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PRACTICAL EXPERIENCES IN THE USE OF RUBBERWOOD FOR THE PRODUCTION OF PULP AND PAPER 1/

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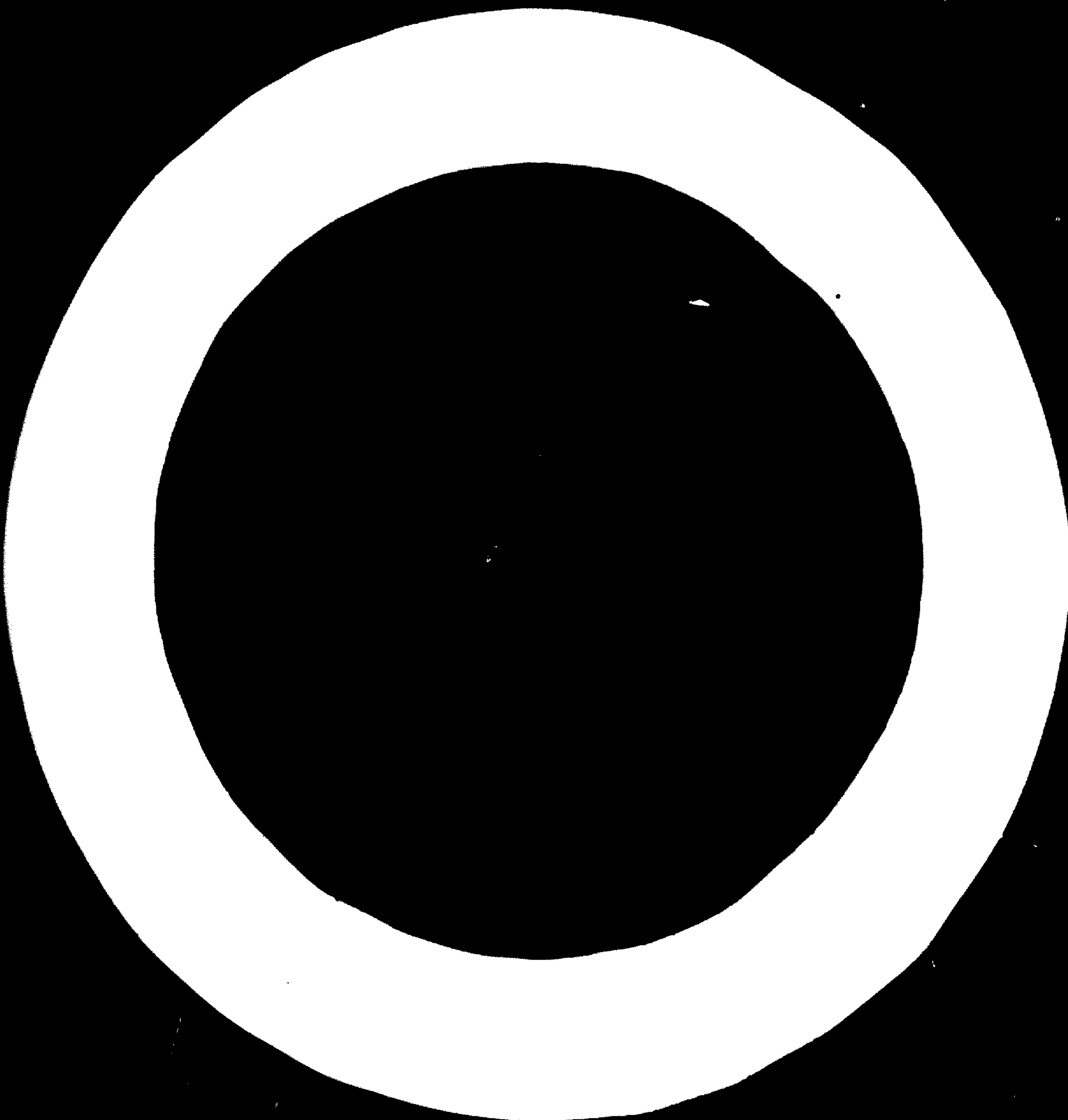

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INTRODUCTION

Not infrequently a kind of euphemistic "logic" is heard which says for example :-

There are 4,000,000 hectares of rubberwood growing in Asia and the Far East. On the average there are 150 cubic metres of rubberwood per hectare. This totals 600,000,000 cubic metres of rubberwood available. Assume a use of four cubic metres of solid wood as a very conservative weighted estimate of hardwood usage per a metric ton for all kinds of papers ranging from newsprint through to finest quality woodfree papers and include rayon pulp, then there is enough for 150,000,000 metric tons of paper. Spread over a 30 year rotation, this means ample for an annual supply of 5,000,000 metric tons annually in perpetuity. Why isn't this being used ? The answer lies in many factors, some of which this paper points out.

There are initial errors in planted areas and in the age groups of plantations. One hundred and fifty cubic metres of rubberwood per hectare is the total wood on a given area including trunk and branches down to a seven centimetre diameter size. Only a portion of this volume is commercially collectable at present. Furthermore, the volume refers to older bigger sized rubber trees only. These errors are compounded and then rounded by averaging. They bear as much resemblance to fact as another humourous apocryphal statement on averaging, namely "The Himalayas are only 3,000 metres high on the average."

We will attempt to clarify the scope of this work by limiting the parameters. To commence, we will define rubberwood.

RUBBERWOOD - DEFINITION

There are some ten widely divergent species of trees and vines which give a latex-like fluid material upon wounding.

Ficus religiosa, the "Boh" tree under which the Lord Buddha sat, is one such. However, since 99% of the world's natural rubber comes from but one species, namely Hevea brasiliensis, that one species is defined as rubberwood henceforth in this paper.

HISTORY OF RUBBERWOOD

Less than 100 years ago there was not one rubberwood tree in the whole of Asia and the Far East. Now there are over 1,000,000,000 of them and they form a major part of the exports of some of the countries in S.E.Asia.

In 1736 trees in Ecuador were known locally as Hheve. In 1762 Fresnan gave a paper on a tree described as Hevea guianensis. In 1865 J.Müller described in some detail a tree Hevea frasiliensis. About this time the then government of India was anxious to find a further cash crop which it wished to plant near Tenasserim in Burma.

