

# The Effect of AGE And Height on The Fibre Length And Pulping Characteristics of Eucalyptus

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## ABSTRACT

A study was made to investigate the utilisation of Eucalyptus Hybrid (*Eucalyptus tereticornis*) wood upon felling and to know if there were any major variation in the properties of fibre along the height. Sulphate digestion experiments were conducted with stem samples of Eucalyptus Hybrid at different levels from the butt end of the tree. Both unbleached and bleached pulps were evaluated for strength properties and fibre length. The yield of the pulp of the wood stem samples towards the butt end is lower than at heights above 1 meter from the ground level, while they are on the increase upto a height of thirteen meters. The Permanganate number drops from 28 to 18 from 1 meter height to 10 meters and this is reflected in the total chlorine and alkali consumption in the bleaching process. Fibre length attains its maximum at one meter height while it drops gradually to lowest value at 13 Meter height.

## INTRODUCTION :

Eucalyptus, being the fast growing broad leaf species, is naturally receiving world wide attention as a pulpable raw material for the manufacture of paper. Forest Research Institute, Dehradun has evaluated various broad leaved Eucalyptus species alongwith other species for their suitability as pulp wood. Among the several species of Eucalyptus genus, *Eucalyptus citriodora*, *Eucalyptus globulus*, *Eucalyptus grandis* and *Eucalyptus hybrid* have been found most suitable for the manufacture of pulp.

*Eucalyptus hybrid* (Mysore gum), mostly *Eucalyptus tereticornis* is one of the fast growing broad leaf species widely planted throughout India mainly as pulp wood. It is known to grow 20' in one year in coastal area and attain 40 ft. in 7 years. The wood is clear felled normally on a 10 years rotation and coppiced vigorously thrice during the following 30 years.

Large scale plantations of *Eucalyptus tereticornis* have been taken up and an area of nearly 1,00,000 hectares or more has already been planted under the

name "Mysore hybrid", covering many states like Mysore (Nandi Hills) Nilgiri Hills in Tamilnadu, Tarai region (U P), Kodanad (Kerala) and Gujarat. It is expected to yield not less than 10—12 tons per ha. at a planting density of 1500/ha. It is fairly sensitive to frost but has grown on well drain soil receiving an annual rainfall of over 800 mm.

Extensive studies were carried out by Forest Research Institute Dehradun with specific reference to (1—3) :

1. The growth and utility of Eucalyptus varieties.
2. Pulping qualities of Eucalyptus hybrid received from different localities.
3. Evaluation studies of Paper making qualities, of *Eucalyptus grandis* and *Eucalyptus tereticornis* with special reference to the effect of age, chemical composition, density and wood structure on bleaching and physical properties.

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It is a common knowledge that the physical and chemical properties of any wood, change with age and also within a tree of a given age the properties vary greatly, longitudinally from bottom to top, as transversely from periphery to the core of the wood. This phenomenon has been well established earlier for coniferous woods(4). Determination of this variation in properties of wood is of fundamental importance from the pulping of view and in turn may also facilitate arriving at appropriate rotation and production of raw material of a grade best suited for pulping.

Studies undertaken at Forest Research Institute, Dehradun have indicated that Eucalyptus hybrid wood is best suited for pulping when it is 4 — 5 years old. This suggests following a cutting cycle shorter than the normal rotation of 10 years, although ways and means of achieving equivalent yield within this short rotation needs further investigation from economic point of view. The most outstanding feature of the juvenile wood of Eucalyptus hybrid is the complete absence or nearly so, of the heart wood. The better pulpability of 4 — 5 years old stems of this specie is obviously brought about by its total sapwood content which reacts readily to pulping process(5).

On the basis of an exhaustive study(6) (unpublished) undertaken by Shri A.V.R.G Krishnamurthy, I.F.S., the then District Forest Officer, Kakinada (A. P.), Andhra Pradesh Paper Mills undertook a detailed investigation on the fibre length variations at different heights of the 10 years old Eucalyptus hybrid stem supplied

A parallel study was also undertaken by us to investigate the utilisation of the wood upon felling the same and also to know if there were major variation in the properties of the fibre along the height. Different sulphate digestion experiments were conducted and the pulps were evaluated for strength and the fibre length were measured.

