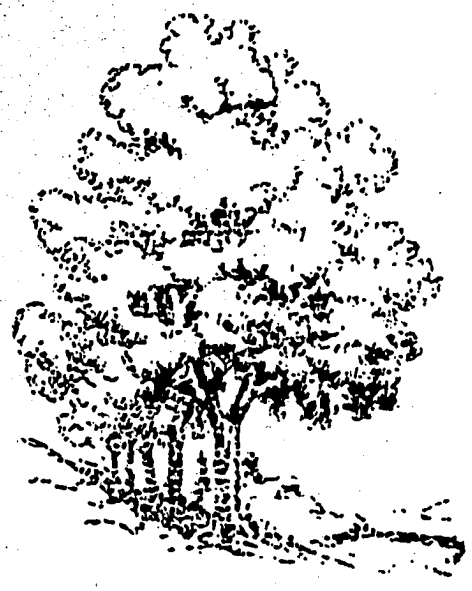

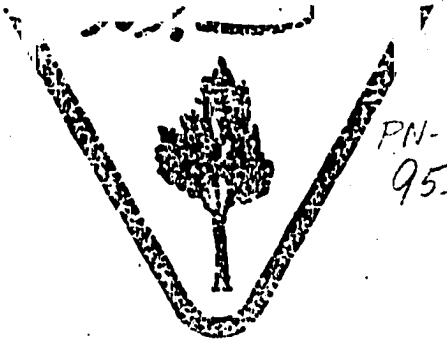

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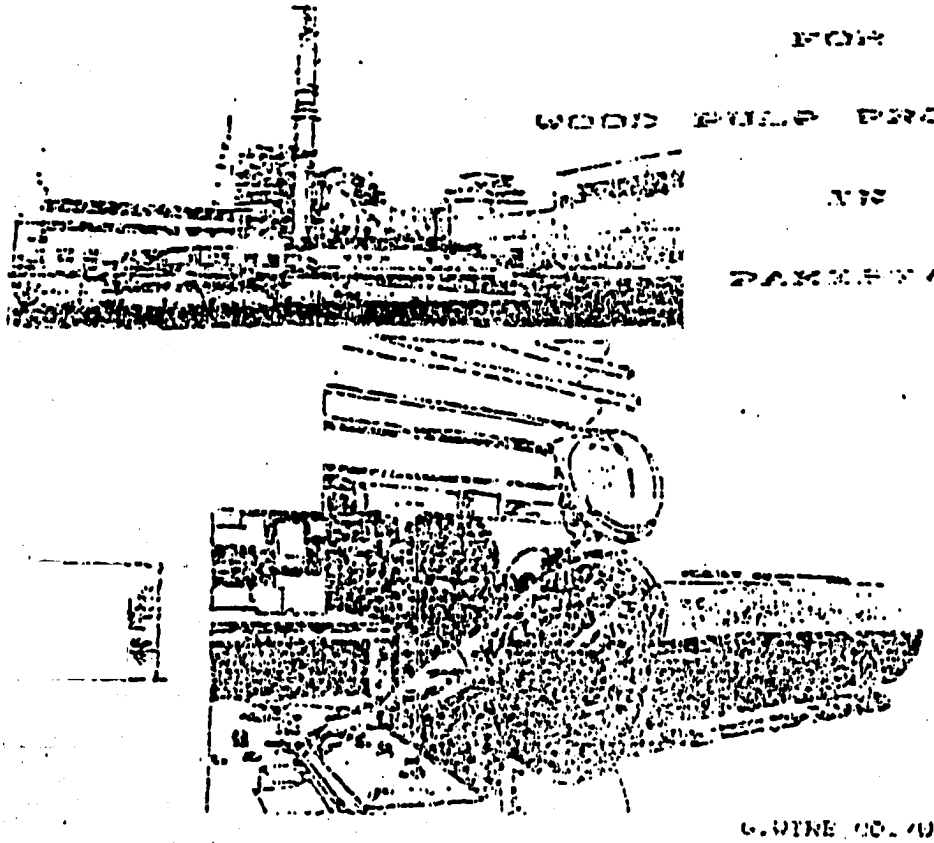
A STUDY OF TREE FARM WOOD UTILIZATION FOR WOOD PULP PRODUCTION IN PAKISTAN



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STUDY OF TREE FARM WOOD UTILIZATION FOR WOOD PULP PRODUCTION IN PAKISTAN

by

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GOVERNMENT OF PAKISTAN - USAID

16 AUGUST 1990

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PRELIMINARY FEASIBILITY STUDY OF
TREE FARM WOOD UTILIZATION
FOR
WOOD PULP PRODUCTION IN PAKISTAN

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STUDY OF TREE FARM WOOD UTILIZATION
FOR WOOD PULP PRODUCTION IN PAKISTAN

EXECUTIVE SUMMARY

This report is an overview of Pakistan's present and future paper pulp and related fiber requirements and resources; her papermaking industry; and relevant technology. The purpose was to elucidate and recommend appropriate supply and demand options with respect to the traditional fiber supply, tree farm enterprise, and other possible wood fiber supply.

Pakistan is an economically emerging nation. She is amongst the lowest per capita pulp and paper consumers; she must import much of her requirements, about Rs.2.2 billion/yr. Growth of demand will accompany economic growth; this is projected at 894,000 TPA by 1999 compared with 392,000 TPA in 1988-89.

The Pakistani pulp and paper industry was examined. Fourteen paper mills and several other institutions were visited and key personnel interviewed. We estimate present capacity at 273,000 TPA operating; another 192,000 TPA in planned or idle capacity for 465,000 TPA total. 1988-89 reported domestic production was 164,000 tons paper products and about 100,000 tons pulp.

About 30% of pulp used is imported, primarily bleached softwood chemical types. There is no domestic wood pulp production. Most mills are interested in using wood and in position to commence using wood in modest amounts as soon as available and chip preparation apparatus installed.

Three of the largest operators have stated intentions to build new facilities or substantially expand by 25,000 to 50,000 TPA pulp and higher. They will design for and use wood, if it is available in sufficient quantity to justify added investments. These are established, experienced pulp and paper mill operators.

The country is very poor in forest and woodlands. Endeavors are underway to ameliorate this through tree farming, particularly Eucalyptus camaldulensis and Poplar species. A stable market needs be established, remunerating growers of these tree crops, if planting is to continue and aforestation succeed.

Tree farm stands and potential harvest were estimated to be sufficient to support chemical pulp production of about 170 TPD in 1995 and 260 TPD in 2005. The geography ranges from Multan to Pershawar. Smaller groupings indicate wood supply for 90 to 130 TPD. Thus, capturing all of this wood might enable a small Kraft mill. It could support about twice that amount in TMP. This wood is generally within economical transport of existing paper mills. More aggressive planting could substantially increase this.

We estimate capacity for about 20-30 TPD in the Khipro circle vicinity of Sind; less in the the D.M. Jamali circle. This was not further assessed.

A new, 100 TPD market TMP-type mill (minimum economic size) would cost $25-$40 million. Smaller, used equipment mills are possible and could be installed for substantially less. But TMP types are high power consumers, e.g. 240,000 Kw-hr./day for 100 TPD, 10 MW, and much beyond the willingness of WAPDA to service. Power generation facilities costs about $1 million/MW and require fuel.

A 100-150 TPD bleached kraft pulp mill (minimum economic size) will cost $75-100 million. A used equipment mill would be $40-70 million . The Kraft mill would generate 50%-70% of its own power and with supplementary fuel, often biomass, even surplus power.

E. camaldulensis pulp quality was investigated from the standpoint of Pakistani use and processing methods. Bleached kraft, would be most desired and could displace up to 70% of that imported. Satisfactory pulp can be produced from other chemical processes including the soluble base sulfite and soda currently used by the Pakistani industry. Satisfactory TMP-ECTMP could also be produced, but power requirements at over 2000 Kw-hr./ton are problematic, and it would displace straw, not imported pulp.

Pulpwood supply commercial relations, transportation, distribution and wood processing facilities do not currently exist. It will take some time to get this established, especially in volume to support a market pulp mill. The fiber supply to a pulp mill must be dependable for the mill to be viable. Therefore, we conclude that proposals for near term establishment of new Kraft or TMP pulping facilities to be, at best tenuous. Particularly as compared with other opportunities.

Most Pakistani mills desire to use pulpwood as available; initially around 10%-20% of their fiber requirements - 30,000 TPA pulp; 60,000 m3PA wood. This would get supply-demand flow established on a modest, orderly basis. Their potential wood usage capability is 220,000 m3PA for 170 TPD of pulp by 1995.

The use of wood for pulp can be expected to bring the following product, production and cost benefits:

-Pulp yield of 45% vs. less than 30% for straw/Kahi; 36% higher.

-Reduce digester charge time to 20-40 minutes to 4 Hours cover to cover from current 5-6 hours; increase production 25%-50%.