Henry A.Wickham was sent to the Amazon valley to collect seeds from Hevea brasiliensis trees. In their natural habitat these grew just above the flood plain level near the left hand mouth of the Amazon. There they grew to a tree, 30 metres in height and some two metres in diameter when measured at breast height. Some 70,000 seeds were collected by Wickham and conveyed to Kew Gardens in the United Kingdom where some germinated. Some of these seedlings, packed in suitable containers, were despatched to India, Ceylon and Singapore respectively. Owing to the budget having been cut that year, the Indian venture did not proceed, but those delivered to Colombo and Singapore were planted in their respective famed Botanical Gardens. The twenty two plants which arrived in Singapore on 11th June, 1877 later attracted the attention of the new curator, Mr.Ridley, who in 1888 developed both a suitable refined tapping tool and a technique for latex collection much less severe on the tree than the previous hatchet and bruising methods. In 1955, on his 100th birthday, Ridley was honoured by the industry he had played such a major part in establishing, for it was the progeny from those twenty-two trees that as "unselected seedlings" established today's rubber growing industry. In 1839 Goodyear discovered a process of vulcanization which he brought to England in 1842. Hence, there was the fortunate coming together of a need to develop a new crop, a successful seed collection of a virile strain, good horticultural techniques at Kew, and above all, two very competent Botanical Garden Curators in Asia and the Far East at that time both possessing perspicacity, wisdom and perseverance, aided by longevity in one case. A successful vulcanization method opened a much wider market for waterproof clothing and footwear in the late 19th century, while in the 20th century the advent of the automobile provided the major use in tyres for transportation. However, these markets were aided by the rubberwood species itself. It was a remarkably disease resistant strain, and fortuitously, the samples did not bring the leaf disease from its native South American habitat. Hevea brasiliensis prefers temperatures of 15^{o} to 40^{o}c plus a rainfall of 2000 - 4000 mm annually, preferably evenly spread. This occurs in those parts of South East Asia subjected both to the South West and the North East monsoons. It will tolerate the long dry period peculiar to the one monsoon area if the annual rainfall is over 3,000 mm. Rubberwood tolerates a wide range of soil types and additionally it will grow up to approximately the 800 metre altitude contour. Hence the tropic zone is its preferred habitat. As 90% of the world's natural rubber comes from Burma, Cambodia, Ceylon, Indonesia, Liberia, Malaysia, Thailand and Viet Nam and as all the areas except Liberia fit generally within the area generally described as Asia and South East Asia, only that zone will be considered further.

CURRENT AVAILABILITY

(i) Result of Replanting to High Yield Latex Plantations

To recapitulate, the original trees in the Amazon forest grow as a jungle tree to a height of 30 metres with a straight stem of diameter, at breast height, of two metres or more.

However, the unselected seedlings from these trees when cultivated in plantations were allowed to vary only between a three to four metre high bowl crowned by a heavy branching leaf canopy, but one not sufficiently extensive to be likely to be blown over. Such trees would be about seven metres in overall height. The tree itself could often be one to one and a half metres in diameter at age 50 years after being subject to much wounding and healing of scar tissue around the tapping zone. On old rubberwood plantations like this it is possible to get a yield 150 cubic metres of rubberwood per hectare from 500 trees spaced at 6m x 3.5m apart when cutting everything down to a branch size of seven to eight centimetres. However, in one operation currently collecting rubberwood in West Malaysia, it has been estimated that 33% of the available rubberwood was not within economic hauling distance within the 16km working circle being covered. This was due to distance of the wood from an adequate road, the type of terrain and seasonal conditions, to mention but three factors. Again rubberwood can have very twisted branches so that it can be difficult to stack a reasonable pay load on a road truck.

Replanting of rubber plantations has been, and is being, done from clonal grafted stock which yields much more latex from much smaller trees. Thus at 500 trees per hectare and those trees only 0.5 to 0.7 metres in diameter, the rubberwood yield can be expected to be considerably less at the end of the second rotation in approximately 26 years time as the following example shows -

Income from Latex per Hectare per Rotation of 26 Years Compared with Income from Sale of Rubberwood at the End of Rotation

Assumptions

(i) Trees felled and removed, branches windrowed and burned and stumps removed free. At 1970 prices this was rated as being worth US$70 per hectare if the planter had to pay for the work himself.

(ii) New trees planted. An untapped growth period for 5 years followed by 21 - 25 year economical tapping period gives a 26 - 30 year rotation. Take the 26 year rotation as being the most favourable for rubberwood versus rubber income.

(iii) 1000 kg per hectare yield for next 21 years. This is very conservative as the all Malaysian average for 1969 was 1000 kg/ha. Some higher yielding estates were getting 2000 kg/ha and a reasonable estimate for 20 years ahead is 5,000 to 7,000 kg/ha)

(iv) Assume rubber price stays at US$0.62 per kilogram, which is the median post war price

THEN

INCOME FOR 26 YEARS ROTATION FROM LATEX PER HECTARE

$$US\$ \left(21 \times 1000 \times \frac{\$62}{100}\right) = 13{,}000\ \$ \text{ (at 1970 values)}$$

Contrast this with US $70 once per rotation

$$\text{Then :- } \frac{\text{Wood Income}}{\text{Latex Income}} = \left(\frac{70}{13{,}000} \times \frac{100}{1}\right) = 0.58\%$$

This demonstrates that under even the most optimistic conditions only 0.58% of income would come from the sale of rubberwood. Assume the latex yield to rise by 250% and the rubberwood volume of these high yielding clones to drop to 1/3 of the present volume and prices to stay as in the first example-

Then :- Latex Income = 32,500 $
Rubberwood income = 23 $

$$\text{and the } \frac{\text{Wood Income}}{\text{Latex Income}} \left(\frac{23}{32{,}500} \times \frac{100}{1}\right)$$

$$= 0.07\%$$

This would be roughly the ratio in which the plantation owners would allocate their energies and attention. The point to be stressed is that income from the sale of rubberwood provides but a miniscule return. The main purpose is, and will remain, to grow more latex. Furthermore, with competition from synthetic rubber and the price of natural rubber being variable from year to year, estate owners are tending to diversify into other production.

There has been a considerable swing towards planting oil palm which also provides a good income and needs less labour to tend and gather the palm nuts. This means that rubberwood is likely to further diminish in the future.

The following table gives the post war yields and estimates future production of both natural and synthetic rubber to the year 1980 :-

TABLE I

RUBBER PRODUCTION

(million metric tons)

WORLD PRODUCTION	1948	1967	1970	1975*	1980*
Natural Rubber	1.4	2.45	2.80	3.70	9.
Synthetic	0.6	3.41	3.88	4.4	11-12
Total Rubber	2.0	5.86	6.68	8.1	20-21

* Estimated

Source - Natural Rubber Producers' Research Assn.

PROBLEMS IN THE COLLECTION OF RUBBERWOOD

There are two major possibilities of collecting rubberwood in Malaysia which is the major producer of rubber.

(i) Firstly, from estates which are, by definition, plantations of at least forty hectares in area. Of the total of 1,830,000 hectares of rubberwood plantations in West Malaysia in 1968 nearly 45%, or 830,000 ha, were in plantations. Some 310,000 ha or 38% of these estates were owned by five major companies. In fact 17% of estates were public companies, 23% were private companies and 39% were partnerships.
These estates employ 250,000 people directly and support at least 550,000 people in all. Naturally these large well-organized areas, intensively cultivated, would be the best source for rubberwood.

(ii) Secondly, from small holders. These tend to be between 2 and 3 hectares each in area, yet they comprise 55% or 1 million hectares in total. They provide a living for well over 1,000,000 rural people who live, and depend, on them.

This establishing the indiginees on the land is often actively, and financially, sponsored by government. From the point of view of rubberwood collection, however, it means purchasing small packets of rubberwood from more than 200,000 small owners for a comparable estate area. There are concomitant problems of land tenure, of determining who owns the trees and of delineating the exact boundaries. Hence any company wishing to purchase commercial amounts of rubberwood,which itself is a large scale operation, would have problems increased when dealing with a multiplicity of small holders.

