High Yield Pulping of Mixture of Maharashtra Hardwoods

by Neutral Sulphite Semi-chemical process and sulphate semi-chemical Process

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Importance of high yield pulping is growing with the increase in demands of packaging material. Studies were undertaken on the pulping or Maharashtra hardwoods growing in Achalpur area by neutral sulphite semi-chemical process and sulphate semi-chemical process as the mixture of hardwoods in sustained yields could be available at cheap price and the two processes could yield higher amounts of pulp of requisite quality. Effect of variables like temperature and amount of chemicals on the pentosan content, lignin content and the quality of the pulp were studied. On bleaching by multi-stage bleaching it was found that the strength properties improved considerably.

INTRODUCTION

The Third World Forestery Conference held at Hilsinki in 1949 made the following recommendation :-

(i) To conserve softwoods, hardwoods and specially tropical hardwoods are to be used in larger quantities.

(ii) The development of semi-chemical processes are to be extended thus conserving pulp wood through the higher yields obtained.

These two proposals are closely related since the hardwods are particularly suitable for semi-chemical pulping. In the tropical forests a large number of species of hardwoods may occur in one and the same forest and may not yield a particular species for an economic unit. Our forests are of mostly tropical hardwoods and so it is highly desirable that extensive work should be done in this direction.

Semi-chemical pulping is a two stage process involving chemical treatment of wood chips to obtain a softening and partial removal of ligno-cellulosic bonding material followed by mechanical treatment to complete the fibre seperation. This process though old has progressed considerably since 1944.

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The primary objective in the development of semi-chemical process was not only to utilize hardwoods to obtain higher yield of usable pulp than could be obtained by the conventional pulping processes but also to counter act the steadily increasing raw material cost. This process is attractive economically because of the high yield attainable, low chemical consumption, and because the process lends itself to small units and a minimum of plant investment. In this case because the action of cooking liquor and bleaching agents is directed selectively on the lignin, bleached hardwood pulps could be obtained in higher yields also. It also produces a stronger pulp than can be obtained by fully chemical cooking when the hardwood species are used. Unbleached semichemical pulps at present are used for making corrugating board , speciality boards, newsprint and wrapping papers and may have possibilities of being used as liner and towelling. The bleached semi-chemical pulps at present are being used for making book, magazine (coated and uncoated), bond, writing, glassine, greaseproof paper, foodboard speciality and may have possibilities of being used as waxing, carbonizing and towelling tissues etc.

In our country the consumption of wrapping and newsprint has increased from 20,000 tons to 100,000 tons and from 50,000 tons to 185,000 tons respectively from 1950 to 1968. The production of other varieties of the product which can be produced from these varieties of pulps are on the lower side. With the increase in the living standard and for conserving wood the production of these varieties by high yield pulping is bound to increase in the near future. At the present moment there is not a single mill in the country which is producing these types of pulps in appreciable quantities and of required quality. With these ends in view investigations were undertaken to find the suitability of Maharashtra mixed hardwoods for the production of semi-chemical pulp by both the neutral sulphite semi-chemical and sulphate semi-chemical processes. The following species of woods occuring in Achalpur area of Maharashtra State were used:-

Sl. No.	Botanical name	Local name
1.	**Anogissus** sp.	Dhawal
2.	**Adina cardifolia**	Haldu
3.	**Careys** sp.	Kubhi
4.	**Madhuca sp.**	Moha
5.	**Terminalia** sp.	Saj
6.	**Emblica officinates**	Aula
7.	**Garuga pinata**	Kakad
8.	**Lannea carmandehelis**	Mohani
9.	**Butea sp.**	Palas
10.	**Terminalia**	Bheda
11.	**Boswellia serrata**	Salai
12.	**Schleichera ollosa**	Kusum

Table-1 Proximate chemical analysis of mixture of Maharashtra hardwoods growing in Achalpur area

	% on Oven-dry basis
1. Ash	1.61
2. Cold water solubility	4.18
3. Hot water solubility	6.16
4. 1% caustic soda solubility	16.65
5. Alcohol benzene solubility	5.11
6. Ether solubility	1.23
7. Pentosans	10.1
8. Lignin	30.1
9. Cellulose (Cross and Beven)	55.8

Effect of variables like temperature and amount of chemicals on the pentosan constant, lignin and the quality of the pulp were studied keeping the time of cooking and the bath ratio constant. One set of pulps obtained under identical conditions by both the processes were bleached by multi-stage bleaching process.