-Packed chip bulk density 200-250 Kg/m3 vs. 130-170 for straw; Increase digester charge 50-90%; comparable production increase.

-Eliminate need for rotating digesters; power and mechanical maintenance saving; speed up charging and dumping.

-Improved runability for the balance of the pulp mill and on the paper machines.

-Product substitution for imported pulp costing Rs.20,000-22,000 per ton vs. ~Rs.9,000-10,000 for straw; higher product quality.

Disadvantages from using wood are possible increase in chemical requirements in both pulping and bleaching, and increased power for defibration. These should be modest.

To the extent gains over straw are achieved, the value of pulpwood will increase. This can be as high as Rs.6,000/OD-ton for full imported pulp substitution. The mill operators will develop and learn the value; competition will bring the price.

The initial wood price would be Rs.800-1200/OD ton (Rs.32-48/mound; Rs.400-600/m3) FIS mill; RS.20-30/mound to the grower. This is competitive or better than straw and bagasse, and somewhat higher than fuel. It is expected that price paid will respond to value and supply, quickly reaching Rs.1,500 and higher. When tree-farm stands, harvest and deliverability are sufficient, a full-scale pulp will become necessary and viable.

Use of wood requires installation of receiving, scaling, chipping and screening facility, preferably at the mill. This will cost Rs.3-5 million ($150,000-300,000). Initially hand debarking can be done, by farmer, middleman or mill. With higher volume mechanical debarking will be more desirable.

All mills visited express willingness to do the following:

-Announce their desire to purchase substantial wood

-Offer a reasonable **minimum** price, but pay at market

-Install the necessary chip processing and handling apparatus

-Modify their pulping facilities to enable processing chips.

NSSC Processing of Eucalyptus and Poplar could be compatible with their existing processes. However, development work is needed, to find the most promising pulping conditions. This should be on a pilot scale, to minimize mill trial work and production loss. A memo proposal in this regard is in Exhibit 9.

A mill exists in Pakistan capable of bleached kraft pulp production. That is Pakistan Paper Co., Charsadda, NWFP. It is in liquidation, and will come out free of the debilitating debt.

This could be a good paper-making plant, and has most features for a 100-150 TPD bleached Kraft pulp mill. There are evidences it could be in advantageous position to receive a substantial portion of tree-farm hardwood as well as develop some NWFP, North and Kashmir softwood supply. There are problems relating to labor and politics. According to our information, none of the indicated purchase candidates has pulp & paper experience; existing paper industry management stated dis-interest due to the labor and political situation. A feasibility study needs to be made to certify its capabilities, condition and needs.

CONCLUSIONS:

The Pakistan pulp and paper industry consists of small mills, with largely pre-1950 vintage apparatus and methods. They produce pulp from grasses and import chemical pulps. Present papemaking capacity could consume 1.1 million m3PA of pulpwood.

Tree farming is underway, capable of supporting 200-300 tpd chemical pulp, but no pulpwood trade exists today. The existing industry can use wood for 10%-20% of their production quickly and easily; This should be developed to get supply-demand underway. Once supply is established, larger facilities will become viable; as production increases they will be necessary.

Three avenues for increasing wood pulp production and for utilization of tree-farm wood exist:

1. Establish bleached kraft market pulp mills; minimum capacity: 100 TPD; Cost Rs.1-2 billion ($50-100 million). This would displace part of present imports and satisfy papermaking needs.

2. Establish market BCTMP mills; minimum capacity, 100 TPD; cost Rs.50-80 billion ($25-80 million). This would only displace straw pulp and be most useful for newsprint-type papers.

3. Wood utilization by existing industry, essentially within existing plant and process; minimum capacity: 4-8 hr./day, 10%, of current capacity; cost: Rs.2-5 million ($200,000-500,000). This could displace as much imports as would option 1, and enable evolution of the wood supply.

The capital cost and availability of startup wood supply are formidable obstacles to options 1. and 2. They could be reconsidered when the wood supply capability becomes adequate. The viability of Option 3 is dependent upon development of conditions satisfactory for producing the pulp. There is historical precedence for this, although it is not fashionable in the current industrialized world. However, technical assistance in developing satisfactory conditions for pulping the E. Camaldulensis is necessary, at both pilot and mill scale.

The existing Pakistani pulp and paper industry is in good position to develop viable methods of wood supply and pulp production. However, no prior experience exists in the country. Therefore assistance as recommended above will catalyze getting this going and established. Technical and financial assistance in developing methods of harvest, transport and preparation of the wood will further facilitate getting this underway.

As the volume of pulp production increases, processes for chemicals recovery, energy production, environmental preservation, etc. can be considered as appropriate to economics and other circumstances. This will lead to Option 1., above. The market and cost savings will make it financially feasible; the wood supply and pulp market should then be in place.

RECOMMENDATIONS

1. Encourage the existing industry to commence purchase and utilization of tree farm wood.

2. Assist organizing meetings between the pulp industry and farmers. These would be to familiarize farmers with mill pulpwood requirements, familiarize mills with farmers needs and concerns, and establish initial lines of supply-demand. This would include presentation of our findings, mill/farm visits and announcement of purchase agreements. The mills are willing to sponsor the meetings at their premises.

3. Organize technical and business meetings for each group, pulpwood supplier and user. For the mills, this would include technical presentations as to utilization methods: preparation, handling, pulping, paper-making, etc. Also procurement and contracts. For the farmers, experience of others in planting, harvesting, debarking, and delivery.

4. Assist formation of supplier-user co-operative or trade organization. This will strengthen the buyer-user marketplace circumstance vis a vis middleman traders. This is not to preclude them, but create a better competition. It will also assist technical and commercial communications.

5. Sponsor and fund the "neutral" sulfite pilot research and development to find the conditions satisfactory for pulping wood and compatible with those for existing fiber. Subsequent work should seek to find the best quality conditions.

6. Sponsor and fund design of wood handling, transport and most particularly chip processing apparatus; fund or assist funding purchase and installation of these.

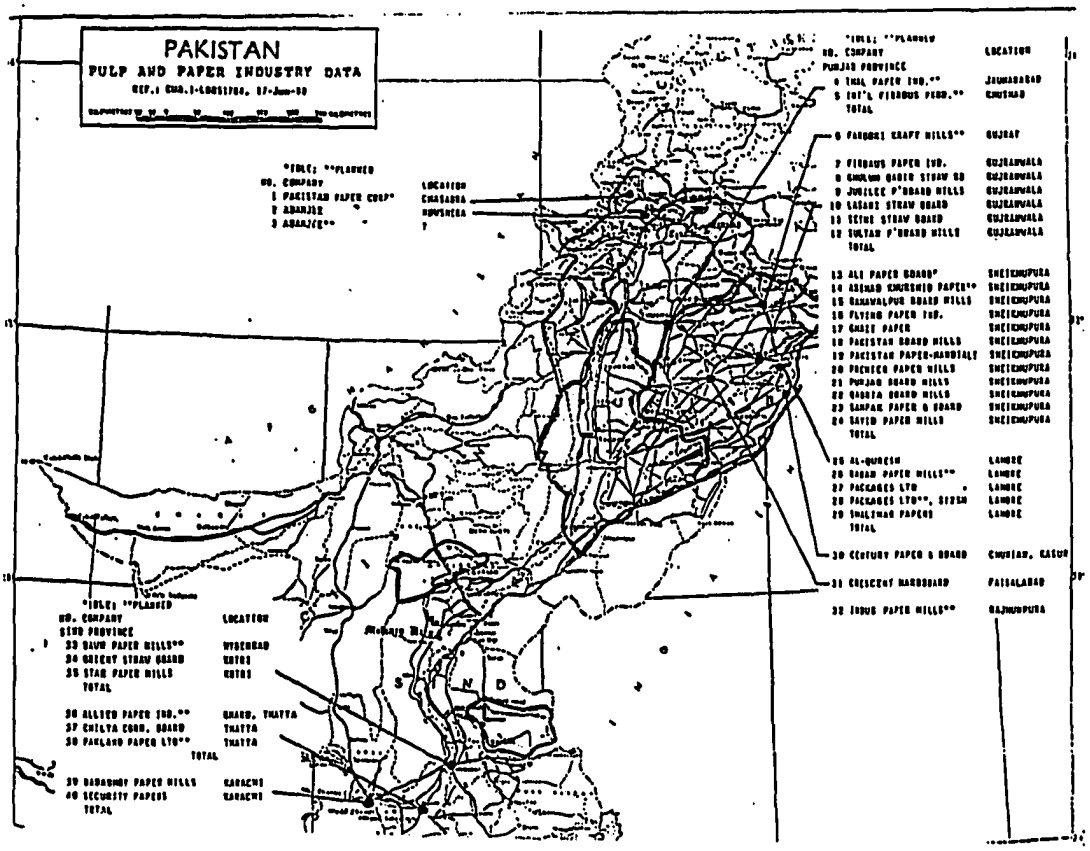
7. Sponsor and assist education programs. There is great need for pulp and paper technology education at all levels. Particularly the entry professional and vocational level for operators, technical, supervisory and management personnel. This could be through the above trade/technical organization via, e.g. Punjab University Chemical Engineering School, PFI and other appropriate institutions.