In other countries, for example, the Southern portion of Thailand, these small holdings of rubberwood are further complicated by the fact that the local people tend to go in for mixed farming. They practise wet rice cultivation with water buffalo for traction. They also crop bananas, other fruits and coconuts, as well as growing rubber so that collection of rubberwood is extra difficult. Added to this, only shallow ports occur along the Western shore of the Gulf of Thailand. This restricts berthage to small vessels of less than 1,000 dead weight tons. This partially explains why a rubberwood pulp and paper expansion scheme mooted by consultants in 1966 for that portion of Thailand has not yet eventuated.

Thus to get perspective regarding the possible extraction of rubberwood from plantations, it can now be seen that the problem has expanded to not just a commercial transaction, but a socio economic situation. Rubberwood gives an infinitesimal yield and only once every 26 - 30 years relative to other estate income.

Mr.Robert S.McNamara, President of the World Bank Group, in an address to the University of Notre Dame, May 1st, 1969, summed up the problem this way :-

"To put it simply, the greatest single obstacle to the economic and social advancement of the majority of peoples in the underdeveloped world is rampant population growth."

Many nations realize this and are attempting to establish methods by which their native people can earn a useful and reasonable standard of living and maintain their pride. There is still much scope for cost improvement. For instance :-

- tapping covers 50% of the cost of natural rubber production,
- the cost of producing natural rubber is US$0.23 per kilogram,
- if the latex yield can be increased from the post war 666 kilograms per hectare to 1,333 kilograms per hectare, then the cost of production is lowered by US$0.091 per kilogram. This increased yield has been achieved quite extensively, firstly by growing better latex bearing strains of rubberwood and, secondly, by increasing the duration of the latex flow by the use of chemical stimulants which retard coagulation.
- If tapping can be reduced to every second day or, even better, to every fourth day, still greater savings in natural rubber production costs can be made. This development is progressing actively and seems likely to be successful.
- A US $0.05 increase in natural rubber price per kilogram increases the smallholder's annual income by US $240 and there are 500,000 of them. Together with dependents, they total between 2,500,000 to 3,000,000 people.

synthetic rubber (1, 4 polyisoprene) costs US $0.36 to $0.39 per kilogram to produce, so that natural rubber at a production cost of US $0.23 per kilogram is still competitive. Hence in the use of land resources for the benefit of the people Government generally evaluates three criteria :-

(i) What is the most profitable use of natural resources ?

(ii) What provides a continuing reasonable standard of living for rural people for the longest time ?

(iii) What crops will ensure continuance of that living standard in the future for the most practical producers ?

The Malaysian Government apparently has answered these questions to its satisfaction because it is actively sponsoring a land-for-the-people movement and is currently sponsoring economic and physical aid to enable 22,000 families involving 132,000 people to set up rubber and oil plantations on 60,000 hectares of land being hewn from virgin tropic jungle.
It is also setting up small group rubber processing units to serve existing groups of smallholders.

COMPETING USES FOR RUBBERWOOD

(i) In many of the small holdings and estates rubberwood is used as fuelwood for cooking food for all of the dependents of the workers. This is the major usage in Malaysia, Thailand and Indonesia.

Secondly, rubberwood is used as the fuel for smoking the rubber sheet before it is marketed.

(ii) In the Northern portion of West Malaysia some 900,000 green metric tons of rubberwood is used annually to make wood charcoal for the steel mill operating there. It is stated to be 20% cheaper than coke. The 900,000 green metric tons so used is double the existing rubberwood chip tonnage exported to Japan for pulp and paper manufacture.

It amounts to enough rubberwood to manufacture 200,000 metric tons of chemical pulp per annum.

AGE CLASS DISTRIBUTION DISTURBED

When people talk of cutting 3% or 4% of total wood per annum, they envisage a 33 year, or a 25 year rotation, respectively, in perpetuity.

Most of the papers advocating this cyclic rotational rubberwood reaping were written before 1960. Since then, disturbances in West Malaysia (Malaya as it then was) Indonesia and, more recently, Cambodia and Viet Nam have meant that the planned replanting schedules have not been carried out on time. Malaysia inaugurated a crash replanting program in the 1960-70 decade so that by 1967 in West Malaysia 78% of the rubber estates and 50% of small holdings had been replanted to high yielding clonal types. This replanting was stimulated by a government subsidy which expired in 1967. This means that a lot of the rubberwood from those replanted areas, and bear in mind there will be less wood available per unit area from these improved latex bearing strains of tree, will not come on to a 3.4% sustained yield until 1989. Furthermore, there will likely be zero wood available from 1975 to 1980.

SUCCESSFUL USE OF RUBBERWOOD FOR PULP AND PAPER MANUFACTURE

Why should rubberwood be used for pulp and paper manufacture ? Who needs it and why ? In an attempt to answer these questions tables have been drawn.

Table 2 shows the countries of Asia and the Far East and including Oceania in alphabetical order. It shows their population, their land mass in hectares, their paper and paper board production in metric tons and their per caput usage of paper and board in kilograms.

Table 3 shows the major eight paper and paperboard producers in the region. In this connection all countries manufacturing over 100,000 metric tons per annum were classed as major producers. The first eight of twenty three countries in Asia and the Far East produce 98.5% of the total production. In the future this percentage is more likely to increase than decrease.

Table 4 shows that Japan which is the major producer is short of raw wood material for pulp and paper manufacture. In the decade to 1980 her pulpwood demand will steadily increase and more of it will progressively come from overseas so that imported chips are estimated to rise from :-

7,000,000	cubic	metres	of	solid	wood	in 1970
to 8,000,000	"	"	"	"	"	" 1973
to10.000,000	"	"	"	"	"	" 1975
to 23,000,000	"	"	"	"	"	" 1980

Table 5 shows that only 3,924,516 metric tons were imported in 1970 but rapid expansions and new sources of supply indicate it will be close to target imports in 1971 - 72.

Table 6 shows that the main competing tropic countries which can supply mixed tropic light hardwoods are Indonesia, Philippines and the three sectors of Malaysia.

To summarize, Japan is, and is likely to remain, the major importer of wood chips in general and hardwood chips in particular.