The yield of the pulp from this wood towards the butt end is considerably lower than at heights above a meter from the ground level as also the strength properties. The fibre length of the pulp varies very marginally. More work is planned to study such variations in stems and branches of different age groups.

## EXPERIMENTAL :

Logs of 10 years old plantation from the Divancheruvu East of reserve forests were received with bark on them. The One Meter billets from a number of trees corresponding to specific portions of the stem with respect to height from the ground level were grouped together to enable the different experiments to follow. The moisture in the logs were measured after debarking using a moisture meter and recorded in Table-I. They were chipped in the plant chippers before the experiments.

A typical chip classification data is recorded in Table-II. The screened chips were used for the experiments. The moisture in the chips changed during the period of study from 20% at breast height level of the tree to 11% at 13 meters height.

## DIGESTION :

The digestions were done in a tumbling digester provided with electrical heaters and an automatic temperature controller. For each digestion experiment, 3 Kilogram of chips on O.D. basis were taken up in the digester and pulped with 16% active alkali as  $\text{Na}_2\text{O}$ . The conditions for the cooks are recorded in Table-III.

After the digestion the pulps were carefully washed over a 150 mesh stainless steel screen and the yield computed in each case. At this stage a portion of the pulp was taken-up for bleaching experiments, while the remaining unbleached pulp was evaluated for strength properties per Tappi Standards T-200 ts-66, T-205 nr-58, and T-220-m-60 and the strength properties are recorded in Table-IV.

## BLEACHING :

The conditions followed for bleaching the pulp from each cook are listed in Table-V. The sequence followed for bleaching was CEHH followed by a sulphurous acid wash. The bleach requirements at various stages were computed and added as per Tappi Standard No. T-214 ts-50. The brightness as well as the viscosity of the pulps after bleaching were carefully measured in Elrepho reflectance photometer and Prolabo Viscosimeter respectively. The strength properties of the bleached pulp were also evaluated as stated above and recorded in Table-VI.

Table I  
MOISTURE IN EUCALYPTUS LOGS

Sample Identity No.	Wet weight without bark—Kgs. (A)	Weight of Bark Kgs.	Dry Weight without bark—Kgs. (B)	Moisture (%)
447/1	27.00	8.0	19.5	27.75
447/4	12.75	3.75	8.75	31.37
447/7	7.9	1.7	4.5	29.04
390/1	15.25	4.25	11.25	26.23
390/4	8.0	2.1	5.15	34.3
390/7	4.3	0.9	2.5	41.86
379/1	8.5	3.5	6.0	29.41
379/4	3.3	1.2	1.5	54.55
446/1	8.6	2.65	6.5	24.42
446/4	4.25	1.25	2.75	35.3
446/7	2.1	0.65	1.0	52.38
387/1	14.4	4.85	11.0	23.61
387/4	7.7	2.55	5.0	35.06
387/7	4.4	0.85	2.0	54.54
524/1	23.5	4.25	16.0	31.92
524/4	9.5	2.0	6.25	34.22
524/7	6.6	1.3	4.0	39.41
526/1	8.25	3.75	6.0	27.27
526/4	3.9	1.1	1.75	44.86
445/1	12.0	4.25	9.25	23.00
445/4	5.25	1.35	3.0	42.85
445/7	2.6	0.9	1.5	44.23
523/1	21.0	4.0	16.5	21.43
523/4	9.25	2.00	6.25	32.43
523/7	2.7	1.0	1.25	53.70
518/1	16.0	5.5	12.0	25.0
518/4	7.0	1.5	4.5	50.0
518/7	4.4	0.7	2.75	62.48
386/1	18.75	5.5	14.0	25.23
386/4	10.5	2.25	7.00	33.34
386/7	5.5	1.1	3.0	45.44

Legend of Sample Identity :

No. 447/1

447/1 — Tree identifying number.

1 — Height of the tree from the ground level.