RAW MATERIAL

The twelve species named earlier occuring in Achalpur area of Maharashtra State were identified, debarked, chipped and screened. They were mixed in equal proportion and used in these sets of experiments.

PROXIMATE CHEMICAL ANALYSIS

The mixture of the twelve species was converted into dust in a laboratory disintegrator. Dust passing through 60 mesh and retained on 80 mesh was used for carrying out the proximate chemical analysis of the mixture of hardwoods according to TAPPI Standards. The results of analysis are recorded in **Table-I.**

These results show that the mixture has a high cellulose content and lignin content and low pentosans content. These results are comparable with hardwoods analysis.

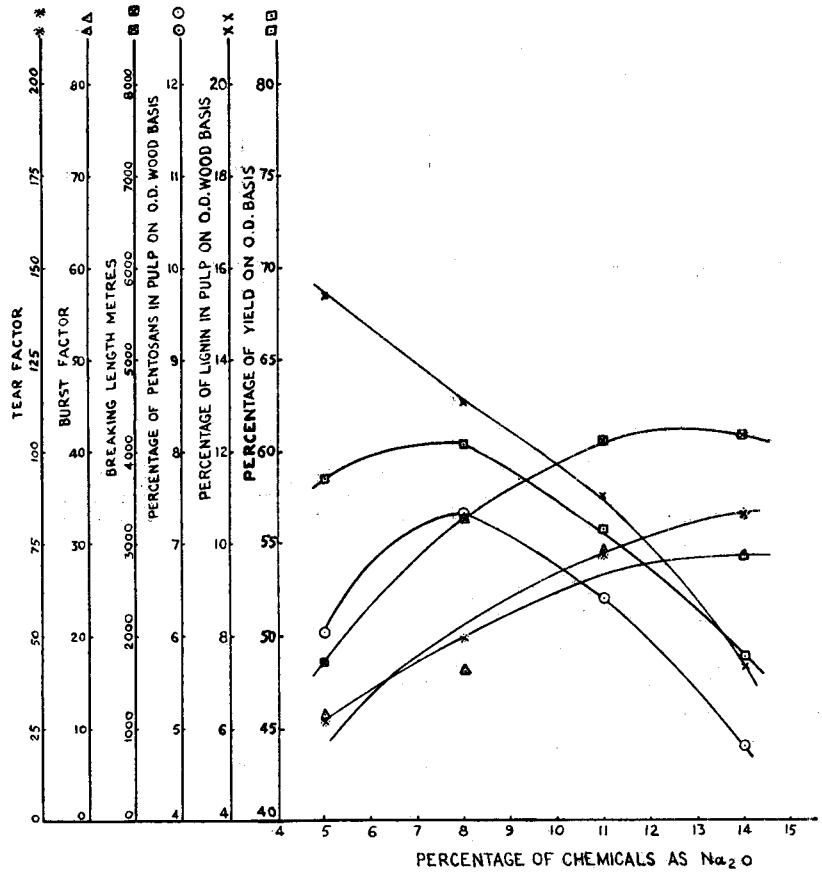

Fig. 1A. Effect of chemical variation on yield, chemical and physical properties of N.S.S.C. Pulp at 170°C for 3½ hours.

TABLE II — Neutral sulphite semi-chemical pulps from a mixture of Maharashtra hardwoods.

Sl No.	Total chemicals as Na_2O	Time to maximum temperature	Time at maximum temperature	Maximum temperature	Refiner clearance	Yield	Pantosan content	Lignin content	Pantosan content on O.D. wood basis	Lignin content on O.D. wood basis	Bulk	Breaking length	Burst factor	Tear factor	Remarks
	%	hrs.	hrs.	°C	mm.	%	%	%	%	%	—	meters	—	—	—
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	3	3½	¼	185	0.762 0.127 0.000 0.000	61.00	6.98	30.87	4.26	18.83	2.76	990	3.7	16.3	
2.	5	3¼	¼	185	-do-	60.75	8.79	26.48	5.34	16.09	3.26	1180	4.8	20.6	
3.	5	3	½	170	-do-	58.60	10.31	26.28	6.04	15.40	2.55	1710	11.3	27.4	
4.	5	3	½	162	-do-	65.90	11.56	24.69	7.62	16.27	2.88	1700	7.8	23.8	
5.	5	3	½	153	0.762 0.127 0.000 0.000 0.000 0.000	67.80	13.45	26.79	9.12	18.16	2.92	960	4.3	18.7	
6.	8	3	½	180	0.762 0.127 0.000 0.000	58.10	12.87	21.70	7.48	12.61	2.39	3260	25.8	76	
7.	8	3	½	170	-do-	60.40	12.14	21.68	7.33	12.09	2.16	3300	16.2	49.4	
8.	8	3	½	162	-do-	60.74	13.03	23.28	7.91	14.14	2.54	2560	16.4	38.8	
9.	8	3	½	153	-do-	63.90	12.51	23.11	7.99	14.77	2.46	2080	13.9	38	
10.	11	3	½	170	-do-	55.08	11.15	19.80	6.41	11.05	2.32	4130	29.2	72	
11.	11	3	½	153	-do-	61.6	12.23	21.81	7.53	13.43	2.50	2380	17.2	34.3	
12.	14	3	½	170	-do-	48.8	9.84	15.05	4.81	7.34	2.21	4190	33.6	82.7	
13.	5	2	½	153	0.762 0.127 0.000 0.000 0.000 0.000	70.6	13.05	25.51	9.21	18.01	2.79	920	5.6	54	