TABLE 2

POPULATION, LAND AREA, PAPER AND BOARD PRODUCTION AND PER CAPUT USAGE OF COUNTRIES IN THE ASIA FAR EAST REGION (1969)

Countries (alphabetical)	Population 1969 (millions)	Area Hectares (millions)	Prodn.Paper & Bd.Metric Tons (thousands)	Paper used Kilograms/ Caput
Australia	12.309	772	1,010	118
Burma	26.389	67.8	0.45	0.7
Cambodia	6.557	18.1	5.0	1.7
Ceylon	12.532	5.7	8.4	3.1
China	747.(Est.)	900.5	3,500	4.9
China (Taiwan)	14.3	3.6	364	25
Fiji	0.5	1.8	0	8
India	525	305	750	1.6
Indonesia	112.8	190	20	0.5
Japan	102.6	36.9	11,300	111
Korea South	31.8	10.0	296	10
Laos	2.8	23.5	0	0.4
Malaysia	11.0	33.2	11.8	14
Nepal	11.3	14.1	0.5	1.1
New Zealand	2.76	26.9	440	112
Pakistan	120	95.5	136	1.1
Philippines	37.1	29.6	108	6.3
Singapore	2.0	0.6	1.5	41
Thailand	34.5	51.3	53	6.0
Vietnam South	17.4	17.1	22	3.8
Western Samoa	0.1	0.28	0	0.7
Territory Papua/ New Guinea	2.1	56.3	0	1.7
U.K. Hong Kong	4.0	0.1	0	71
	1,835.	2659.	18,026	-

Source - Partially derived from Pulp & Paper International, July 1970 and Stateman's Year Book 1970-71 and adapted.

TABLE 3

MAJOR EIGHT PAPER AND PAPERBOARD PRODUCERS IN ASIA AND THE FAR EAST

(1969)

Country	Metric Tons (thousands)	Per Cent
Japan	11,300	62.8
China (Mainland)	3,500	19.4
Australia	1,010	5.6
India	750	4.2
New Zealand	440	2.4
China (Taiwan)	364	2.0
South Korea	296	1.6
Philippines	108	0.6
Sub-Total	17,768	98.6
Total for Asia & Far East (23 countries)	18,026	100%

Note: (i) Percentages may not add, due to rounding.

(ii) First five countries of the twenty three produce 93.4% and are expanding.

Source: - Pulp & Paper International World Review Number July, 1970 and adapted.

TABLE 4

PREDICTED PAPER AND BOARD EXPANSION FOR JAPAN UNTIL AD.1990

(all figures in millions)

Year	Paper & Board M.T.	Total Pulpwood Demand M^3	Total Pulpwood Imported M^3	Imported Chips M^3 (S)	Pulp Imports M.T.
1970	12	30	7	7	0.8
1973	15	38	15	8	0.8
1975	18	42	19	10	0.9
1980	22	47	24	23	1.0
1985	28	-	-	-	1.1
1990	35	-	-	-	1.2

M^3 = Cubic Metres M^3 (S) = Cubic Metres Solid Wood

M.T. = Metric Tons

Notes:

(i) The above table is based on 7-8% expansion annually to 1973 and then 5% to 1990.

(ii) Maximum Japanese indigenous wood supply is 23,000,000 M^3.

(iii) First marine chiptanker delivery was 20,000 M.T. (Jan. 1965). By 1969, 33 tankers were in service providing 5,000,000 M^3 By 1972, 100,000 dead weight ton tankers will service Brazil.

Source: - Derived from Japan Pulp & Paper, Vol. 7, No. 4 Dec. 1969.

TABLE 5

JAPAN'S IMPORTS OF WOOD CHIPS - 1969 & 1970

METRIC TONS

Country	Metric Tons 1969	Value US$(000s)	Metric Tons 1970	Value US$(000s)
U.S.A.	2,989,955	57,998	3,315,780	68,283
Malaysia	193,797	3,492	420,144	8,254
New Zealand	15,701	300	172,509	3,075
Canada	-	-	10,808	255
Others	10,290	182	5,275	133

Source: - Japanese Lumber Journal, May, 1971.

TABLE 6

MAJOR ASIA LOG EXPORTING COUNTRIES' FORESTS (million hectares)

Country	Total Land Hectares	Forest Land Hectares	Forest % Total
Indonesia	190.4	121.7	64
Philippines	30.0	14.6	48
West Malaysia	13.1	8.3	64
Sarawak	12.3	8.9	73
Sabah	7.5	5.9	80

Source: Derived from country statements for - Asia Pacific Forestry Commission Meeting Seoul, Korea, May 1969.

Prior to 1960 it was estimated that within 40 kms of Kuala Lumpur there were 40,000 hectares of mature rubberwood available for exploitation. Subsequently this has been developed in what was the pioneer commercial operation of rubberwood being chipped at dockside and carried by 19,000 dead weight ton marine ship tanker some 6,000 kms to Japan.

For a plant with an annual output of 400,000 metric tons (M.T.) of green rubberwood chips, the following are basic requirements :-

- adequate turning space for road transport carrying in approximately a 5 M.T. payload cut to approximately 2 metre lengths,
- adequate storage for pulp wood in 2 metre lengths,
- conveyors to the chipper,
- a chipper of approximate 100 M.T. per hour capacity. This requires about a 700 kilowatt motor.
- a vibrating chip screen to give an accepted chip fraction passing through a 20 millimetre square mesh screen and being held on a 3 mm perforated screen. The fraction passing through a 3 mm perforation is rejected.
- provision for returning oversize chips back through the chipper until they pass as accepted material.
- chip conveyors to storage. These may be either belt, or pneumatic, but preference is for pneumatic because of the ease of distribution to a chip pile. Normally there are two piles each varying from 10,000 to 20,000 metric tons.
- a reclaiming device. Generally this is a crawler bulldozer-type tractor unit which both consolidates the stored chips and later feeds them back to a pocket feeder from whence they feed either by belt, or pneumatic, conveyor to the ship tanker which itself can be located alongside either a pier or dolphins. The rate of chip feed to ship is approximately 300 metric tons per hour. Feeding to ship continues for 24 hours daily.

Equipment as described would normally cost between US $2,000,000 - 2,500,000.

Such plant is at its most efficient when being run for about 20 hours per day with the remaining time being used for chip knife changing plus other requisite maintenance for a nominal continuously operating heavy duty operation. There are various problems with hardwoods in general, and more specifically rubberwood in particular.

- The wood needs to be barked when green because then the bark which can be removed manually fairly easily in the plantation does not become a waste disposal problem at the chipping plant site.

  Because this wood is fresh and green, half of its weight is water. This imposes an inert load on the transportation system which materially affects costs. Generally, wood transportation cost would be 4 to 5 cents per metric ton per kilometre for tropic conditions.
- Rubberwood is very prone to bluestain fungi which will penetrate deeply into the pulpwood billets from the sides and also one metre in from the ends within a two month period.
- In outdoor tropical storage chip piles can generate a lot of heat. It is not unusual for the temperature within a chip pile to reach 80°C. Furthermore, intense tropic rain falling on the chips in storage wets the pile still further so that severe degradation in both colour and quality can occur on chips near the bottom of the storage pile. If possible, it is desirable to have a concrete floor slab and completely reclaim one storage pile and then replace it with a new one. If a concrete slab is not available, it is desirable to use the bottom metre of chips as a base bed and to leave them indefinitely. They will become intensively discoloured but will keep the good chips above water and mud level.
- Deterioration in chip quality will give a lower yield of unbleached pulp. In addition, bleaching costs may rise as much as 10% in order to obtain a pulp of comparable brightness to that obtained from fresh rubberwood chips.
- There can be a marked deterioration in chip quality between the chipper and the ship's hold. All conveyors degrade but pneumatic conveyors are particularly prone to produce dust and reject material which is by definition below 3 mm diameter, because the chips impinge against the delivery pipe forcibly at every point where they change direction. Replacement bends of square cross section in resistant material are available.
- Bulldozer action too abraids the chips both in storage and when being reclaimed.
- There need to be quality checks for :-
  - (i) bark, rotten wood and sub-standard chip sizes,
  - (ii) moisture content of the shipment,
  - (iii) blue stain, latex penetration.