8. Conduct a pulpwood supply projection: stands, growth, optimum and probable harvest; determine and recommend optimum pulpwood rotation, i.e. young wood and maximum, rapid returns.

9. Investigate tree farm planting of conifers; these are most desirable and valuable for both solid wood and pulp products. Are there not robust, fast growing species available?

10. Encourage and facilitate takeover and operation of Pakistan Paper Corp., Charsadda by one of the leading Pakistani pulp & paper firms. Before this can happen the counter-productive government, political and labor situations must be remedied.

PAKISTAN TREE FARM CIRCLES & PAKISTAN PULP AND PAPER INDUSTRY MAP



ANNUAL VOLUME AND CHEMICAL PULP YIELD ESTIMATE

	CIRCLE	KOHAT	PINDI	LAHORE	MULTAN	JAMALI	KHIPRO	TOTAL
1991	HECTARES	1,264	3,298	2,247	3,222	750	2,564	13,345
	1000m3	13	37	25	36	7	29	147
	TPD KRAFT	10	28	19	28	5	22	113
1995	HECTARES	1,264	8,878	5,417	4,639	750	2,564	23,512
	1000m3	13	99	60	52	7	29	260
	TPD KRAFT	10	76	46	40	5	22	200
2000	1000m3	19	144	87	76	12	42	380
	TPD KRAFT	14	104	63	55	9	30	274
2005	1000m3	20	150	91	79	12	43	395
	TPD KRAFT	15	116	70	61	9	33	304

Nm3 = 1000 cubic meters annually; TPD = tons per day of chemical pulp
mechanical pulp would be double.

PULPWOOD VALUE vs. STRAW/KAHI COST

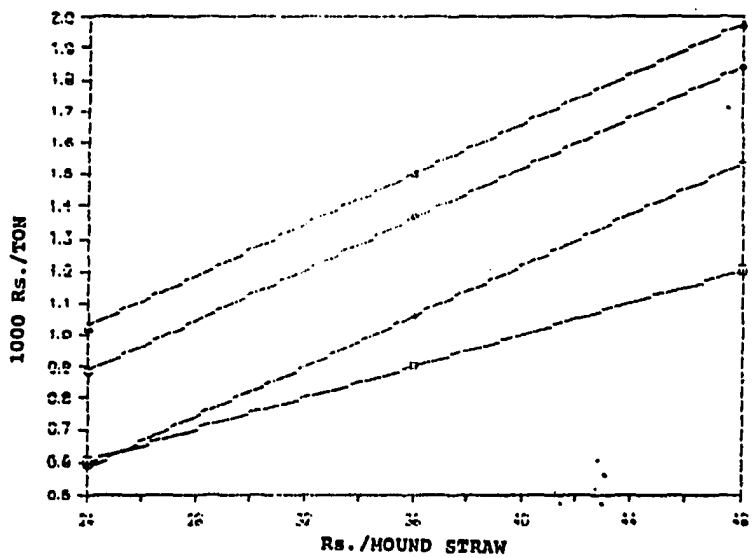
The following considerations were applied.

ITEM	ANNUAL FIBER	WOOD CHIPS
NET PULP YIELD, %	28	45
CHIP BULK DENSITY RANGE, Kg/M3	130-170	160-250
CHIP BULK DENSITY USED, Kg/M3	150	200
UNBL. Ka. No., ml	20	25

Variable and fixed costs were adjusted accordingly:

PAKISTAN PULPWOOD VALUE EXAMPLE

FIBER/CONDITION	VALUE, Rs.			PRODUCTION INCREASE
STRAW, KAHI COST/MOUND	24	36	48	
STRAW, KAHI COST/TON	600	900	1,200	0%
PULP COST/TON	9,740	10,800	11,860	
WOOD VALUE/TON				
Replace straw pulp	582	1,059	1,536	0%
Yield benefit	887	1,364	1,841	137%
Bulk density benefit	1,026	1,503	1,980	187%
Replace Bleached Kraft	5,744	5,744	5,744	187%



▫ STRAW/KAHI

→ WOOD REPLACEMENT FOR STRAW/KAHI

◇ PLUS YIELD BENEFIT @ 137%

△ PLUS YIELD AND BULK BENEFIT @ 187%

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16 AUGUST 1990

INTRODUCTION

Pakistan recognizes a number of socio-economic needs relating to her agriculture, forestry and land use circumstance. As one avenue addressing this, she has embarked upon programs for enhancing and better managing the existing forests, and for establishing new woodlands. An important aspect of this is aforestation of private lands - tree farming. If this is to continue successfully there must be an economic basis, i.e. compensation to farmers; revenue for their endeavor.

A potential market for wood is the manufacture of cellulose paper pulp. Pulp production is a complex process requiring large quantities and continuous supply of resources - fiber, water, power, chemicals, etc. It has large physical plant, infrastructure and other capital requirements. And it has large skilled labor requirements. The processes and operations have important energy, effluent and environmental ramifications.

The thermo-mechanical pulping (TMP) process was specified in the initial directive for this study. We felt that such scope was excessively limiting relative to the purpose and for several technical reasons. e.g. high electric power requirement. Therefore, it was proposed that the scope be revised to that of examining the feasibility of wood utilization for producing wood pulp in Pakistan for paper and paperboard production, and that the processes and method be left open. This change was approved.

The subjects covered here are:

1. Pakistan pulp and paper; requirements and industry.

2. Pakistan fiber resources and supply projections.

3. Pakistani pulpwood utilization ideas;
   Existing industry; new industry

Appendix A is a pulp and paper technology and production methods review. Other background and information is in the Exhibits.

PULP AND PAPER OVERVIEW

Paper is one of the basic commodities of modern civilization; per capita consumption is a common index of cultural and economic achievement. paper products are pervasive to modern society--sanitary and hygienic products; writing, printing and publishing; packaging and wrapping; and hosts of industrial products such as wallboard, insulation board, formica, rayon, plastics, etc.

The pulp and paper industry is a virtual microcosm of modern agricultural, chemical and manufacturing industry. Most cellulose pulp is manufactured from wood, and as such it is a major forest products industry. Its processing and manufacture involve complex chemistries, apparatus and procedures. It is a major consumer of energy and power, but also may be a net producer as well. It is a capital intensive industry, usually requiring Rs. 6-20 million ($0.3 to $1. million) per ton per day of capacity, depending on nature and extent of facility. See Exhibit 4.

By far the major portion of paper in the world is made from vegetable fiber. There is a growing synthetic fiber usage, but this is still very small and mainly for highly specialized products. The dominant world fiber source is of wood origin. However in some areas of the world annual crop fiber such as bagasse, straw, grasses, bamboo, and Kenaf are used. The first three of these are the primary fiber source for Pakistan today.

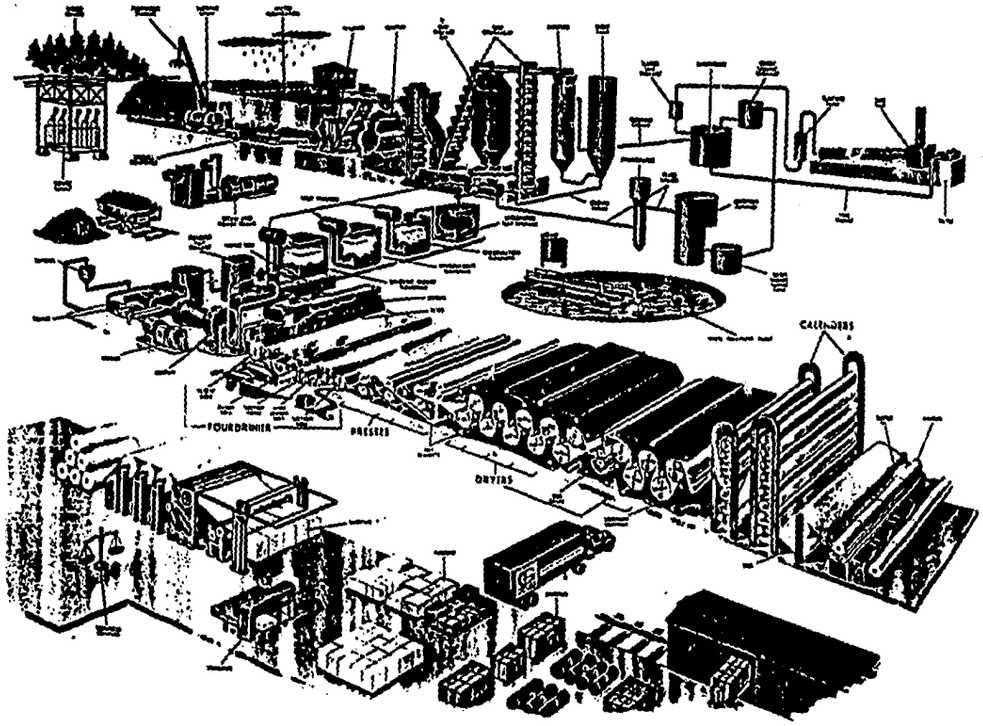
Annual crop fiber sources yield pulp inferior to wood in terms of world market expectations; however, where used, products satisfactory for the market served have obviously been developed. But usually with substantial price reduction or tariff and customs protection from competition. Cotton and hemp (linen) also are used for papermaking. These produce superior quality papers and are primarily used for bond and very long lasting papers.