PRODUCTION OF PULPS

The semi-chemical pulping can be carried out both by the batch as well as continuous processes. In the batch process the pulp is produced by using either spherical rotary digester of about 430 cm. to 490 cm. diameter or a stationary digester. At the end of the cook the digester is blown usually under full pressure to a hot chip bin from which the chips are fed to the refiner. There are many continuous processes adoptable to semi-chemical pulping like Kamyr, Pandia, Defibrator, Sprout Waldron, Baurite pulping process, Condii system etc. Continuous pulping processes not only offer the usual benefit of uninterupted operation but has a further advantage in furnishing the softened chips to the refiner at elevated temperature. Other advantages are the economy of space required, the uniform boiler load maintained and the fact that the pulp rather than the chips is blown to the blow tank, thus facilitating handling and washing It is more rapid than the batch process. Commercially the equipments used for the production of semi-chemical pulps by both the neutral sulphite semi-chemical process and the sulphate semi-chemical process are the same except for the material of construction. Laboratory experiments were caried out by the batch process using a stationary autoclave of 3 litre capacity and 12" Sprout Waldron refiner described in an earlier publication !

Neutral sulphite semi-chemical process experimental and discussion :

Pulping trials were carried out by the neutral sulphite semi-chemical process in an autoclave of 3 litre capacity using a mixture of sodium sulphite and sodium carbonate (keeping the ratio of sodium sulphite and sodium carbonate 4:1) The material to liquor ratio was kept as 1.4, and total time of digestion was kept

TABLE — III Permangnate number, bleaching conditions of Neutral sulphite semi-chemical pulp of Serial No. 10 of Table-II and strength properties of bleached pulp.

1.	Permangnate number	— 37
2.	**Bleaching conditions**	
	1st stage	
1.	Amount of chemicals*	— 11%
2.	Consistency	— 3%
3.	Time	— 1 hr.
4.	Temperature	— 30 °C
	2nd stage	
1.	Amount of chemicals**	— 2%
2.	Consistency	— 5%
3.	Time	— 1 hr.
4.	Temperature	— 60 °C
	3rd stage	
1.	Amount of chemicals*	— 11%
2.	Consistency	— 3%
3.	Time	— 1 hr.
4.	Temperature	— 30 °C
	4th stage	
1.	Amount of chemicals**	— 2%
2.	Consistency	— 5%
3.	Time	— 1 hr.
4.	Temperature	— 60 °C
	5th stage	
1.	Amount of chemicals***	— 5%
2.	Consistency	— 5%
3.	Time	— 3 hrs.
4.	Temperature	— 30 °C

* Chlorine water % expressed as available chlorine on oven-day basis of pulp.

** Caustic soda % expressed on oven-dry pulp.

*** Calcium hypochlorite % expressed as available chlorine on oven-dry pulp.

3.	Yield	— 49.0%
4.	Bulk	— 1.59
5.	Breaking length	— 8560 m.
6.	Burst factor	— 64.8
7.	Tear factor	— 129
8.	Brightness, MgO = 100	— 61
9.	Pentosan contnet	— 12.35%