In general, a marine surveyor determines the green volume to an accuracy of plus or minus 0.5 to 0.6%. The moisture content is determined accurate to ± 0.5% on whole shipment by adequate representative sampling so that the accuracy for invoicing normally

lies between ± 0.6%. There are other deductions to be made, particularly if working in tropic areas where rainfall can be intense If the rainfall is over 3.0 millimetres per hour and the ship's hatches are open, this water needs to be allowed for. In monsoon areas 100 mms per hour is not unusual in the wet season.
If there is an excess of sub-acceptable size chips, rotten wood, bark and stained chips, then a penalty is generally applied.

In the dry season it may be necessary to add water as a lubricant to prevent air pollution at the dock side near where the pneumatic conveyor discharges. This water is generally metered into the chip feeder with an appropriate allowance made for evaporation under the pneumatic conditions prevailing at the time. Finally, it must be remembered that a 19,000 DWT vessel needs a berth about 200 metres long. It draws a minimum of 10 metres when fully laden so that ample deep water is needed close to the chipping plant because it is unusual to blow chips for a longer distance than 800 metres due in turn to the heavy power requirements. In summary, chip tankers are a large scale expensive operation in themselves. They require sophisticated reliable equipment ashore and operating around the clock, a fast loading and an ability to leave port immediately loading is completed regardless of the state of the tide. Under other conditions where neither quantities nor berthage facilities are adequate for large scale marine chip tankers it is usual to bring rubberwood out in shallow draught vessels. Generally it is carried in lengths of one to two and one half metres long by 10 cm to 100 centimetres in diameter. It is either barked at felling site or at the destination. If barked at the final destination, that is the pulp mill, then the bark is generally removed by hydraulic jet or by mechanical means. The rejected bark is squeezed to improve its calorific value and is burned in wood waste boilers to generate steam for processing acceptable chips to pulp and paper. Under tropic conditions intensive fungi can occur both under bark and at the ends of sawn pulp wood logs within 2 months so that it is usual to try to use wood within a maximum period of 3 months from the living tree to the finished product.

Blue stain can be controlled, at least partially, by the addition of organic fungicides such as pentachlor phenol which is not water soluble. Alternatively, the water soluble salt may be used. This is sodium pentachlor phenate, but its use is prohibited in developed countries if the final paper or paperboard is to be used for food packaging.

PHYSICAL PROPERTIES OF RUBBERWOOD

Firstly, it is important to remember that rubberwood is a young, fast grown plantation hardwood. It will grow to an overall height of 7 metres in 6 years and it will crown heavily. With this fast rate of growth, individual tracheids, hereafter incorrectly called fibres, will continually grow in length with increasing age. This means that those cells nearest to the centre, or pith, of the tree will be the shortest, being approximately1.0 mm long, whereas those nearest the bark, or cambium layer, will be about 1.7 mm long in a typical tree which would be approximately 30 years of age.

Finally,as rubber plantation rotations are about 30-33 years the tree, even when felled, is comparatively speaking very young relative to the cycle of any normal tropic hardwood tree where a typical life would be 60-100 years.

Individual young wood fibres tend to have thin walls surrounding the central cavity or lumen. These fibres tend to collapse in process somewhat in the manner of a deflated bicycle tube. While this may be beneficial for certain physical strength properties,it does not give good opacity. Furthermore, the ink may show through the finished paper.

Rubberwood too is particularly susceptible to insect attack. Rubberwood's other deleterious property arises from the method of collecting the latex where bad tapping can cut right through the cambium layer. Rather severe black scar tissue then occurs. This may be overgrown as healthy cambium grows over the scarred area. It is not unusual to see such scar tissue occurring at a depth of more than three centimetres under the cambium and yet overlain by three centimetres of a creamy coloured healthy wood. Such scar tissue is a completely deleterious material in that it is difficult to bleach, difficult to remove and contributes no useful properties whatsoever to any type of finished paper.

TABLE 7

PHYSICAL PROPERTIES

RUBBERWOOD (HEVEA BRASILIENSIS)

Specific gravity when green	1.1 - 1.2
Specific gravity air dry (i.e. 15% moisture content)	0.50 - 0.6
Fibre length range (mms)	1.1 - 1.7
Fibre width green (microns)	27 - 29
Fibre width dry "	16 - 19
Single cell wall thickness green (microns)	5.5 - 7.0
Single cell wall thickness dry "	2.1 - 3.7
Height of trunk in plantations (metres)	3 - 4.5
Diameter of old unselected seedlings (metres)	0.5 - 1.5
Diameterof new grafted clonal stock "	0.25 - 0.5
Ash content of dry wood (%)	0.74 - 2.35
Lignin content of dry wood (%)	22 - 29
Pentosan content of extractive free dry wood (%)	20 - 22

Source: Pulp & Paper Prospects in Asia & Far East Vol. II and adapted.

Rubberwood, therefore, should be suited for those applications where a hardwood of fibre length 1.0 to 1.7 mm is appropriate. This includes writings and printings, food wrappings, duplex boards, as part furnish for industrial papers, to name but a few. Such troubles as it has comes from its latex content.

NEWSPRINT FROM RUBBERWOOD

Newsprint needs to have the following properties :-

- It must be cheap.
- It should have good opacity.
- It should print well, particularly on high speed printing machines.

The minimum newsprint standards generally acceptable are :-

- A cross machine direction tear test of 24 gm.
- An opacity of 86.
- A brightness of 50% (using Magnesium oxide as a reference brightness of 100%).
- A basis weight 52 grams per square metre approximately.

Newsprint generally consists in long fibred (2.5 - 3.5 mm) coniferous groundwood reinforced by a percentage of chemical pulp. This percentage increases with increasing machine speed. For a machine speed of 800 metres per minute, the long fibred chemical component would be of the order of 20-25% of the total fibre furnish. However, as coniferous woods become scarcer and more costly, newsprint types of paper have been made from hardwoods not dissimilar from rubberwood. Thus both Japan and Australia have been making newsprint for over two decades from temperate zone hardwoods of birch, beech, oak and eucalypt species.

This year the first major commercial installation to make newsprint from mixed tropic light density, and light colour, hardwoods has started up in the Philippines.

While rubberwood has been made into an acceptable type of newsprint sheet on the laboratory scale, there is no known commercial operation working. In times of extreme national stress rubberwood has been used as an emergency supply for a newsprint type paper, but such operations have either finally shut down or converted to an alternative raw wood resource.

In summary, as at 1971, rubberwood does not seem to have found commercial acceptance as a major raw wood resource in the manufacture of newsprint.

WRITING AND PRINTING PAPERS

These are the types of paper most needed by developing nations as they try to educate their peoples. In this context it is probably not inappropriate to quote an old Chinese proverb.