Table No. II  
CHIPS CLASSIFICATION

Dust	:	0.5 %
0 — 5 mm	:	8.4 %
5 — 10 mm	:	12.6 %
10 — 15 mm	:	15.5 %
15 — 25 mm	:	38.5 %
25 — 35 mm	:	9.5 %
35 — 50 mm	:	14.0 %
Above 50 mm	:	1.0 %

Table No. III  
CONDITIONS FOR DIGESTION  
SULPHATE COOK

T.A.A. as Na <sub>2</sub> O	% :	16.0
Bath Ratio	:	1.3
Maximum Temperature	°C :	160
Heating time	Mts. :	120
Cooking time	Mts. :	120

Table No. IV  
PROPERTIES OF UNBLEACHED PULP

Sl. No.	Particulars	Unit	Height of the tree from the ground level							
			1 Metre	4 Metres	7 Metres	10 Metres	13 Metres			
1.	Knots yield	%	3.93	3.4	1.0	0.93	0.43	0.53	0.83	0.8
2.	Pulp Yield	%	39.2	39.92	47.8	48.0	48.7	48.3	49.03	44.4
3.	Total Yield	%	43.13	43.32	48.8	48.93	49.1	48.33	49.86	45.2
4.	K. No.		28	27.8	25.8	25.9	24.8	24.6	18.5	18.0
5.	Pulp Brightness	%	14	14	21	22	24	24	25	25
6.	Initial Freeness	°SR	15	15	15	16	15	15	16	15
7.	Final Freeness	°SR	43	41	40	40	40	40	40	41
8.	Power consumption of refining	KWH/tonnes	1351	1275	943	841	700	660	638	484
9.	Burst Index	kpa m <sup>2</sup> /g	4.41		7.72		4.85	4.70	4.41	
10.	Tensile Index	N.m/g	49.98		65.66		75.46	77.71	71.54	
11.	Tear Index	m.N.m <sup>2</sup> /g	8.23		7.35		6.57	6.02	5.59	
12.	Folds	Nos.	96		180		160	118	60	
13.	Strength Index		1951		2006		1935	1823	1654	

Table No. V  
CONDITIONS FOR BLEACHING CEHH SEQUENCE

Bleaching in CEHH Sequence with Final So<sub>2</sub> Wash

<b>1. Chlorination Stage :</b>		
(a) Pulp consistency	:	% 3.0
(b) Temperature	:	°C 32.0
(c) Time	:	Hrs. 1.0
<b>2. Alkali Extraction Stage :</b>		
(a) Pulp consistency	:	% 8.0
(b) Temperature	:	°C 50
(c) Time	:	Hrs. 2.0
<b>3. Hypochlorite Stage 1 &amp; 2 :</b>		
(a) Pulp consistency	:	% 8.0
(b) Temperature	:	°C 32.0
(c) Time	:	Hrs. 2+2
(d) pH	:	8.5
<b>4. So<sub>2</sub> Wash :</b>		
(a) Pulp consistency	:	% 5.0
(b) Temperature	:	°C 30.0
(c) Time	:	Mts. 15
(d) pH	:	6.5—7.0

Table No. VI  
**PROPERTIES OF BLEACHED PULP**

Sl No.	Particulars	Unit	Height of the tree from the ground level						
			1 Meter	4 Metres	7 Metres	10 Metres			
1.	K. No. of unbleached pulp		28.0	27.8	25.8	25.9	24.8	24.6	18.5
2.	Total chlorine consumed :	%	15.9	15.9	13.9	13.3	12.7	12.7	9.12
3.	Total Caustic Soda consumed :	%	4.4	4.4	3.9	3.9	3.3	3.2	2.8
4.	Brightness :								
	Before So <sub>2</sub> wash :		77	75	74	75	76	75.5	76.0
	After So <sub>2</sub> wash :		79	77	76	77	78	77.5	78.5
5.	Viscosity :	Cps.							
	Before So <sub>2</sub> wash :		7.6	8.0	7.9	7.3	8.2	8.1	7.7
	After So <sub>2</sub> wash :		7.4	7.8	7.7	7.0	7.9	7.9	7.5
6.	Yield on chips	%	38.64	39.07	44.31	44.3	44.68	44.24	45.57
7.	Pulp initial freeness	°SR	17	16	17	16	16	16	16
8.	Final Freeness	„	40	40	40	40	40	40	40
9.	Power consumption	KWH/tonne	612	620	918	841	930	860	739
10.	Burst Index	kpa. m <sup>2</sup> /g	3.24		3.82		4.31		4.61
11.	Tensile Index	N m./g.	42.34		64.68		69.09		73.01
12.	Tear Index	m.N.m <sup>2</sup> /g	5.88		5.29		4.90		5.39
13.	Folding Endurance	Nos.	18		103		90		79
14.	Strength Index (T. FxB. FxLOG FOLD) <sup>1/3</sup>		1358		1613.9		1621.5		1694.3