as 3½ hours. The quantity of the chemicals was varied from 3 to 14% as Na_2O. The temperature of digestion was varied from 153 °C to 185 °C. only in case of 5 per cent chemicals as Na_2O at 152 °C, pulp was also produced by reducing the total time of digestion to 2½ hours from 3½ hrs. After digestion the pH of the spent liquor was noted to vary between 7 and 8. The softened chips were washed and refined in the 12" Laboratory Sprout Waldron refiner. The unbleached pulp yield was determined after washing the refined pulp free of the chemicals. Pentosan content and lignin conten t of the pulps was also determined according to TAPPI Standards. Standard sheets of approximately 60 g.s.m. were made after beating in the Lampen mill to a freeness of 250 ml. C.S.F. Strength properties of these standard sheets were determined after conditioning them at 65% R.H. 27 °C. The digestion conditions refiner clearance, unbleached pulp yield pentosan content, lignin content and strength properties are recorded in **Table II.** Permanganate number of the pulps described in serial No. 10 of Table-II was determined. This pulp was bleached by multi-stage bleaching under der the conditions recorded in **Table-III.** Bleached yield of the pulp was determined. The bleached pulp was beaten in the Lampen mill to a freeness of about 250 ml. C.S.F. Standard sheets of approximately 60 g.s.m. were made and tested for their strength properties after conditioning them at 65% R.H. and 27 °C. Brightness of the pulps was determined using Photovolt meter 610. Pentosan content of the pulp was also determined. These results are also recorded in **Table-III.**

In **Fig. 1(a)** the effect of the chemical variation on yield, chemical and physical properties of the neutral sulphite semi-chemical pulps is shown when the materi-

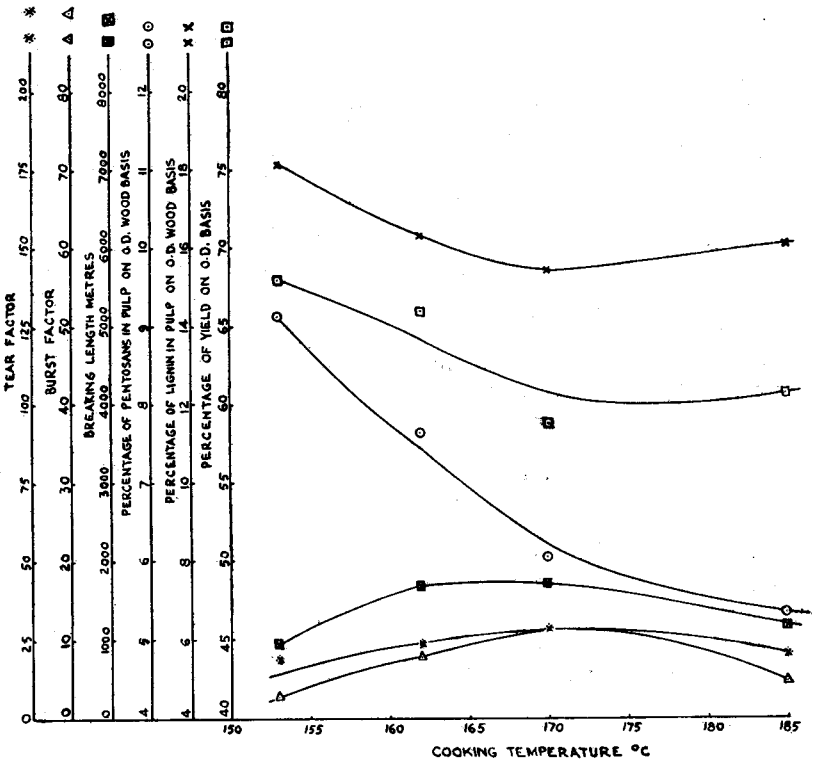

Fig. 2A. Effect of temperature variation on yield, chemical and physical properties of N.S.S.C. Pulps cooked with 5% chemicals as Na_2O for 3½ hours.