"If you plan for a year, plant rice.
If you plan for a lifetime, plant trees.
If you plan forever, educate your people".

The desirable properties in writing and printing grades of paper are that they should have :-

- good printability and ink retention,
- adequate opacity,
- dimensional stability,
- a good even web formation,
- satisfactory surface smoothness,
- be suitably bright in colour,
- have adequate bulk (that is, the thickness to weight ratio)
- low porosity (to enable vacuumatic actuating gear to work)
- should not "pick". That is, the small stubby "vessels" which occur in hardwoods, but not in conifers, should not pick out from the smooth surface of the sheet and ultimately cause fluffing, linting and concomitant poor printing.

Printing papers do not need strength properties as a prime requisite. They are preferentially made from hardwoods. If these hardwoods have been separated from one another by chemical pulping methods, which in turn may be either alkaline pulping or acid pulping methods, then the subsequent paper is of highest quality and and is traditionally, but incorrectly, called "woodfree". This means free from mechanical groundwood.

What are the various grades of writings and printings ? They vary from bank papers either of bleached or coloured qualities at a basis weight approximately 45 - 55 grams per square metre in basis weight. These are generally the most expensive grade on a weight basis, but being of light weight their area per metric ton is highest. Bond papers are somewhat similar in quality but are heavier being in the 60 to 75 gram per square metre range. They give less area per metric ton and are correspondingly slightly cheaper than bank papers. Envelope papers are another grade which require to have an adequate resistance to being folded.

Duplicator papers require a good bulk and low porosity.

Coated papers need to have sufficient dimensional stability to reproduce four or five colours in good register and they must retain their coating well.

PULPING METHODS

The main pulping basic methods for making chemical pulps which subsequently can be converted to wood free papers are :-

(i) Alkaline (ii) Acid

Alkaline Pulping

Kraft process.

In laboratory work first reported by Peel & Peh in 1960* they did laboratory cooks in which they cooked rubberwood, in alkali, to a temperature of 150 °C for a total cooking cycle of three hours with 16% of active alkali and 20% sulphidity on mature rubberwood samples from various estates in West Malaysia. The 16% percentage is the dry weight of the chemical, expressed as a sodium sub-oxide divided by the oven dry weight of the wood.

They obtained a yield of $\frac{\text{oven dry pulp}}{\text{oven dry wood}} = 50 - 52\%$

A three stage bleaching involving a total 6% of chlorine lowered the yield by approximately one tenth to give a bleached oven dry yield of pulp ratio to oven dry wood of 47%. This is about what would have been expected for a laboratory scale of operation on a hardwood of specific gravity 0.55 for an easy bleaching grade of pulp.

In a commercial operation, that is one making some 270 metric tons per day from a large continuous type digester, it has been found that about a two hour cooking cycle is satisfactory if the maximum temperature is about 168 - 170°C.

The active alkali expressed as a percentage of oven dry wood was 17% while the sulphidity was held at 25 - 28%.

This gives a well cooked sulphate pulp at approximately a 50% yield.

In Japan there is a major shortage of raw wood resource and so the 10 - 20% of rubberwood which was used in the total hardwood furnish was mixed with chestnut 15%, oaks (Quercus species) 10%, Beech (Nothofagus species) 5%, with nearly 100 other hardwood species, making up the remaining 45 - 50%.

Such a blend of short fibred pulps when washed over modern vacuumatic rotary filter type washers would have a soda loss of

(* Pulp & Paper Prospects in Asia & Far East, Vol. II) approximately 11 kilograms per metric ton. Conventionally this is expressed as anhydrous sodium sulphate per air dry metric ton of unbleached pulp (Na_2SO_4/A.D.M.T.)

Although latex particles are held in a suspension in the highly alkaline conditions prevailing up to the stage of brown stock washing on the rotary vacuumatic filters, there is a pronounced tendency for these same particles to agglomerate into larger masses in the conditions of violent swirl that occurs in standard rotary continuous type pulp screens. "Balling" of the particles can cause trouble in the screens and subsequent partial plugging of the screen perforations. These latter cover a range of shapes from circular holes of 0.5 to 2.0 mm diameter for hardwood pulps to longer slits of up to 100 mm long by 0.5 to 1.5 mm wide.

Following screening, the reject material is sent to further secondary screening and the reject material from that stage is generally rejected from process.

Acceptable pulp is thickened to approximately 5% stock concentration in water prior to being bleached in a continuous five or six stage operation consisting of :-

- a chlorination stage at about 2% stock concentration, at room temperature, and using approximately 3-4% of available chlorine expressed as a percentage of the oven dry pulp. The reaction time is very fast with the bulk of the chlorine being used in the first few minutes. Because of the ease and cheapness of building many similar sized units and the utilization of standerd sized towers for each operational stage, the reactor is often built for a retention time of 60 - 70 minutes. This pulp which often has an orange colour indicative of chloro lignins is then passed over a rotary vacuum type washer. It then passes to the second stage where it is mixed with hot caustic soda at an amount equal to 2 to 2.5% of the oven dry pulp at a stock concentration of 12 - 15% and a temperature approaching 100°C. This is to render the chlorolignins which are insoluble in water to a soluble and extractable form in alkali.

After about a one hour retention the base section of the continuous reactor is diluted to about 2% stock concentration by mining nozzles injecting water. A second stage washing follows. Pulp at this stage has reverted to the brownish colour typical of unbleached kraft wrapping paper.

Stage three is a medium density, medium temperature, medium time stage where pulp at 5-10% stock concentration and at a temperature of about 45°F and a calcium (or sodium) hypochlorite stage, using about 1.5% of available chlorine bleaches in about a 60 - 90 minute retention period to give a semi-bleached pulp of the approximate colour range of fresh newspaper or blotting paper. This is often referred to as a General Electric brightness range of 58 - 68 degrees.

The next two stages are merely refinements which remove further encrusting, or absorbed impurities and give a high white colour of 90 degrees brightness measured on the same scale as before.

These stages are again a high density 10 - 12% stock concentration at near 100°C for about a one hour retention time while using 0.5 to 1.0% of caustic soda again expressed as a percentage of oven dry fibre.

The final chlorine dioxide stage is one calculated to raise the final brightness a unit or two and to minimise colour reversion on the paper machine when the paper is dried by contact with steam heated rolls maintained at temperaturesof 140°C by dry saturated steam at 2-4 kilograms per square centimetre pressure.

The final stage bleaching usually employs freshly generated chlorine dioxide made on site because this dioxide is inclined to explode if stored in cylinders, or transported.

Approximately 0.3 - 1.0% of chlorine dioxide is added to squeezed pulp at as high a stock concentration as is possible but preferably higher than 15% stock concentration, and then steam heated to about 80 - 90°C. This reaction has to take place in a specially acid resistant tile lined tower. Reaction time is between 4 to 6 hours.

Finally, this pulp is again washed and a small amount of sulphur dioxide either as a gas, or in solution as sulphurous acid may be added to stop deleterious reaction of residual chlorine dioxide. This pulp is again washed and then centricleaned in inverted conical type cleaners, which by working under a strong cyclonic effect induced by a pressure differential, tend to spin out dense particles to the periphery where they are rejected at the narrow basal section of the cone.