#### FIBRE LENGTH :

The fibre length measurements were made for each bleached pulp. Nearly two hundred readings were recorded for each measurement in the binocular microscope, and the weight average fibre lengths were computed as per the formula :—

$$lw = \frac{\sum ni \cdot li^2}{\sum ni}$$

Where lw : weight average fibre length.  
ni : number of fibres measured.  
li : the individual fibre length.

The fibre length of each pulp studied above is recorded in Table-VII alongwith the maximum length of fibre in each case.

#### RESULTS AND DISCUSSIONS :

The pulp yields are low at a meter height from ground level, while they are on the increase upto a height at thirteen meters. The lower portions are heavily lignified, and the heart wood content is rather high when compared to heights above four meters. The Brightness of the unbleached pulp produced varies from 14% to 25% from 1 meter to 13 meters height. The rejects in the form of knots were quite considerable in the pulp wood at breast height. Figure-I illustrates the trend of pulp yield and permanganate number of the pulp produced from the wood at different heights. The permanganate number drops from 28 to 18 while the yield increases from 43% to 50% from one meter height to ten meters ; however the yield drops to 45% above this height.

Table No. VII  
FIBRE LENGTH WITH RESPECT TO HEIGHT

Height of the tree from the ground level	1 Metre		4 Metres		7 Metres		10 Metres		13 Metres	
Fibre Length—mm										
Maximum	1.48	1.35	1.30	1.25	1.14	1.22	1.44			1.33
Fibre length—mm										
Minimum	0.46	0.40	0.43	0.48	0.40	0.46	0.42			0.44
Average Fibre length—mm	0.86	0.83	0.77	0.81	0.77	0.78	0.81			0.76
Average—mm	0.845		0.79		0.775		0.81		0.76	

