper. To entrap short fibers and M F resin, non-ferric alum was added to maintain a pH ranging between 6.5-7.0.

3. All other properties of laboratory - made hand sheet like, substance, wet strength, water klemn and oil absorbency were in close

Table 5 Comparative test results of imported overlay paper, mill made paper, specifications prescribed by decorative laminates manufacturers and laboratory made hand-sheets

Sl No	Particulars	Specifications prescribed by sun-mica manufactures	Imported overlay paper	Mill made paper	Laboratory made overlay paper
1	Substance, g/m^2	40±2.5	40	45	40
2	Thickness, µm			90	100
4	Burst factor		10	11	38
5	Tear factor				
	MD		80	66	
	CD		75	68	
	Avg.		77.5	67	58
6	Wet strength, g/cm				
	MD		415	225	
	CD		325	195	
	Avg.	150	370	210	230
7	Water klemn, mm (4min)				
	MD			28	
	CD			26	28
	Avg.	25-29	34	27	
8	Oil absorbency, s				
	TS				
	WS		18	26	24
	Avg.	20-35	22	34	33
			20	30	28.5
9	Bendsten porosity, mL/min	600-800	780	920	800
10	Brightness, per cent (ISO)		86	83	85.9
11	Morphological analysis		85 per cent bamboo + 15 per cent softwood	30 per cent softwood + 30 per cent imported hardwood + 40 per cent other pulp	30 per cent softwood pulp + 70 per cent *A. tortalis* pulp

agreement with the prescribed specifications

4. Besides specified value all other properties of laboratory-made hand-sheet are related to mill made paper. However the process conditions may be changed as per requirements to get the desired results during paper manufacturing.

REFERENCES

1. Dutt Dharm, Upadhyay J S, Ray A K, Tyagi C H and Malik R S, Development of speciality paper is an art: Absorbent kraft paper from indigenous raw materials and NDLKCC-Part II, JSIR, **62** 3 (2003) pp173-178.

2. Dutt Dharm, Upadhyay J S, Malik R S, and Tyagi C H Studies on cost reduction of barrier paper without affecting quality, Cellulose Chemistry and Technology, **37** 1-2 (2003) pp159-170.

3. Dutt Dharm, Upadhyay J S, Tyagi C H and Jindal A K, Studies on cost reduction of ivory base paper without affecting quality, JSIR, **61** 4 (2002) pp 294-301.

4. Dutt Dharm, Tyagi C H, Malik R S, Upadhyay J S, and Kumar Dinesh, Development of specialty paper is an art: Padding paper from indigenous raw materials Part VIII, JSIR, **62** 10 (2003) pp 996-1000.