Unfortunately rubber particles tend to plate and being light in density their separation is not as satisfactory as it is for denser sand or grit particles.

It is those latex particles passing through which can cause trouble on the paper machine ultimately.Thereis also a desire to minimise this trouble because it determines the upper limit of rubberwood which can be used currently in various paper pulp blends. These problems are likely to be solved in the next few years.

Acid Pulping

Again it has been shown that acid sulphite pulping could be carried out on the laboratory scale using 100% rubberwood. There they tended to get the phenomenon known as "burning" which manifests itself as a charred like appearance around the thin edges of the chip while the thicker sections have not been cooked adequately in their interior zones.

On the commercial scale rubberwood so far has been used only up to a maximum inclusion of 30% of the total wood furnish. Sulphite pulp has been made commercially in at least six grades ranging from a high alpha pulp suitable for rayon, and subsequent textile manufacture, through to lower alpha grades suitable for tissues of very high quality and finally diminishing to various grades suitable for paper manufacture. The lowest sulphite quality pulp could be used as the long fibred component in the manufacture of newsprint.

These sulphite pulps are made both by the Calcium base bisulphite method which is very old. Being an inadequate method for commercial recovery of spent chemicals, it is not generally regarded as an acceptable method in the 1970-80 decade which is devoting a lot of attention, and money, to an improved environmental control. In other words this is an obsolete method of pulping which is unlikely to last because it pollutes both air and water extensively.

The sodium, magnesium, or ammonium based sulphite methods are all used as industry can reclaim chemicals by recovery systems which are, however, both expensive to install, and sensitive to operate.

A typical sulphite cooking cycle on batch digesters with a 9.5 hour to a 10 hour digester cover-to-cover is somewhat as follows :-

1.0 hour to reach 100°C.

4.5 hours to reach 140 - 143°C.

1.0 hour held at 140 - 143°C.

1.5 hours to relieve the digester pressure down to a pressure of 1.5 to 1.8 kilograms per square centimetre.

0.5 hours to discharge the digester contents at that pressure.

1.0 hour to refill the digester.

This totals 9.5 hours and with a contingency allowance of 0.5 hours this gives a total cycle of 10 hours.

The normal yield of pulp from hardwoods is 50% of oven dry pulp to oven dry wood. For a rayon grade pulp, which is cooked much more and has more impurities removed so as to give a better than 90% alpha cellulose, this is obtained from a more vigorous initial cook followed by multistage bleaching. The final bleached rayon grade yield would be of the order of 38% oven dry pulp to oven dry wood. Normally the total acid used is 9.1% of the weight of oven dry chips and is made up of combined acid 2% and free acid of 7%.

Screened wood pulp rejects would approximate 1.7 to 2.8% for a rayon grade hardwood pulp. This contrasts with 5 - 8% for a rayon grade pulp made from coniferous woods which are "softwoods" by definition.

These rayon grade pulp rejects can be refined and used together with other furnishes to make a paper grade sulphite pulp so that sulphite paper grades can use up to 30% of rubberwood whereas rayon grades can use only up to 20% of rubberwood in the basic wood furnish. For a sulphite rayon pulp the bleaching sequence was similar as for the alkaline pulping, namely chlorination, caustic extraction, caustic hypochlorite, caustic extraction and chlorine dioxide after which it has a further hypochlorite stage bleach added and followed this with a sulphurous acid wash.

A wide range of high quality woodfree grades of paper were made from the sulphite and the sulphate pulps derived from the 20 - 30% rubberwood furnish. They included :-

- Printings, white machine finish, white supercalendered, bulky book, offset cartridge, bible and air brush coated papers.
- Bank bonds and manifolds, both white and tinted.
- Writings, white and azure laid and wove.
- Ledger paper, azure, laid and wove, super white drawing cartridge, envelope super white and blue wove.
- Duplicator paper wove and laid papers.

Rayon pulp has been made on the laboratory scale from 100% rubberwood where the latex can be controlled and prevented from plating out by the addition of an expensive chemical whose current cost is so high that it is not, as yet, a commercial proposition on the industrial scale.

Can there be alternative methods of minimising the latex in the standing tree ? This is done, albeit somewhat crudely, now by the so-called "murder tapping" in which the tree is virtually tapped to extinction in the final six months of its life prior to felling.

Arsenical and other poisons too can be used to help remove bark prior to felling the tree, but to reiterate the use of arsenic, like sodium pentachlor phenate, is severely restricted if that wood is to be used subsequently for a paperboard which may be used for packaging food products. There is little doubt that a suitable debarking chemical agent will be developed within the near future. Then, with perhaps 80% of the latex removed with the bark being substantially self peeling, it may well be possible to step up the rubberwood percentage in the raw wood furnish quite markedly, perhaps even up to 100%. When that stage arrives, there will still be the cost of collection problems. As outlined previously, these costs are high because of the high intensity of labour involved in gathering small quantities of rubberwood from estates by small groups using small trucks and traversing roading not designed or built to withstand the heavy equipment and large scale operation occurring only once in a rubberwood plantation rotation. To date it has only been possible to convert rubberwood collection to a large scale continuous operation commencing at the chipping plant and thence to chip storage, to marine chip tanker, and to final mill destination.

Cordwood operations tend to be carried out with a high level of manual labour, including debarking by hand at the plantations, handloading to a truck, carting to dockside, and thence loading to small coastal vessels of 1,000 dead weight tons, or less, operating out of inadequate shallow ports. Many of the latter are afflicted by an on-shore monsoon wind for a considerable portion of the year. Such operations offer little scope for lowering costs by making economies. As it is both the national, and international, policy to raise the standard of living of the developing world's peasant peoples these labour costs are likely to show a steadily increasing trend so that the rubberwood for pulpwood could price itself out of the pulpwood market. In addition, there are competing uses for rubberwood such as wood charcoal, the biggest single commercial unit of which now is nearly double the size of the biggest rubberwood chipping operation in existence.

What are the competitive materials ?

In naturally occurring monoculture there are mangroves of the Rhizophera and Avicennia species but their costs of collection too are high and not likely to diminish so they are likely to be collected firstly only where peasant indigenous labour is locally available, or secondly, where the end product, for example rayon textiles, may have such a high sales price relative to the cost of the mangrove wood that the finished product may be able to bear a higher cost for its raw cellulosic material.

