Indian Journal of Scientific & Industrial Research
Vol. 63, May 2004, pp. 425-428

Development of specialty papers is an art: Dark brown Turkish umber (DBTU) from indigenous raw materials—Part XI

Dharm Dutt*, A K Ray, C H Tyagi and Vikram Singh

Department of Paper Technology, Indian Institute of Technology Roorkee, Saharanpur Campus, Saharanpur 247 001

Received 03 October 2003, accepted 12 January 2004

Dark brown Turkish umber (DBTU) paper is a highly specialized paper exclusively used for the manufacturing of expensive decorative laminates. Besides other properties, castor oil penetration, water klemn, wet strength, porosity fire retardancy, see-through, colour, and appearance properties are the most important properties for DBTU paper. Fire retardancy and and DBTU shade is achieved by adding yellow, red, and black oxides of iron in to the pulp furnish. The present paper aims at developing DBTU paper from locally available hard woods like, *Eucalyptus tereticornis* and *Populus deltoides* and grass like *Bambusa aurandacea* from Assam origin.

Keywords: DBTU paper, Hardwoods, Oxides of iron, Sun-mica
IPC Code: Int.Cl.[7] : D 21 H 27/00

Introduction

DBTU is a specialized absorbent kraft paper, exclusively used for the development of expensive decorative laminates for furniture, decoration panels, floor, and sun-mica where properties like fire retardancy and DBTU shade are the prime requirement. A laminate consists of multiple layers, each having its own distinct function. The expensive decorative laminate is normally built on a body of DBTU paper, which may be followed by light underlay paper and then a decorative paper. The decorative paper is the most critical of the lamination papers. It is visible a paper giving the appearance to the laminate. The top layer of decorative laminate is made up of ivory base paper which is then followed by 2-4 plies of barrier paper. The top layer is of overlay tissue, which becomes transparent after impregnation with melamine formaldehyde and letting the appearance of the decorative paper come through[1]. These layers are then platinized under pressure and temperature ranging from 250-300 °C. Each layer is impregnated with melamine formaldehyde, which is cured to form an inert hard composite with the fibre structure of the paper.

DBTU paper is basically a hydrophilic, porous medium with high degree of water absorption. It is made from clean low kappa hard wood pulp and has to have good uniformity. The most important characteristics features for DBTU paper and reasons thereof with basic definition are as follows:

- Maximal unbound fibre surface area
- Maximal bulk, which can be developed with minimum level of refining
- Maximal porosity and pore volume
- Softness is very much subjective property for which there is no generally accepted method of measurement. How soft a product depends upon its thickness (bulk) and its flexibility (low kappa no pulp with minimum refining)
- Wet strength is frequently used in order to retain wet strength after impregnation. In order to enhance resin cross-linking, retention of iron pigment poly aluminum chloride are added in to the stock
- In order to mitigate see-through, and to develop DBTU shade and fire retardant character, oxides of iron are added in to the chest. Yellow oxide of iron FeO_6 which can tolerate short air exposure[2] is directly added in to the chest. The white hydroxide $Fe(OH)_2$ is precipitated from Fe++ solutions by base; it can be obtained in crystalline form with Mg $(OH)_2$ structure. The hydroxide is rapidly oxidized in air turning red brown and eventually $Fe_2O_3\ nH_2O$ (red oxide of iron II).

*Author for correspondence
Dharm_dutt@rediffmail.com

The black oxide of iron occurs as the mineral magnetite. It can be made by oxidation of iron Fe^{++} with alkaline KNO_3 in the presence of phosphate or by reaction of acidified jarosites, M $Fe_3(SO)_4(OH)_6$ and Fe_2SO_4 in ammonia[3]. After controlled treatment this pigment can be used as a black pigment (iron III) oxide. The reaction is as under:

$$2(H_2O)Fe_3(SO_4)_2(OH)_6 + 3Fe_2(SO4)_3 + 14NH_4OH \rightarrow 3Fe_3O_4 + 7(NH_4)_2SO_4 + 16H_2O$$

- Mechanical strength is less important, only it should be sufficient not to break during running of paper machine and saturation steps. Wire mark and stiffness are also less important.
- Water klemn is related to water rise in capillary and can be improved by selecting long fibred furnish. COP is related to retention of melamine formaldehyde during saturation steps and can be improved by refining. The properties, i.e., water klemn and COP opposite to each other, therefore, optimum refining level must be selected.

Experimental Methodology

Pulp Characteristics

Semi-bleached kraft pulp of permanganate number 10+ was collected from peroxide reinforced extraction (EP) stage. The approximate composition of *E. tereticornis*, *P. deltoids* and *B. aurandacea* in the pulp is in the ratio of 60:30:10

Pulp Beating and Stock Preparation

The semi bleached pulp was beaten in WEVERK made laboratory valley beater to 30 0SR. The pulp was treated with poly aluminum chloride in order to maintain pH 6.5. 10 kg/t of Eph resin was added in the stock with continuous stirring. Further, 10.0, 6.0, and 10.0 per cent yellow, red and black oxides of iron respectively, were mixed. The quantities of non-fibrous additives with reasons are reported in Table 1.

Sheet Making

Laboratory hand-sheets of 90± 2.5 per cent were prepared on British sheet forming machine. These hand sheets were air dried, conditioned and tested as per Tappi testing methods for basis weight, thickness, COP, water klemn, wet strength, ash, and air permeability. The results of laboratory made hand-sheets were compared with specifications prescribed by converters for mills and DBTU paper of mill made (Table 2).