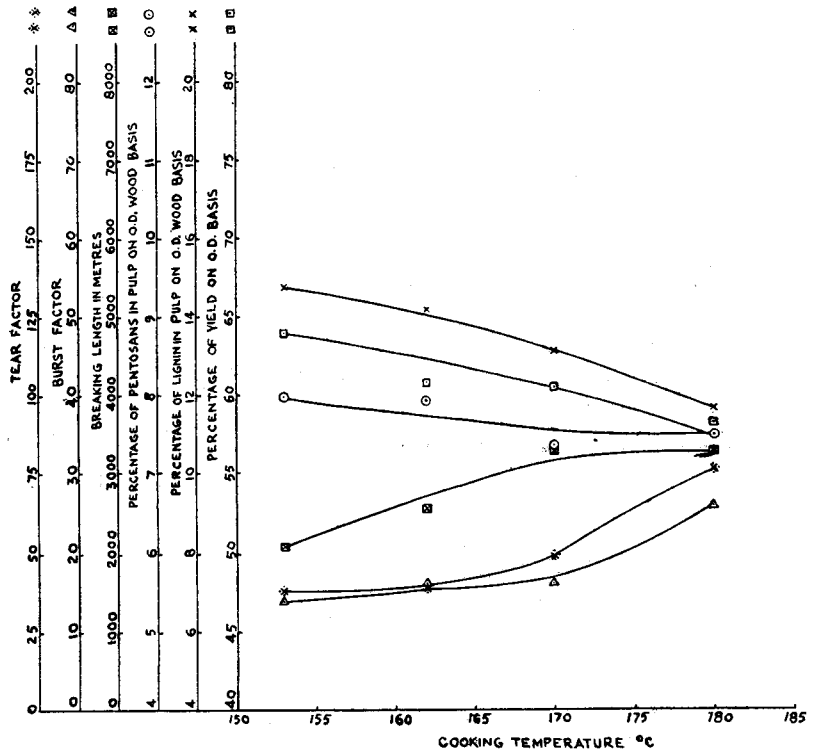

Fig. 3A. Effect of temperature variation on yield, chemical and physical properties of N.S.S.C. pulps cooked with 8% chemicals as Na_2O for 3½ hours.

TABLE IV—Sulphate Pulps from a mixture of Maharashtra Hardwoods

Sl .No.	Total chemicals as NO_2O	Time to maximum temperature	Time at maximum temperature	Maximum temperature	Refiner clearance	Yield	Pantosan content	Lignin content	Pantosan content on O.D. wood basis	Lignin content on O.D. wood basis	Bulk	Breaking length	Burst factor	Tear factor	Remarks
	%	hrs.	hrs.	°C	mm	%	%	%	%	%	—	meters	—	—	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1.	3	3¼	¼	185	.127 .000	62.0	1.81	35.10	1.12	21.76	2.22	1230	5.1	38.8	
2.	3	3¼	¼	185	.381 .000	58.1	8.6	29.45	5.00	17.11	2.54	2580	14.0	40	
3.	5	3	½	170	.000	69.2	10.22	28.73	7.07	19.88	2.47	2510	11.1	60.1	
4.	5	3	½	162	.381 .000	65.5	11.58	28.41	7.59	18.64	2.64	2150	9.3	81.2	
5.	5	3	½	153	.381 .000 .000	64.2	10.97	27.77	7.05	17.83	2.54	2040	8.1	46.4	
6.	8	3	½	180	.000	56.1	10.26	30.14	5.75	16.92	2.29	3840	24.8	60.8	
7.	8	3	½	170	.000	56.7	20.42	27.18	5.90	15.40	1.59	4700	25.6	71.0	
8.	8	3	½	162	.000	60.7	11.90	25.46	7.22	15.48	2.49	2980	12.9	43.3	
9.	8	3	½	153	.000	61.7	11.49	24.11	7.33	15.35	2.52	2580	13.0	46.0	
10.	11	3	½	170	.000	51.4	10.95	17.85	5.62	8.16	2.01	5100	29.7	131.9	
11.	11	3	½	153	.127 .000	56.2	10.89	21.08	6.12	11.85	2.08	4550	20.9	54.7	
12.	14	3	½	170	.000	46.5	12.33	10.63	5.75	4.95	1.89	6800	44.0	170	
13.	5	2	½	153	.381 .000	67.8	9.04	29.80	6.13	20.19	2.58	2030	7.4	54.7	

al was cooked at 170 °C for 3½ hrs., keeping the bath ratio as 1:4 and varying the chemicals from 5 to 14%. It is seen that the yield increases when the amount of chemicals is increased from 5 to 8% but falls with the further increase in chemicals. The pentosan content shows the same trend as that of the yield while the lignin content falls steadily with the increase in the amount of the chemicals. The strength properties improve with the increase in the proportion of the chemicals.

In Fig. II (a) the effect of temperature variation on yield, chemical and physical properties of the neutral sulphite semi-chemical pulps is shown when the material was cooked with 5% chemicals for 3½ hours keeping the bath ratio as 1:4. and varying the temperature from 153 °C to 185 °C It is seen that the yield, lignin and the pantosan content falls as the temperature rises from 153 to 170 °C but from 170 °C to 185 °C there is no significant change except in the case of pentosan content of the pulp. The strength properties increase steadily upto 170 °C and then fall gradually.