The other major competitor is mixed tropic light hardwoods. Superficially these appear to be quite a competitor because there is much wood left in virgin forests after cutting the first crop of logs. However, this virgin forest is a once occurring windfall asset. The logs generally are large and the scale of operations in the Philippines, Sabah, Indonesia and West Malaysia call for expensive very heavy duty logging equipment, good roads and heavy road transport for moving these prime logs. The felling, skidding, hauling and roadside loading equipment is designed to handle individual logs of 5-10 metric tons. These are prime logs. They command a premium price and return a profit on investment that pulp wood never has, and never will, be able to emulate. The American slogan "We saw the best and pulp the rest" is nearly 50 years old, but is just as valid today. Even greater profit comes from selling the prime log to another processor. In order to clean pulp wood from a logged over area would involve both lighter logging and transport equipment running completely independently of the main prime logging operation. Some major logging companies have studied the feasibility of this but none, so far, has commenced operations on a commercial scale in the tropics. In 1969 it was announced that a Japanese consortium was to operate in order to extract pulp wood from an 800,000 hectare concession in Indonesia following major logging operations. That should be operating now. In the Philippines waste from logging on the first rotation plus wood from plantations, plus silviculturally treated second rotations of mixed tropic light hardwoods has started on a large scale to supply a 160,000 M.T. production of both kraft paper and newsprint pulped separately and run on separate paper machines. These are but some of the various forms of competition that rubberwood must face.

TROUBLES WITH RUBBERWOOD ON PAPER MACHINES

When alum has been added to the pulp suspension previously treated with an alkaline rosin solution in order to impart water repellance to the finished paper, there is a tendency for latex particles from rubberwood to coagulate. This tendency is accentuated by the intense swirling motion imparted in centrifugal type cleaning units used. Furthermore, because this latex is light and bulky, it is not separated by centricleaners particularly well.

The particles that pass through the system cause trouble by :-

- Clogging the interstices of the paper machine wires, thus causing pin hole type perforations in the paper sheet.
- Plugging the paper machine felts at the wet end of the paper machine and again causing a degradation in paper quality when the wet sheet is pressed in the wet end press rolls.
- Adhering to the drying cylinders of the paper machine and causing the paper sheet to adhere to the cylinder or alternatively pick fibres from the paper sheet surface.
- Adhering to the calender stack and causing a blemish each time the rotating calender roll presses against the paper sheet.
- Being trapped in the paper sheet itself and being squeezed to a flat plate like translucent blemish upon passing through the calender rolls.

Corrective action to date has been ameliorative. Either the paper machine is run until the deterioration in quality goes beyond accepted standards. Then the paper machine system is shut down and cleaned both by purging the machine water system and also by removing adhering latex particles from metal parts by solvent or other means. This is extremely costly in terms of lost production and cannot be tolerated.

Alternatively, the rubberwood in the initial raw wood furnish is kept to such a level that the latex coming to the paper machine will not reach an objectionable level. Paper machines in Japan have tended to this latter course, pending their working out a method to reduce the latex in the standing rubberwood tree prior to its being felled. Some degree of success in this latter research is reported.

In India a paper machine which was using rubberwood pulped by the kraft process and run together with bagasse to make duplex and liner boards had to desist from using the rubberwood because it tended to cause the troubles listed above. Because of space limitations they were not able to blend the rubberwood in steadily. They are now using both bamboo and albizzia species for long and short fibred pulps respectively.

SUMMARY OF THE MAIN PROBLEMS AFFECTING RUBBERWOOD UTILIZATION FOR THE PRODUCTION OF PULP AND PAPER

Rubberwood comes from rubber plantations either from small holdings of less than three hectares or from estates ranging in size from a minimum of 40 to a maximum of 40,000 hectares. The wood is available only once per a rotation of 33 years. It contributes only between 0.07 and 0.6% of the rotation income. Rubber provides more than 99%. Thus rubber production does, and will continue to, attract the main interest of planters. Furthermore, as these planters do not want income tied to just one product, there is an increasing tendency to diversify to palm oil cultivation on some of the estates. This will further limit the rubberwood available at the end of future rotations.

Owing to a wide range of factors in Asia and the Far East but most particularly to a lack of security, plantations have not been replaced at 3.4% per annum which is the percentage corresponding to a 30 year rotation. A severe imbalance has now occurred particularly in West Malaysia, the largest planted area, where following heavy replanting programs stimulated by government financial assistance which terminated in 1967, there will be a dearth of rubberwood between 1975 and 1980 and the plantations will not come back into a semblance of even rotation before 1989.

Fast grown plantation rubberwood tends to have thin walled fibres which in the final paper, particularly newsprint, can impart deleterious properties.

There are competing uses for rubberwood. The main one is as fuelwood mainly as a wood charcoal for all persons directly, and indirectly, connected with plantations for a livelihood. In West Malaysia over 2,000,000 people are thus affected.

Rubberwood is also used as a fuel in process firstly for concentrating and later smoking the rubber sheet.

There is a market industrially for wood charcoal in a steel process. This uses 900,000 metric tons of green rubberwood a year. It is also sold as urban wood charcoal for domestic cooking.

There are serious difficulties on converting the rubberwood collection from many small holdings into a large scale continuous shift operation requisite for pulp and paper enterprises at ratio in excess of 50,000 M^3 of solid wood per month except in a few favoured localities.

Where rubberwood is being successfully used for rayon and pulp and paper manufacture, it is being used by very successful, mature, sophisticated companies. Yet even with their competence and experience, they have only been able to use rubberwood in blends of up to 30% of the total wood input because of subsequent difficulties in process in both acid and alkaline pulping processes.

The physical problems associated with rubberwood in pulp and paper manufacture are mainly concerned with the latex material embedded in the wood either under the tapping zone area, or from the latex penetrating into the wood face where the wood has been cut to pulp wood lengths.

In process this latex type material coagulates into small spheres inside equipment operating with high turbulence. These particles tend to plug machinery. Furthermore, being light in weight they are not removed effectively by the currently used centrifugal separating machinery used in most pulp and paper mills.

The material that gets through to the paper machine plugs the paper machine fourdrinier wires and felts at the wet end. That which passes to the dryer stage causes damage to the paper by adhering to the heated drying cylinders or by being squeezed under the high pressures occurring in the calender stacks. The unsatisfactory quality of paper that can result causes unscheduled, and costly, shut downs on the paper machine to purge it and solvent clean the affected zones.

Rubberwood, itself a hardwood, too only supplies a miniscule amount of the total wood imported into Japan for pulp and paper manufacture. Furthermore Japan is the only significant buyer of pulpwood for the whole area in Asia and the Far East. The main competing suppliers of pulpwood are the West American seaboard of Canada and the United States with 5,000,000 M^3, Australia and New Zealand. Brazil is likely to become a major supplier of eucalypt chips in 100,000 dead weight ton tanker shipments by 1972.

It is likely that severe competition will come from the use of mixed tropic hardwoods material, both as salvage operations following the logging of prime virgin forest in Indonesia and the Pacific Islands since plans have progressed to the stage of exploiting both these sources this year. Another alternative is for the customer to move his processing units out to the wood source itself and only freight out the more highly valued finished product. This already has happened in the U.S.A., Canada and New Zealand and will, no doubt, increase.

Thus the utilization of rubberwood for pulp and paper cannot be viewed from the narrow viewpoint of wood in one country and customers with processing units in another. It has to be studied in the terms of efficient land use, efficient cropping, providing a long term socio economic advantage to all concerned and relative to competing sources and end products on a willing buyer/ willing seller market. Then, and only then, will the likely place, and true importance, of rubberwood in the industrial economic structure of each country assume its real importance in a dynamic and changing world.

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