Results and Discussion

Table 1 shows the non-fibrous additives required for the development of DBTU paper. Mill pulp comprising of *E. tereticornis*, *P. deltoids,* and *B. aurandacea* is blended with 20 per cent soft wood pulp in order to achieve water klemn, which is related to penetration of melamine formaldehyde through capillaries during saturation step. The pulp is refined to 30 °SR in order to develop COP so that the sheet can retain melamine formaldehyde in the voids during impregnation stage. DBTU differs from the normal absorbent kraft in terms of heavy loading of iron. A quantity of 10 kg/t of yellow oxide, 6kg/t of red oxide, and 10 kg/t of black oxide of iron are added to develop fire retardant characters, DBTU shade and to mitigate see through in decorative laminate. As indicated, besides other properties like, water klemn, COP, air permeability, and wet strength which are required for normal absorbent kraft paper fire retardancy, colour, and appearance are the most important properties for DBTU paper. In order to entrap oxides of iron and the fines, polyaluminum chloride is added to maintain at pH 6.5. Excessive amount of polyaluminum chloride may cause agglomeration of iron particles and may disturb formation and appearance and may also lead to see through in the decorative laminate. In order to develop cross-linking 1 per cent epichlorohydrin resin is added so that it may retain wet strength after impregnation.

Table 2 shows the results of laboratory made hand-sheets which are compared with specifications supplied by converters and mill made DBTU paper. It is observed that basis weight of DBTU paper from mill a deviates by 1.5 per cent than that of the given specifications. COP of laboratory made DBTU paper resembles with specifications and also those from DBTU paper of mill B. COP of DBTU paper of mill a is 21/19 s, which is very high against the specified value. However, it can be controlled by blending the mill pulp with long fibred pulp and reducing refining. Wet strength of mill B is 133 g/cm compared to specifications. It is necessary either to increase curing temperature during sheet making or increase the dose of epichlorohydrin resin. Water klemn of DBTU paper of mill A is 16/17 compared to given specification which is 20/25 mm /4min. It can be controlled by enhancing fibrillation and less fibre

Table 1—Non-fibrous additives for the development of DBTU paper

Sl No.	Non-fibrous additives	Quantity	Purpose of addition
1	Polyaluminum chloride	To maintain pH 6.5	• To entrap iron oxide particles and fines
2	Epichlorohydrin resin	10 kg/t	• To develop strong cross linking in paper
3	Yellow oxide of iron	10 kg/t	• To develop fire retardancy
4	Red oxide of iron	60 kg/t	• To mitigate see through
5	Black oxide of iron	10 kg/t	• To match DBTU shade
6	Furnish composition, Hardwood: Softwood	80:20	• To develop required water klemn sand COP

Table 2—Results of laboratory made DBTU hands-sheets

Sl No.	Particulars	Specifications prescribed by converters	Laboratory made hand sheets	Mill made DBTU Mill A	Mill B
1	Basis weight, g/m^2	90±2.5 per cent	92	94	90
2	Thickness,µm	—	139	137	155
3	COP, s at 35±1 ^{0}C				
	WS	12	10	21	8
	TS	7	9	19	7
	Avg	10	9.5	20	7.5
4	Water klemn, mm/4min				
	MD	25	—	17	22
	CD	20	—	16	10
	Avg	22.5	21.5	16.5	21
5	Porosity (Gurley), s/100 cc	—	162	156	133
6	Bulk, cm^3/g	—	1.42	1.46	1.72
7	Ash, per cent	14	14.2	15	18
8	Burst factor	—	24		
9	Wet strength, g/cm				
	MD	—	—	166	—
	CD	—	—	147	—
	Avg	150	162	156	133
10	Tear factor				
	MD	—	56	52	73
	CD	—	58	54	81
	Avg	—	57	53	77

cutting or by blending of long fibred pulp. Ash content of laboratory made DBTU paper resembles with specifications of DBTU paper of mill A DBTU paper of mill B contains 17 per cent less ash content. All other properties of laboratory made DBTU paper resembles to those of mill made DBTU paper.

Conclusions

(i) A mixture of 80 per cent hard wood pulp contains *E. tereticornis*, *P. deltoids* and *B. aurandacea* in the ratio of 60:30:10, and 20 per cent soft wood pulp is found suitable for the development of DBTU paper.

(ii) A freeness level of 30 °SR is sufficient to give optimum water klemn and COP.

(iii) An amount of polyaluminum chloride at pH 6.5 is enough to entrap fines and iron oxide particles.

(iv) A quantity of 10 kg/t of yellow oxide, 6kg/t of red oxide, and 10 kg/t of black oxide of iron are found suitable to develop fire retardant characters, DBTU shade and to mitigate see through in decorative laminate.

(v) One per cent epichlorohydrin resin is sufficient to develop cross-linking and retain wet strength after impregnation.

(vi) Basis weight of laboratory made hand-sheets and DBTU paper from mill B resembles with the specifications, whereas DBTU paper of mill A deviates by 1.5 per cent. COP and water klemn of DBTU paper of mill A deviates from specifications. Wet strength and ash content of DBTU paper of mill B are less than the specified. Laboratory made DBTU paper meets all the specifications quite well.

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