In **Fig. III (a)** the effect of temperature variation on yield, chemical and physical properties of the neutral sulphite semi-chemical pulps is also shown when the material was cooked with 8% chemical for 3½ hrs. keeping the bath ratio as 1:4 and varying the temperature from 153 to 180 °C. It is seen that there is a fall in yield, pentosan content and lignin content with the increase in temperature. Breaking length improves with the increase in temperature upto 170 °C after which it tends to be constant while the burst factor and the tear factor increase slightly upto 170° and then there is an increase at 190 °C.

It is also seen on comparing the results recorded in **Table-II** serial No. 10 and of **Table-III** that the strength properties of the pulps improve considerably on

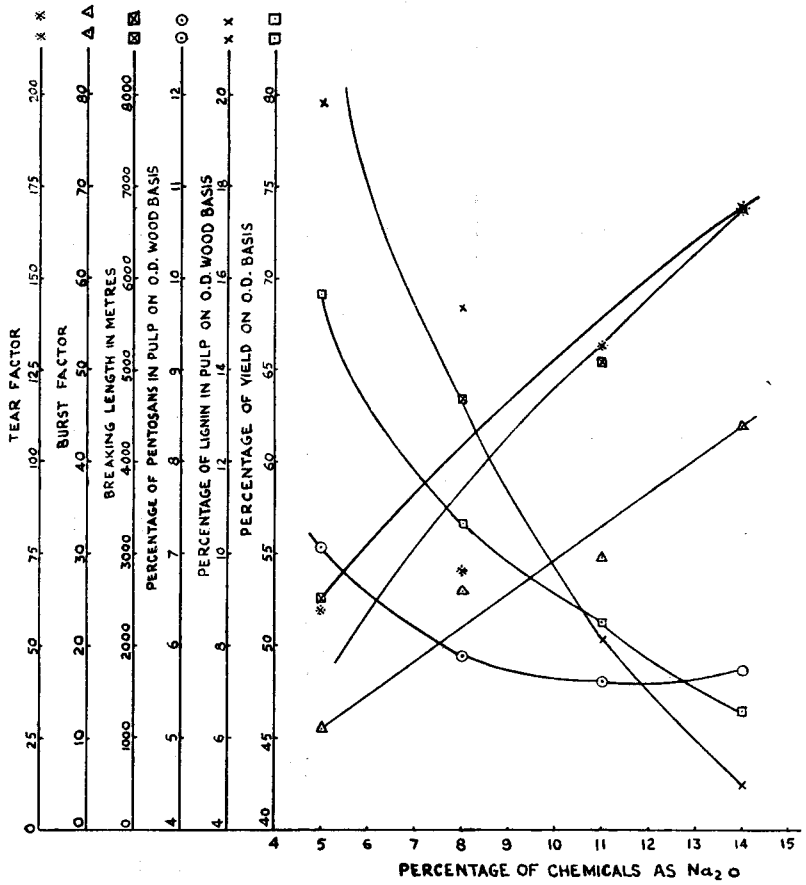

Fig. 1B. Effect of chemical variation on yield, chemical and physical properties of Sulphate semi-chemical pulps at 170° C for 3½ hours.

TABLE — V Permangnate number, bleaching conditions of Sulphate semi-chemical pulp of Serial No. 10 of Table-IV and strength properties of bleached pulp.

1.	Permangnate number	..	..	..	— 36
2.	**Bleaching conditions**				
1st stage					
1.	Amount of chemicals*	..	..	..	— 12%
2.	Consistency	..	..	..	— 3%
3.	Time	..	..	..	— 1 hr.
4.	Temperature	..	..	..	— 30 °C
2nd stage					
1.	Amount of chemicals**	..	..	..	— 2%
2.	Consistency	..	..	..	— 5%
3.	Time				— 1 hr.
4.	Temperature	..	..	..	— 60 °C
3rd stage					
1.	Amount of chemicals*	..	..	..	— 10%
2.	Consistency	..	..	..	— 3%
3.	Time	..	..	..	— 1 hr.
4.	Temperature	..	..	..	— 30 °C
4th stage					
1.	Amount of chemicals**	..	..	..	— 2%