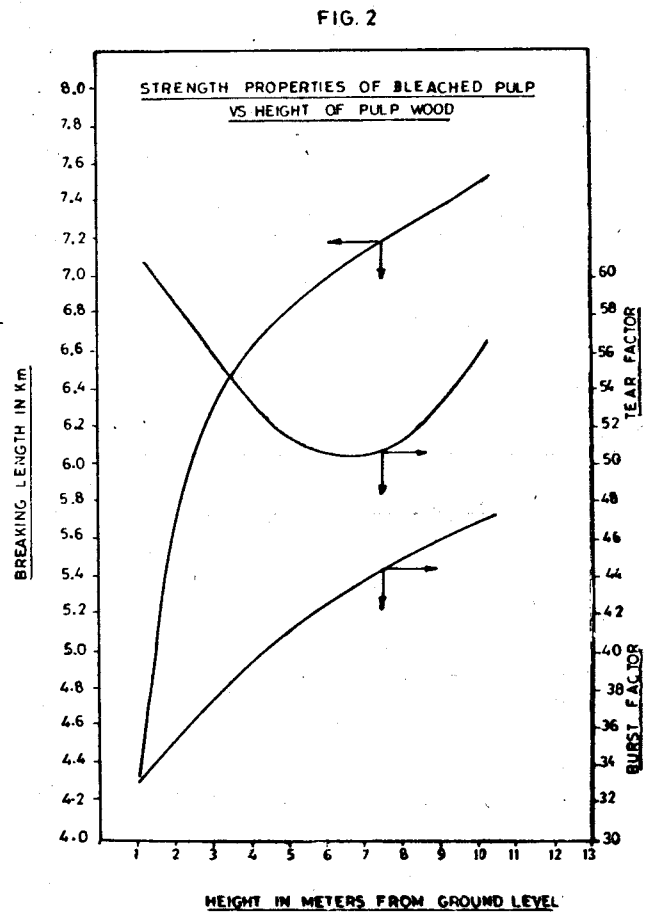
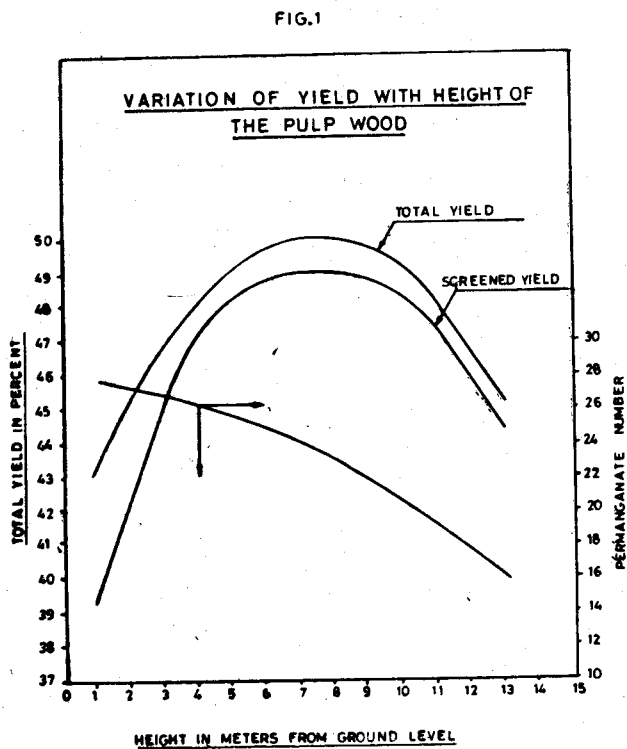


Fig. 4 illustrates the trend of total chlorine consumption and alkali consumption in bleaching of pulps with respect to height of stem above the ground level.

The results of bleaching experiment reveal that the pulp woods at one meter height have heavy lignification with the consequent 15% higher chlorine demand for bleaching to the same degree of brightness when compared to pulps produced from the wood

above breast height. The bleaching losses are about 10%.

The Strength properties of both unbleached and bleached pulps are comparable with published data. The burst factor and breaking length pass through a maximum of 49 and 7.9 Km corresponding to a height of 10 and 7 meters respectively, while the tear factor drops from 84 to 57 along the height of the