Paper is a construction, usually made by "forming" a sheet from a very dilute (0.3%-0.8%) suspension of pulp in water. Depending upon the grade of paper and the mill situation it may contain one or more fiber types along with chemicals, pigments and dyestuffs, to render the desired sheet characteristics. After formation on a wire mesh arrangement, the water is further removed, first by pressing then by drying. Finally the sheet is finished by calendering to make it smooth, and may be coated with a pigment-binder "paint" for improved printing or other application purpose. A simplified papermaking diagram is shown in Fig. 1.

Cellulose pulps have a wide variety of characteristics depending upon the fiber source, its preparation and the pulping process employed. These properties are further developed by mechanical, and occasionally chemical, treatment prior to the paper machine.

Appendix A, Table A1 shows a typical paper composition. Table A2 shows typical pulp furnishes for a variety of paper types; Table A3 shows important properties and relative values for a variety of pulp types.

FIGURE 1: PULP AND PAPER MANUFACTURE FLOW DIAGRAM
KRAFT PULPING PROCESS



PULP TYPES, PROCESSES AND CHARACTERISTICS

Pulps have specific characteristics according to process type and fiber source; some fibers are limited technically or economically as to suitable processing. The fiber types are generally softwoods, hardwoods and annual fibers. The processes are divided into mechanical and chemical. Table 1 shows this relationship.

The Pakistani paper industry produces about 65% of its pulp. This is from straw, Kahi grass and some bagasse and other annual fibers. It is chemically processed by "neutral" sulfite, soda and lime methods. There is no kraft or mechanical pulp currently produced, nor is wood currently used. The balance of pulp requirement is from purchased local and imported waste paper, and imported pulp, primarily bleached softwood chemical.

Details of fiber source and pulping technology are of the greatest importance, for success or failure derive from such detail. A substantial review of the technology is in APPENDIX A.

TABLE 1: PULPING PROCESSES & PULP CHARACTERISTICS

```
PROCESS TYPE----------> MECHANICAL---------------------->CHEMICAL
PROCESS        YIELD----> 92%---------------------------------->40%
  GROUNDWOOD               *--*
  RMP                      *--*
  TMP                        *---*
  CTMP                        *----*
  BCTMP                       *------*
  NSCM                          *-------*
  NSSC                                  *--------------------*
  KRAFT                                                  *------------*
  SODA                                                           *-----*
  SULFITE                                            *---------------*
CHARACTERISTICS
  BRIGHTNESS, Unbl./Bl.    55-65/60-75                      40/70--94
  TEAR STRENGTH            LOW                                   HIGH
  TENSILE STRENGTH         LOW                                   HIGH
  BULK                     HIGH                                   LOW
FIBER SOURCES:
  SOFTWOOD                 YES                                    YES
  HARDWOODS                ??-->                                  YES
  BAGASSE                             *------------------------->YES
  STRAWS & GRASSES         NO                                     YES
POWER REQUIRED, per ODT    >2,000 Kw <------------------------700 Kw
ENERGY & POWER COGEN.      NO-------------------------->         YES
CHEMICALS RECOVERY         NO----------------->   ------------->YES
MILL COST, MM$/TPD         0.3-0.6<------------   --------->0.7-1.2
PAPER GRADE EXAMPLES:      NEWSPRINT               PRINTING/WRITING
                           CATALOG, BOOK           TISSUE, SANITARY
                           PUBLISHING, LABEL      BOXES; CONTAINERS
OTHER USE EXAMPLES         MOULDED PULP               RAYON & FILMS
```

PAKISTAN, PULP AND PAPER

Pakistan is often described as an emerging nation struggling to raise its economy, standard of living and self reliance. By most economic measures she is relatively poor. But, paradoxically the country exhibits evidences of being advanced and advancing to levels of economic and social accomplishment considerably beyond statistical indication.

Perusal of statistics show a population of about 115 million growing at the rate of 3.1% annually, one of the world's fastest. Statistics on the nation's 1988 pulp and paper activity compared with some others are shown in Tables 2 - 4.

We note that the calculated per ton values are substantially lower than list prices for the same period, 30% - 80%. There is much product sold internationally at distressed prices, but there also is likelihood that values are under-reported to reduce duties and taxes, which run to 57% ad valorum. Total paper & board imports are reported from Rs.2.2 billion to Rs.3.4 billion.

Pakistan pulp and paper demand is reported to be growing at a rate of 11.5%. If the country is to grow in literacy, education, economy and culture, approaching even the average per capita paper consumption of Asia (17.7 Kg) or Latin America (25 Kg) from her present 2.7 Kg, very substantial increase in paper products consumption will occur. For this to happen without debilitating foreign exchange, fiber source must be obtained and more domestic pulp and paper produced.

All evidences indicate substantial growth in Pakistan paper consumption will occur. We estimate this to be 224% from 392,300 tons 1988-1989 to 894,000 tons by year 2000. See Table 5. With favorable circumstances, this could be much higher. However, as it stands, conditions are not favorable.

Pakistan has one of the lowest per capita area or stands of forest and timber land. There has been no source of wood fiber. Her circumstances regarding wood and fiber resource is well recognized and is the essential subject of the forestry planning and development project. This has brought about planting of trees on both public and private lands. More is needed.

Capital projects financing is difficult and costly, 14%-16% interest. Devaluation of the Rupee increases the cost of repaying foreign capital loans and imported processing materials. This is exacerbated by import duties and taxes amounting to 37% to 57%.

The bureaucratic requirements and traditions impede and delay project development, discourage the established industry and seems to encourage exploitative entrepreneurs in an eventually un-fruitful projects. We are aware of over ten projects proposed in recent years, none of which were implemented. The Charsadda mill, after 18 years, and 6 managements, is in liquidation.

TABLE 2: PAKISTAN PULP & PAPER PRODUCTS PRODUCTION, IMPORTS & DEMAND

DESCRIPTION	CAPACITY	PRODUCTION	IMPORTS	CONSUMPTION
	METRIC TONS, 1988-1989			
Newsprint			51,800	51.800
Printing & /writing	133,200	61,900	46,200	128,700
Wrap & Pack. Papers	38,400	36,000	39,400	74,900
Paperboard & Other	105,300	65,900	81,100	136,900
Total Paper & Board	**276,900**	**163,800**	**218,500**	**392,300**
Paper Articles			14,900	14,900
Fiberboard	na	na	12,200	12,200
Total	**276,900**	**163,800**	**245,600**	**419,400**
Pulp & Waste Paper			52,700	
Total Pulp Products			**298,300**	

TABLE 3: PAKISTAN PULP & PAPER IMPORTS, 1988-1989

DESCRIPTION ---------->	TONS	MIL.Rs.	Rs./TON	$/TON*	$/TON**
Paper Imports					
Newsprint	52,706	393	7,450	355	570- 650
Printing & /writing	46,212	592	12,812	610	900-1500
Kraft Paper & Board	39,445	235	5,968	284	360-410+
Fiberboard	12,181	26	2,160	103	
Other Paper & P'board	81,048	509	6,280	300	
Paper Articles	14,908	149	10,008	477	
Total	**245,611**	**1,905**			
Pulp & Waste Paper Import	52,706	259	4,918	234	610-760
Total Paper & Pulp Import	**298,317**	**2,164**			

Total Pulp & Paper Imports, here: US$103; Reported: $170 million

* @ US$ = Rs. 21;
**1988-1989 reported prices.

Note: $/Ton per this data are below world market; this disparity may be due to under-reporting to avoid duties & taxes, about 57%.

Sources: Suleman & Kauser, Pakistan Forest Institute (May-90),
Economic Survey, GOP (88-89)
PULP & PAPER; PULP & PAPER INT'L: Freeman Pub. (Aug-89)
G. Wire (June-90)

TABLE 4: PULP AND PAPER CAPACITY, CONSUMPTION & PRODUCTION

PAKISTAN AND SELECTED OTHER COUNTRIES

VALUES (THOUSANDS)	PAKISTAN	INDIA	S. KOREA	JAPAN	MEXICO
POPULATION	114,939	818,782	42,621	122,424	84,884
CAPACITY					
PAPER	160	2,760	4,674	27,143	3,375
PULP	100	1,450	390	13,176	1,060
CONSUMPTION					
PAPER	288	1,915	3,484	25,035	2,483
PULP	111	1,350	1,218	13,492	1,109
PRODUCTION					
PAPER	101	1,915	3,659	24,624	2,593
PULP	70	1,050	313	10,415	809
APPARENT IMPORTS					
PAPER	187	865	-195	411	-110
PULP	77	565	3,346	14,209	1,784
Kg/CAPITA CONSUMPT.	2.73	2.27	81.8	204.5	17.7

The Kg/capita paper and board consumption was 17.7 in Asia, 204.5 in Japan, 151.8 in Europe, and 311 in the U.S., the world leader.