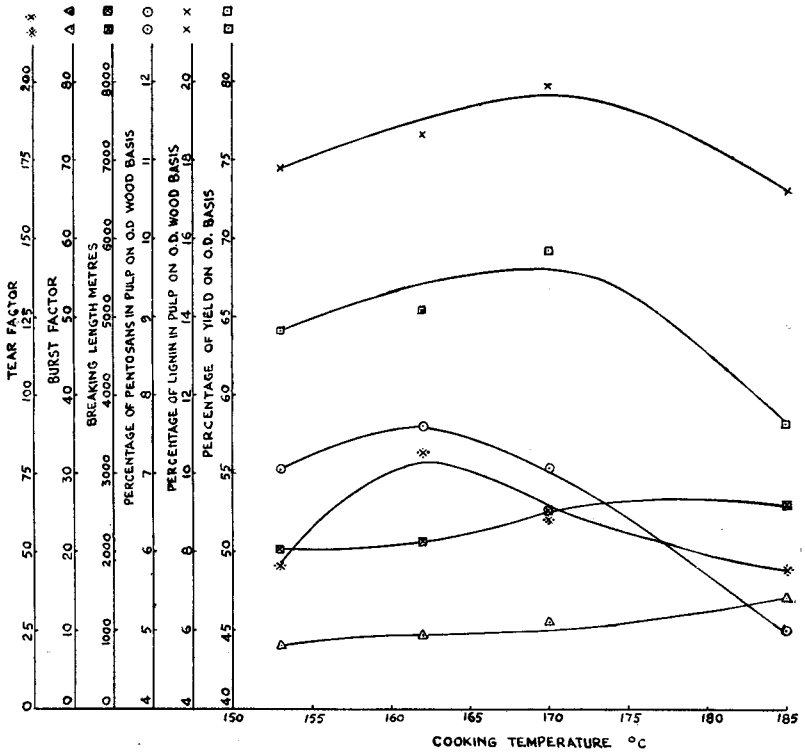

Fig. 2B. Effect of temperature variation on yield, chemical and physical properties of Sulphate Semichemical Pulps cooked with 5% chemicals as Na₂O for 3½ hours.

TABLE V.—Contd.

2.	Consistency	..	..	..	— 5%
3.	Time	..	..	..	— 1 hr.
4.	Temperature	..	..	..	— 60 °C
5th stage					
1.	Amount of chemicals***	..	..	..	— 5%
2.	Consistency	..	..	..	— 5%
3.	Time	..	..	..	— 3 hrs.
4.	Temperature	..	..	..	— 30 °C

* Chlorine water % expressed as available chlorine on oven-dry basis pulp.

** Caustic soda % expressed on oven-dry pulp.

*** Calcium hypochlorite % expressed as available chlorine on oven-dry pulp.

3.	Yield	..	..	..	— 46.0%
4.	Bulk	..	..	..	— 1.65
5.	Breaking length	..	..	..	— 7000 m.
6.	Burst factor	..	..	..	— 58.3
7.	Tear factor	..	..	..	— 119.0
8.	Brightness MgO=100	..	..	..	— 57.0
9.	Pentosan content,	..	..	..	— 11.88%

bleaching.

Sulphate semi-chemical process

Pulping trials were carried out by the sulphate semi-chemical process ($NaOH:Na_2S$ :: 3:1) under exactly the same conditions as in the neutral sulphite semi-chemical process using the same equipment and processed in the same fashion. The digestion conditions, refiner clearance, unbleached pulp yield, pentosan content, lignin content and strength properties are recorded in **Table-IV.**

Permanganate Number of the pulp described in Serial No. 10 of **Table-IV** was determined. This pulp was bleached by multi-stage bleaching under the conditions recorded in **Table-V.** Bleached yield of the pulp was determined. The bleached pulp was beaten in Lampen Mill to a freeness of 250 ml. C.S.F. Standard sheets were prepared and tested for their strength properties after conditioning them at 65% R.H. and 27 °C. Brightness of the pulp was determined using Photovolt meter 610. Pentosan content of the pulp was also determined. These results are also recorded in **Table-V.**

In Fig. I (b) the effect of chemical variation on yield, chemical and physical properties of the sulphate semi-chemical pulp is shown when the material was cooked at 170 °C for 3½ hours keeping the bath ratio as 1 : 4, and varying the chemicals from 5 to 14%. It is seen that there is a gradual fall in yield, pantosan content and lignin content of the pulp with the increase in the amount of the chemicals but the strength properties improve with the amount of the chemicals. On comparing Fig. **I (a)** and **I (b)** it is seen that the amount of increase in the strength properties is more in the case of sulphate semi-chemical pulps than in the case of neutral sulphite semi-chemical pulps.

In **fig. II (b)** the effect of temperature variation on yield, che-

mical and physical properties of sulphate semi-chemical pulp is shown when material was cooked with 5% chemicals for 3½ hrs., keeping the bath ratio 1 : 4 and varying the temperature from 153 °C to 185 °C. It is seen that the yield and lignin content increase with the increase in temperature to 170 °C and then fall while the pentosan content increases only upto 162 °C and then fall. There is a slight increase in strength properties, like breaking length and burst factor with the increase in temperature but the tear factor increases with the rise in temperature to 162 °C after which it falls.