FIG. 3

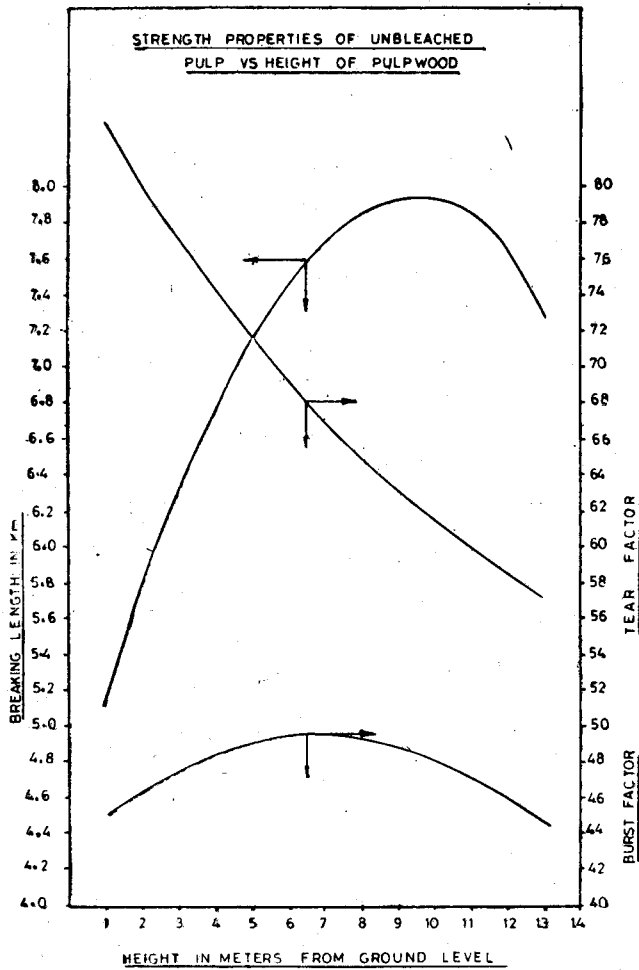


FIG. 4

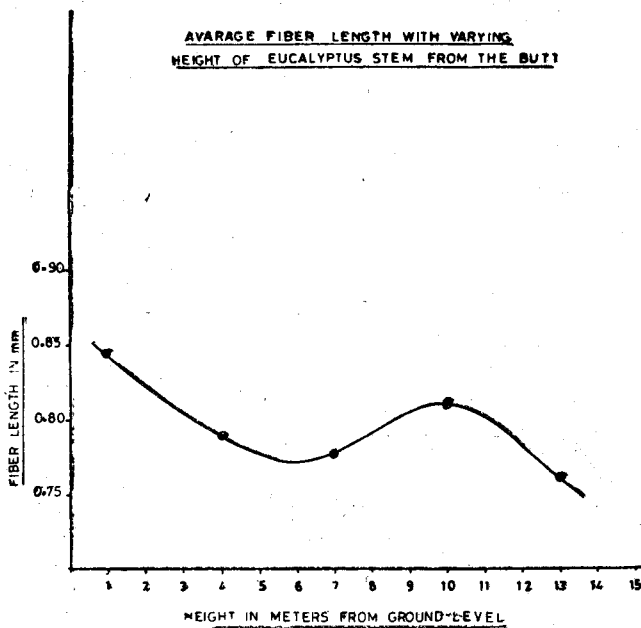
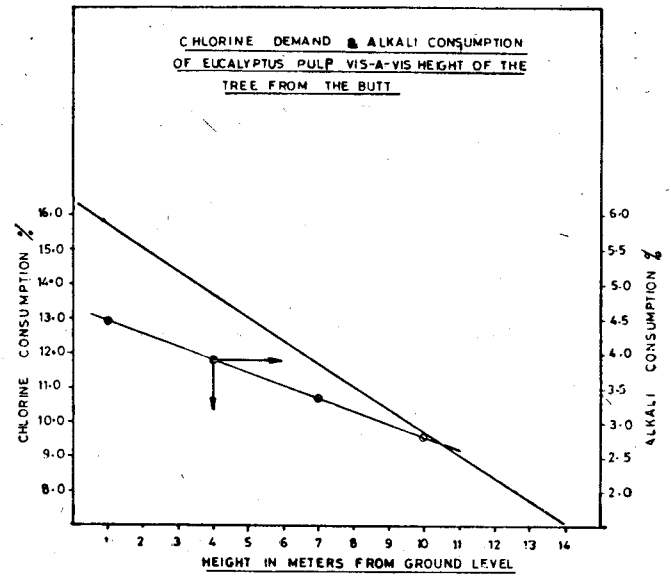


FIG. 5



tree. However, the trend of breaking length, tear factor and burst factor is not the same in the case of bleached pulp. The tear factor passes through a minimum of 50 at a height 7 meters from ground level, while the breaking length and burst factor gradually increase along the different positions in the tree, their range being 4.3 — 7.5 and 33 — 47 respectively.

There is noticeable difference in the fibre length along the length of the tree. The maximum being 0.85 mm at one meter height while it drops to 0.79 mm, 0.78 mm and 0.76 at four, seven and thirteen meters height respectively. For a 3 and 6 years old plantation of eucalyptus hybrid, Guba et. al., report on average fibre length of 0.64 and 0.70mm respectively(7). (Indian Forester Vol. 96, 4 April 1970).

Further work is planned on similar course with different age groups of eucalyptus hybrid to determine the optimum age group and maximum utility to the best properties of this variety as this happens to be one of the best raw material amongst the hardwoods for the paper Industry in India.

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