Source: PULP & PAPER WORLD REVIEW (Aug-89).

TABLE 5 PAKISTANI PAPER PRODUCTS CONSUMPTION FORECAST

CATEGORY TONS---->	1988-1989	1999-2000	INCREASE
PRINTING & WRITING PAPERS	128,700	306,300	238%
PACKAGING & OTHER PAPERS	74,900	181,300	242%
PAPERBOARD & CHIPBOARD	136,900	275,200	201%
NEWSPRINT	51,800	131,300	253%
TOTAL	**392,300**	**894,100**	**228%**

THE PAKISTANI PULP AND PAPER INDUSTRY

We have identified 41 mills in Pakistan; 31 operating, 8 planned and 2 idle. They have capacity for producing about 465,000 TPA paper and 292,000 TPA pulp. These range from under 2000 TPA, to about 30,000 TPA. They are all very small by modern standards. Statistics for all these mills are in Exhibit 2.

Fourteen paper mills were visited during this study, including all of the largest. Their production managers, several chief executives and other key personnel were interviewed. All operations visited produce pulp. The primary fiber sources are wheat straw, Kahi with some bagasse, cotton waste and other material.

There is no wood used with the exception of experiments by one mill. All mills visited are desirous of using wood, if available in dependable supply at an acceptable price. Pulp production accounts for 30% to 60% of requirements, with the balance made up of domestic waste paper and imported waste paper and wood pulp.

The mill operations are located near their fiber supply. Certain patterns of geographic location and practice become clear. These are listed in Table 6 and shown in Figure 2 and Exhibit 2. Potential pulpwood consumption projection is OD wood, based on papermaking capacity and 45% yield. They are as follows:

Charsadda. NWFP: Pakistan Paper Corp. is idle and in liquidation. It was built in 1972, under government auspices, to produce 100 TPD of printing/writing paper from bagasse. It adjoins Charsadda Sugar Refinery. Most equipment is quite good; the paper machines are the best seen in Pakistan. The pulp mill is, in fact, a Kraft mill including recovery furnace and recausticizing. However, the continuous digester would not be adequate for wood, but batch digesters could remedy that. Pulpwood potential: 66,600 TPA.

The debt burden, lack of pulp and paper knowledgeable management, raw materials uncertainty and labor difficulties have frustrated its success; the debt servicing precluded financial success. It is now in liquidation and is expected to be sold for Rs.150-200 million, free of debt. Labor and political situations seem to preclude acquisition interest by existing operators and pulp and paper knowledgeable management within the country's industry.

This mill represents, in place, most of the facility to produce 100-150 TPD of bleached kraft pulp. It is in reasonably good position to establish Eucalyptus supply from NWFP and Punjab, and possibly softwood from NWFP, Northern Territory and Kashmir.

It was indicated that the mill will be acquired in liquidation for Rs.150-200 million ($7.5-10 million). Additional digesters, instrumentation modernization, revamp and cleanup are required, and will cost about the same. This could be about 75% domestic expenditure. This would be modest investment compared with a new, greenfield mill at Rs.1.-2. billion ($50-100 million). But the adverse political and labor circumstances must be remedied.

Nowshera, NWFP: Adamjee Paper Co. operates a 2-machine, 100 TPD paper and board mill, the oldest in Pakistan. They produce about 60 TPD of neutral sulfite pulp from straw, Kahi, cotton, etc. They are using some Poplar and E. camaldulensis on trial basis. The operating and technical management are competent, and the operation is relatively good. They have high interest in using wood. A letter was received asserting interest and willingness to commence pulpwood purchase; Pulpwood potential: 66,600 TPA.

Jauharabad-Khushab, Punjab: Two mills are indicated, but do not presently exist. Both are planned or contemplated. **Thal Paper** at Jauharabad is indicated to make 17,000 TPA of newsprint, about 50 TPD, probably from bagasse. **International Fibrous Products** is indicated at 10,500 TPA. We estimate this to represent about 5,000 tons chemical pulp. Further information was not available on these. However, they represent potential for about 20 TPD chem. pulp and 50 TPD mech. pulp. Pulpwood potential: 44,000 TPA.

Farooki Kraft Mills, Gujrat, Punjab: S.A. Farooki has announced intentions to establish a 100-150 TPD mill to produce market quality bleached kraft pulp from poplar and Eucalyptus. The business plan outlined appears good. The question is whether such a project, to cost not less than $25 million, will get underway. There are reasons for doubt. Pulpwood potential: 116,000 TPA

Gujranwalla, Punjab: There are six mills in this area producing about 30,000 TPA of paper or board and 20,000 TPA of lime-soda pulp, 67 TPD. Of these **Jubilee Paperboard Mills** is the the best and largest at 10,000 TPA pulp, 15,000 TPA paper. These mills are primarily producing cone stock for local textile industry. **Jubilee** indicates interest in using wood, and is capable of folding box type product. For the others, the present fiber is satisfactory for their product and these mills are not considered good wood using prospects. Pulpwood potential: 68,000 TPA

Sheikhupura, Punjab: There are 12 paper mills in this locale, grouped in close proximity one another off the Sheikhupura-Lahore Highway. They range from 4,000 TPA-19,000 TPA paper; 2,000-14,000 TPA pulp. Total paper capacity is 93,000 TPA and we estimate wood utilization capability at 213,000 TPA. Several mills probably have capacity substantially higher than they indicate.

Due to the close proximity of these mills, a joint wood receiving and chip preparation facility might be considered. Likewise, joint chemicals recovery, heat and power generation. This then could lead to a joint pulp mill. This might be by one mill establishing the enterprise, by a cooperative enterprise or a new venture. Pulpwood potential: 250,000 TPA.

Flying Paper Mills: is one of the newest mills, the paper mill started up in 1986; the pulp mill in summer 1989, at the time of this study. A visit was not permitted. It has capacity of 24,000 TPA printing/writing and sack kraft papers; 14,000 TPA straw pulp. Since start-up they have been using imported pulp, thus producing excellent paper. Pulpwood potential: 53,000 TPA.

Premier Paper: stated capacity of 11,000 TPD printing/writing papers and straw NSSC pulp; we judge its capacity could be substantially higher. Pulpwood potential:over 23,000 TPA.

Sampak Paper: stated capacity of 21,000 TPA of packaging/wrapping paper and board. This is a newer mill and had installation difficulties and delay due to supplier failure. However, its staff successfully completed installation with foreign and locally built equipment. The management and technical competence appeared very good. This mill operates Ghazi. Neutral sulfite pulping. Pulpwood potential: over 46,000 TPA

Ghazi Paper Mills: stated capacity of 10,000 TPA printing/writing papers, but pulp washers and bleach capable of over 120 TPD. This is a newer mill and had installation difficulties due to supplier failure, and failed itself. It is now operated by Sampak. Several serious mill problems remain. The management and technical competence appeared good. Pulpwood potential: 22,000 TPA

Lahore, Punjab: There are 5 mills indicated for the Lahore area, three operating now. Total pulpwood potential: 235,000 TPA.

Packages Ltd.: operates three paper machines producing 42,500 TPA of a wide variety of grades including tissue, printing/writing and folding box. It converts all of its production including Tetrapak cartons under license. The management and technical capability are amongst the best in Pakistan. It is the dominant producer in the country, and is the model for most others.

Packages produces 60 TPD of neutral sulfite pulp, primarily from straw and Kahi. It has high interest in using wood, particularly Poplar or Eucalyptus. They have carried out pulping tests and are actively investigating installing wood chip processing and semi-chemical refining apparatus. Pulpwood potential: 94,000 TPA.

Packages plans to establish a new 50,000 TPA paper, 30,000 TPA pulp mill in Lahore. This would use wood to the extent dependably available. Current thinking is for neutral sulfite pulp and a sulfite recovery process. Pulpwood potential 111,000 TPA.

Chunian, Kasur. Punjab: Century Paper is a new mill, just in startup. It has 2 paper machines producing printing/writing and folding box grades. It has stated capacity of 100-120 TPD paper. It produces "bi-sulfite" pulp in 5 digesters from straw and bagasse; we judge its capacity to be much greater if on wood pulp.

The company is owned by the Lachson Tobacco Group of Karachi, in consortium with Rothmans (UK), Colgate and others. It claims a licensing agreement with Kimberly Clark (US). In meetings with the MD and the production manager, very strong interest in using pulp was asserted, with willingness to make early commitment and modify the mill as necessary. Pulpwood potential: 80,000+ TPA.