In **fig. III (b)** the effect of temperature variation on yield, chemical and physical properties of the sulphate semi-chemical pulps is also shown when the material was cooked with 8% chemicals for 3½ hours keeping the bath ratio as 1 : 4 and varying the temperature from 153 °C to 180 °C. It is seen that the yield decreases and lignin content increases with the increase in temperature. The breaking length increases with the increase in temperature while the burst factor increases with the rise in temperature to 170 °C and then becomes constant.

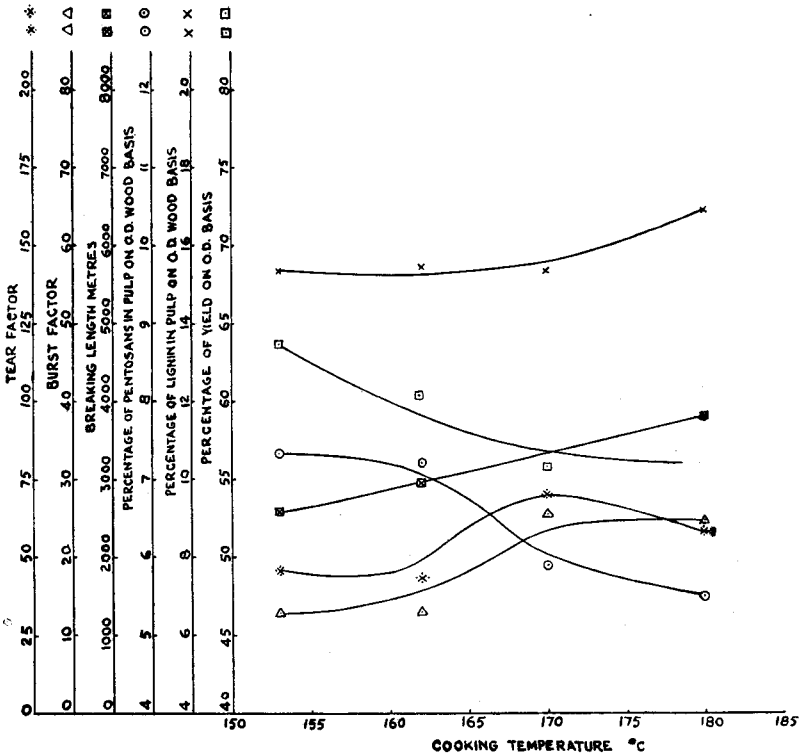

Fig. 3B. Effect of temperature variation on yield, chemical and physical properties of Sulphate Semi-chemical pulp, cooked with 8% chemicals as Na_2O 3½ hours.

CONCLUSIONS

(1) Unbleached pulps can be prepared from the mixture of hardwoods from Achalapur area of Maharashtra by neutral sulphite semi-chemical process in yields of 48 to 70%. The pulps have good strength properties for production of brown wrapping papers.

(2) When neutral sulphite semi-chemical pulps are bleached the pulp have a yield of 49.0% and possess satisfactory strength properties and brightness for the production of writing and printing papers.

(3) Unbleached pulps can also be prepared from the mixture of hardwoods by sulphate semi-chemical process in yields of 46-67%. The pulps have good strength properties for the production of of brown wrapping papers.

(4) When the sulphate semi-chemical pulps are bleached the pulps have a yield of 46% and possess satisfactory strength properties and brightness for the production of writing and printing papers. The bulk, strength properties and brightness of sulphate semi-chemicals bleached pulps are lower than that of the neutral sulphite semi-chemical pulps.

(5) When the same amount of chemicals as Na_2O are used, the yield by the sulphate semi-chemical pulp process is lower than that of the neutral sulphite semi-chemical process but the strength properties are better.

(6) The pulps obtained by neutral sulphite semi-chemical process are bulkier than the pulps obtained by the sulphate process.

(7) The comparative economics of neutral sulphite semichemical, sulphate semi-chemical and conventional sulphate processes for the production of wrapping and writing and printing papers can be worked out before planning a mill in these raw materials. This can also be done after knowing the detailed costing and the location of the mill site.

(8) These unbleached pulps from the neutral sulphite semi-chemical and sulphate semichemical processes could also perhaps be used for making fluting medium. However, as we do not have the testing equipment for evaluating the properties of these varieties of paper, could not confirm their suitability for this purpose.

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