Faisalabad. Punjab: Crescent Hardboard produces 24,000 TPA of hardboard and particle board; the hardboard by the Defibrator process, akin to TMP. Its intended raw material is bagasse; it is owned by Crescent Sugar Co. Although not strictly a pulp or paper producer, its raw materials and process are so similar, that we include it. Their product appears excellent.

Due to non-dependability of bagasse availability, its manager has converted the operation for wood utilization with a woodyard, chipping and shredding apparatus. He is purchasing Mango wood, and has instigated establishment of E. camaldulensis tree farms. Pulpwood potential: 28,000 TPA

Rajhunpura, Punjab: Indus Paper has announced intent to establish a mill; we have no further information.

SIND:
There are six mills in the Karachi-Hyderbad-Kotri-Thatta vicinity plus three announced. All of the existing mills are under 5,000 TPA capacity. Visits to these mills was disallowed due to civil unrest in the region. The following, therefore is based upon published information and other interviews.

Karachi, Sind: two mills, **Dadabhoy Paper** and **Security Paper Mills** produce 3,500 TPA paper. Al Noor Sugar Mills has indicated interest in establishing a Bagasse based mill. The pulpwood potential of 11,000 TPA is discounted.

Hyderbad-Kotri, Sind: there are three mills, **Dawn Paper, Orient Strawboard and Star Paper Mills**. These produce 11,000 TPA paper and 7,500 TPA pulp. Pulpwood potential: 33,000 TPA.

Thatta, Sind: Two existing mills, **Allied Paper** at Gharo, and **Chilya Corp.** produce 13,000 TPA paper and 9,000 TPA pulp. The announced **Pakland Paper Ltd.** is stated at 30,000 TPA capacity. However, we are informed the project is unlikely and discount its potential. Potential pulpwood: 95,000 TPA.

Nooriabad, Dadu, Sind: City Paper Co. produces 7,200 TPA of corrugating medium; no pulp. They are interested in using wood. Pulpwood potential: 16,000 TPA.

TABLE 6: PAKISTAN PROSPECTIVE PULPWOOD USERS BY LOCALE AND MILL

LOCALE	MILL	PULP FIBER	PULP PROCESS	PAPER PRODUCT	PULPWO ODMT/
NWFP	2 mills				133,2
Charsadda	*Pakistan Paper	Bagasse	Soda	P/W	66,6
Nowshera	*Adamjee Paper	Straw, Kahi, Cotton, Wood	Sulfite	P/W, FB	66,6
PUNJAB	29 mills				827,0
Khushab	Int'l Fib.	?	?	P/W	21,0
Juauharabad	Thal Paper	?	?	News	23,0
Gujrat	Farooki Kraft	Wood	Kraft	Pulp	116,0
Gujranwalla	*Jubilee +6	Straw	Lime	Cones	68,0
Sheikhupura	*12-mills	Straw	Sulfite	P/W, FB	250,0
Lahore	*Packages	Straw, Kahi	Sulfite	P/W,T,FB	94,0
	+ 3-mills + new	Packages mill			238,0
Kasur	*Century Paper	Straw, Bagasse	Sulfite	P/W, FB	80,0
Faisalabad	*Crescent Board	Bagasse	THP-like Particle	Hd board Board	28,0
SIND	9 mills				151,0
Hyder.-Kotri	3-mills	Straw	?	L,H	33,0
Thatta	3-mills	Straw	?	L,H	95,0
Karachi	2-mills	Straw, Cotton	?	P/W	11,0
All Pakistan	41 mills				1,112,0

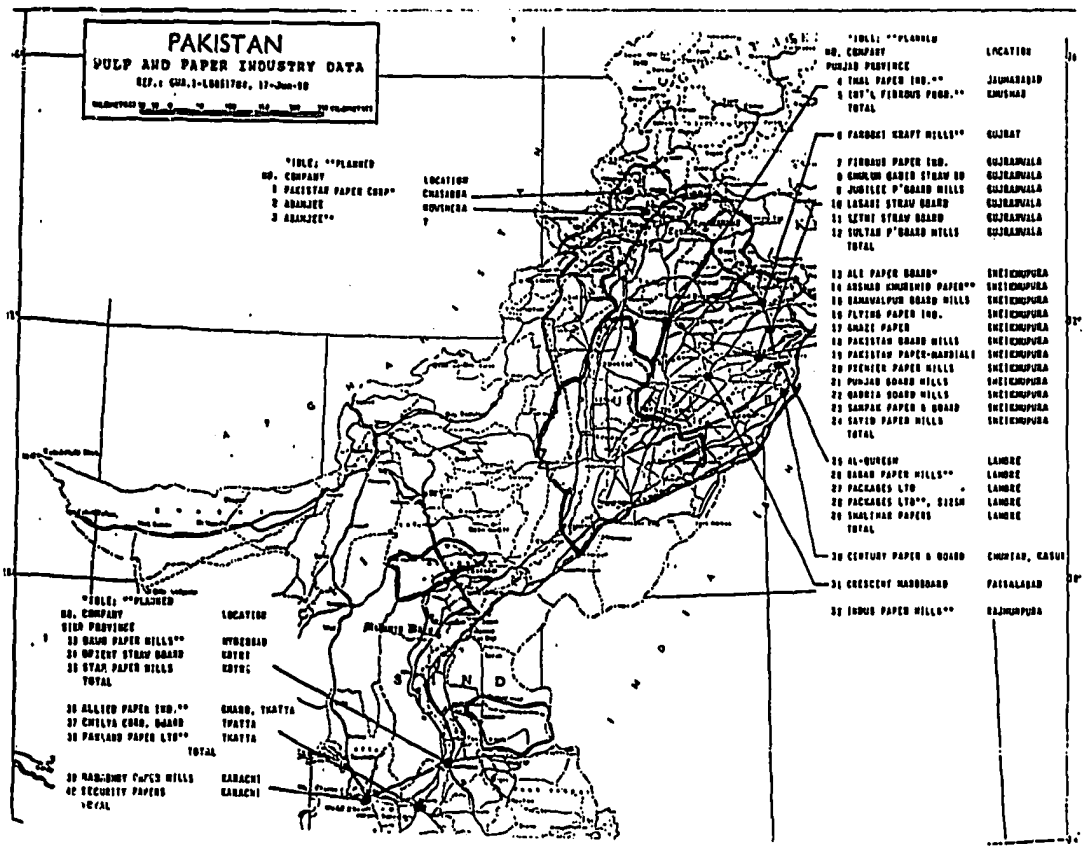
* These are considered immediate pulpwood consumer candidates.

Pulpwood potential estimate is oven dry metric tons per year.
It is based on paper production capacity and 45% pulp yield.
1 ODMT/Y =- 1.6 m3 solid wood and =- 1.9 m3 wood + bark.

Pulpwood use by 1995 is estimated about 10% of these projections.

Grades Key: P/W = printing/writing; FB = folding boxboard;
t = tissue; news = newsprint;
cones = textile cone stock;
h'bozrd = hardboard, particle board, etc.

FIGURE 2: PAKISTAN PULP AND PAPER INDUSTRY MAP



PAKISTANI FIBER RESOURCES

GENERAL

There is no significant use of wood for pulp at the present in Pakistan. All paper mills produce pulp from annual crop fiber. The preponderance is wheat straw and Kahi (elephant grass), with some bagasse and cotton waste used. There is some interest in Sesbania and Berwaza plants with experimental plantings. Kenaf has been tried and bamboo is grown, but no interest in their use was indicated. There appears to be an abundance of annual crop fiber, especially straw and Kahi. In all cases the pulp quality, yield and mill productivity is less than pulp from wood. Availability of pulpwood at satisfactory price and dependable volume are the critical issuis less than pulp from wood. Availability of pulp and secondary fiber cost Rs.20,000-24,000/ADT FIS mill.

Annual Crop Fiber:

Straw consumption has been stated as less than 5% of availability (Babar Ali, Packages 12-JUN-90). It is the by-product of the manual wheat harvest practice in Pakistan, which also facilitates gathering, bundling and transport to the mills. Should wheat cultivation and harvesting practices become modernized, straw availability would likely be compromised. Some predict such will be the case in the next 10-20 years (G. Naughton, 15-JUN-90). But, there is no evidence of such change in the near future. However, price increases due to strong demand is reported, especially in Lahore and Sheikhupura (Hurter, July 1989).

Kahi, elephant or river grass grows wild along the river banks. Its fiber characteristics are very similar to wheat straw, as also are its pulping process conditions. Therefore, it is used virtually interchangeably with straw. Its harvest and availability appear to be complementary with the straw harvest.

Bagasse is the sugar cane waste following crushing. It is a common pulp fiber substance in those areas of the world where grown and without other fiber source. Its chemical pulp fiber is comparable to the above grasses, but substantially inferior to wood pulp. There are several mills around the world attempting to make mechanical type pulp from bagasse especially for newsprint.

A few Pakistani mills use bagasse when available, and several have been proposed. However, the supply is unreliable. Its primary use is to fuel sugar refinery boilers. Surplus availability varies with the harvest, cane syrup concentration, availability of other fuels, and bagasse heat value.

PULPWOOD

Wood is the fiber of choice for paper pulp. Softwoods would be much preferred. Pakistani mills must import long fiber softwood chemical pulp to provide machine run-ability and tear strength This is due to deficiencies in their present annual crop pulp. But let there be no mistaking, hardwoods, especially Eucalyptus would be welcome for 30%-70% substitution of imported bleached chemical pulp, depending upon paper grade. If and as the pulp becomes available, and the cost and quality are in line, mills will probably learn to use more; if the cost is right, they will gladly substitute for straw pulp.

There are extents of wood based enterprise and commerce in Pakistan. It appears that practices and markets are somewhat unique, or at least different from Western practices. Timber harvest and wood processing residuals, even roots, appear to be gathered up immediately, and are in demand for fuel. Although there clearly is high demand for all particles of wood, the report of DR. C. McKenna indicated that there is substantial supply which might be diverted to pulp wood at a straw-Kahi competitive price, with relatively slight affect upon other current uses, particularly fuel (McKenna, WR/AID#1 & #2, JUN-90).

The overall wood supply-demand situation in Pakistan is, at best, confused. The study of this will be underway in August. We have based pulp wood availablilty premise upon the following.

SOFTWOODS AVAILABILITY

Softwoods are most desired for pulp wood, and most other uses in Pakistan. The country has pine, spruce, fir and other conifer forests in NWFP, Kashmir and North areas. Information on the stands, harvest and utilization practices have not been made available. At best the situation seems confused. PIDC and other GOP agencies studied the feasibility of a softwood Kraft pulp mill near Manshera around 1982. The 100 TPD project was judged not feasible due to inadequate and uncertain fiber supply; however there was indicated supply for about 50 TPD kraft pulp.

We continue to request data on stands, growth, harvest rates, and utilization practices for this resource. To that end, we also endorse Dr. C. McKenna's recommendations for this (WR/AID #1, JUN-90). At this time, we conclude that some softwood supply would become available with establishment of a stable market demand. We estimate up to 110 TPD conifer pulpwood could be brought forth, sufficient for 50 TPD chemical pulp production. The is based upon the PIDC-Manshera and other estimates.

There is no indication of exotic conifer planting as part of the tree farming campaign. We wonder as to the reason. Various pine species have been planted under a wide variety of conditions throughout the world: Monterey (P. radiata), Loblolly, etc. Has this potential been exhausted?; should it be investigated?

HARDWOODS AVAILABILITY

There are a variety of indigenous hardwoods growing in Pakistan. We have not received information as to the stands, growth or harvest rate, nor of disposition and availability. This will be part of the forthcoming study mentioned above. However, we are told that this resource is committed and unavailable for pulp wood. Therefor it's potential is not included in this study. As with the softwoods, if a pulpwood market is established, some should come forth, in line with Dr. Mckenna's thesis (op cit).

There has been exotic species tree farm establishment underway for several years; since 1972 in Sind, more recently in the other provinces. Initially this was on government properties; the campaign is now being extended to private lands and farmers. That is the primary purpose of the Forestry Planning and Development Project sponsoring this work.

Several exotic hardwood species have been planted. These are:

Eucalyptus Camaldulensis		65%
Acacia		15%
Poplar		10%
Simul		5%
Shishum	less than	5%
Others,	less than	1%

Young E. camaldulensis is highly desirable as pulpwood, especially for chemical pulps. Poplar and probably Acacia are good; we do not know about the others. But generally, most hardwoods respond well to Kraft, soda and neutral sulfite pulping; mechanical pulping including TMP and CTMP may be more problematic.

These fiber crops, particularly the Eucalyptus, are planted in spacing that provides for 3 to 6 year first harvest, and 4-6 year coppice harvests. Young E. Camaldulensis is very satisfactory for pulp manufacture, up to about 8-10 years; older wood less so. Actual plant spacing and harvest age would be an optimization effort based upon soil, growing conditions and market.

PULPWOOD AND WOODPULP YIELD ESTIMATES

Stands and sustained yield harvest were estimated by planting circle for the years 1991, 1995, 2000 and 2005; this is based upon a rolling average of initial and coppice cut, and no planting increase after 1995. The planting area estimated represents less that 7% of that possible. Yields were taken at 9-17 m3/hectare, whereas yields of 30-40 m3/hectare are obtainable. The lower yield used was to accommodate partial plantings and likelihood of wood going to other uses as well. Land management for pulpwood only could yield substantially more than we have estimated. These data are shown in Table 7 and mapped in Figure 3.

The methodology and additional information is in Exhibit 1.

FIGURE 3: PAKISTAN TREE FARM CIRCLES & PULPWOOD YIELD ESTIMATES

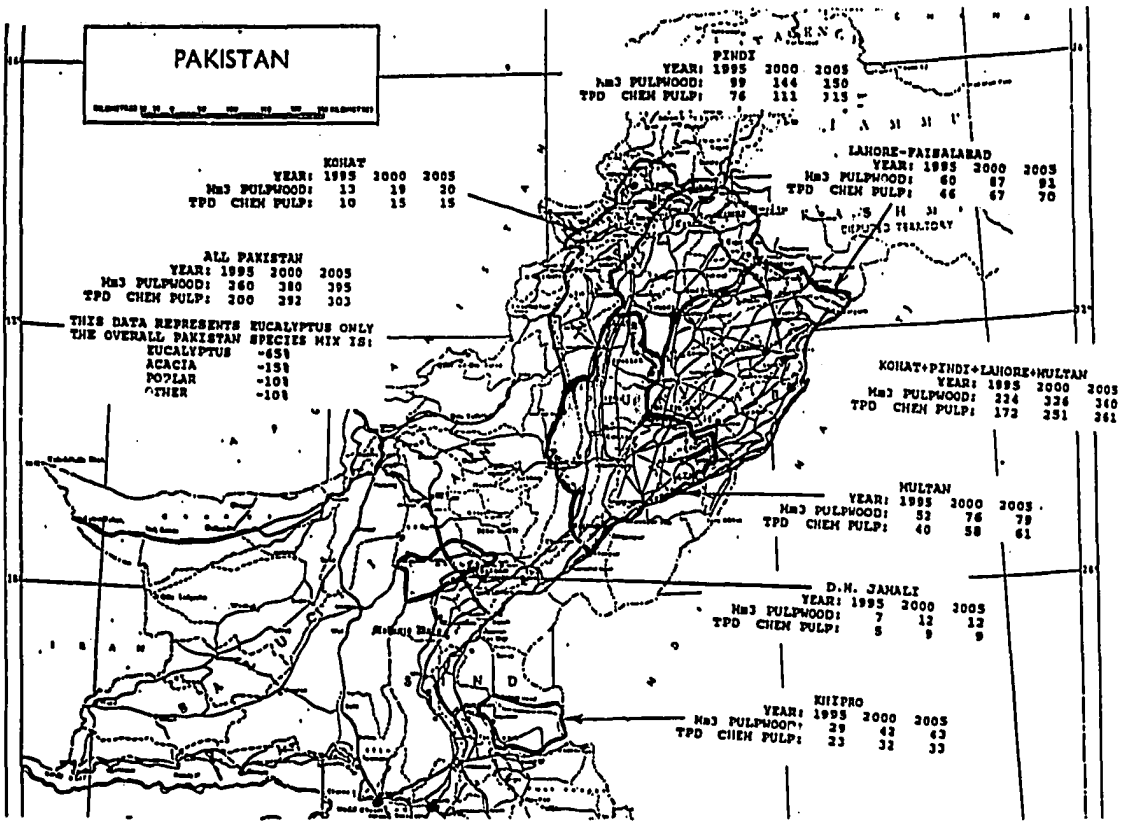


TABLE 7: PAKISTAN TREE FARM CIRCLES

ANNUAL VOLUME AND CHEMICAL PULP YIELD ESTIMATE

	CIRCLE	KOHAT	PINDI	LAHORE	MULTAN	JAHALI	KHIPRO	TOTAL
1991	HECTARES	1,264	3,298	2,247	3,222	750	2,564	13,345
	1000m3	13	37	25	36	7	29	147
	TPD KRAFT	10	28	19	28	5	22	113
1995	HECTARES	1,264	8,878	5,417	4,639	750	2,564	23,512
	1000m3	13	99	60	52	7	29	260
	TPD KRAFT	10	76	46	40	5	22	200
2000	1000m3	19	144	87	76	12	42	380
	TPD KRAFT	14	104	63	55	9	30	274
2005	1000m3	20	150	91	79	12	43	395
	TPD KRAFT	15	116	70	61	9	33	304

Hm3 = 1000 cubic meters annually; TPD = tons per day of chemical pulp
mechanical pulp would be double.

This data indicates 172 TPD expanding to 260 TPD of chemical pulp (Kraft, sulfite, etc.) could be manufactured in the Multan to Charsadda region. Approximately twice that amount of mechanical pulp (groundwood, TMP, BCTMP, etc.). This presumes the full estimated volume goes for pulpwood. This is an all new supply estimate, and, we believe safely conservative. Considering that, and if Dr. McKenna's projections are in line (McKenna, WR/AID #1 & #2, JUN-90), the volume should be deliverable if a fair price is offered. See Pulpwood Value, below.

This subject needs much more and definitively quantitative study, especially regarding developing robust tree varieties, cultivation and rotation techniques. Such study, no doubt will be continuing and evolving. However, unless a market for the wood is established and farmers are motivated to plant, and continue to grow and harvest, the whole thing becomes moot.

PULPWOOD PREPARATION:

Equipment and other capital expenditures will be necessary for chippers, screens, conveyers and storage facilities. All except the chippers must be at the pulp mill. A chipper/screen unit for 25cm logs requires 150 Kw; 40cm max. diameter logs unit requires 200Kw. Units are available electric or diesel powered. A complete facility based upon the larger chipper will cost Rs.3-5 million, the higher cost including a de-barker. See Exhibit 8.

Hardwoods are usually debarked with a drum de-barkers. Ring de-barkers also may be used, especially for low volumes and for Eucalyptus. For initial consumption, hand peeling by supplier labor is suggested. This will increase purchase value and we believe, be economically feasible in Pakistan with its low labor cost. Also there is a fair chance that debarking of young Eucalyptus may not be necessary, although that would increase chemicals consumption and increased risk of dirt.

Chip quality is of high importance to pulp quality. Also chippers require large motors and are high maintenance apparatus. There are portable chippers, gas or diesel driven, but they are more costly than electric drives, and portability aggravates maintenance and chip quality. For these reasons we recommend that chipping facilities be at the mill, and not by suppliers.

An important exception could develop. That is establishment of a wood procurement and processing to chips enterprise. This could supply quality chips to mills, especially those too small to justify their own facility, e.g. the Sheikhupura mills. Also, there is substantial world market for pulp wood chips. This could be by individual or consortia of users, suppliers and dealers. This is a mechanism for bringing the wood supply under management, preceding establishment of a modern, large scale pulp mill.

PULPWOOD VALUE:

We have estimated the value of pulpwood to the **existing** Pakistan pulp and paper industry. This is based upon replacement of present fiber source, i.e., straw-Kahi-bagasse for in-kind pulp, and for a product replacing imported bleached chemical pulp. The following considerations were applied.

ITEM	ANNUAL FIBER	WOOD CHIPS
NET PULP YIELD, %	28	45
CHIP BULK DENSITY RANGE, Kg/M3	130-170	160-250
CHIP BULK DENSITY USED, Kg/M3	150	200
UNBL. Ka. No., ml	20	25

Variable and fixed costs were adjusted accordingly to generate Table 8 and Figure 4. Details are in and Exhibit 6.

TABLE 8: PAKISTAN PULPWOOD VALUE EXAMPLE

FIBER/CONDITION	VALUE, Rs.			PRODUCTION INCREASE
STRAW, KAHI COST/MOUND	24	36	48	
STRAW, KAHI COST/TON	600	900	1,200	0%
PULP COST/TON	9,740	10,800	11,860	
WOOD VALUE/TON				
Replace straw pulp	582	1,059	1,536	0%
Yield benefit	887	1,364	1,841	137%
Bulk density benefit	1,026	1,503	1,980	187%
Replace Bleached Kraft	5,744	5,744	5,744	187%

Young E. camaldulensis chips should make an excellent hardwood pulp, but not on par with softwoods. We believe that it can replace 30% to 70% of imported softwood kraft, 50% on average. This places wood chip value at about about Rs.3,500 per OD ton. This presumes the mill's ability to use the production increase. THis might necessitate plant improvements to enable the increase, but in all events would be much less than total pulp plant expansion.

FIGURE 4: PULPWOOD VALUE vs. STRAW/KAHI COST

FIGURE 4a: INCLUDING IMPORTED PULP AT Rs.20,000/TON

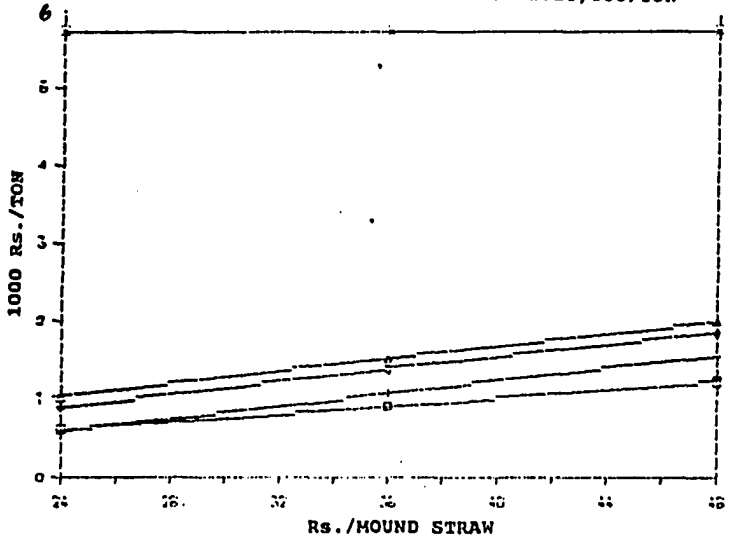
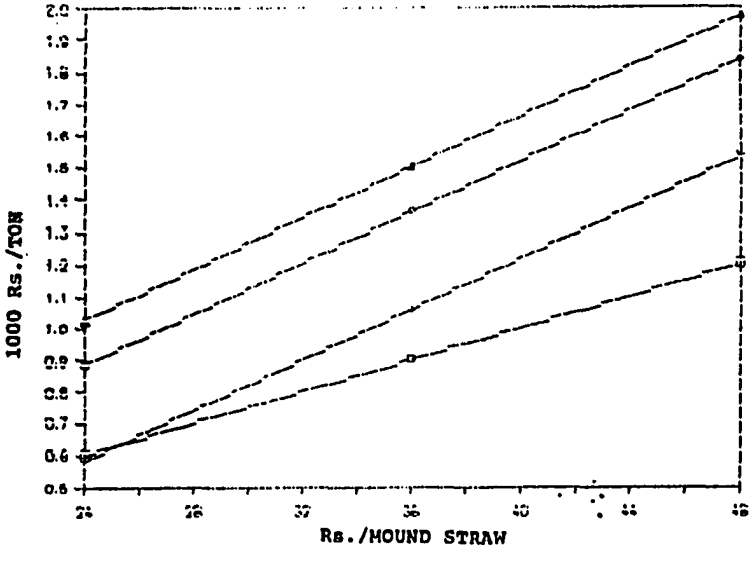


FIGURE 4b: EXCLUDING IMPORTED PULP



- ▫ STRAW/KAHI
- ✦ WOOD REPLACEMENT FOR STRAW/KAHI
- ◇ PLUS YIELD BENEFIT @ 137%
- △ PLUS YIELD AND BULK BENEFIT @ 187%
- ✕ REPLACING IMPORTED BLEACHED CHEMICAL PULP @ Rs.20,000/TON

RECOMMENDED PROCESSING OF PAKISTANI WOOD FOR PAPER PULP

There needs be no particular concern as to the suitability of Pakistani woods for pulp manufacture. The pine, spruce and fir conifers are generally accepted as capable of producing excellent chemical pulps, particularly with the kraft process. Likewise, poplar, acacia and young E. camaldulensis can yield very good hardwood kraft and soda pulp. The conifers are also suitable for most mechanical pulp varieties; the hardwoods yield satisfactory mechanical pulp types with TMP, CMP, CTMP and similar methods. They generally are unsatisfactory for groundwood and refiner mechanical pulps or require excessive power.

Both softwoods and hardwoods can yield satisfactory pulps with the sulfite process. We have not considered acid sulfite. Neutral sulfite and bi-sulfite, i.e. pH from 3-10, might not normally be considered. But since this is the process in most common use in Pakistan, its interim use is recommended. This would enable existing mills to commence wood utilization, on a modest scale and investment. This would facilitate developing pulpwood supply-demand on a gently evolving basis. It would also enable evolving development of pulp process and paper-making technique with very little risk. But pulping process development work is needed.

The neutral sulfite process for bleachable and fine paper pulps is not without precedence; nor is it now very common. However, excellent pulps can be made, particularly from hardwood. The sulfite recovery process is difficult. Therefore most world producers have abandoned it for the kraft process. There are no sulfite recovery operations in Pakistan today; all mills dump their spent liquor. Use of ammonia or ammonium sulfate instead of sodium might be considered; it is usually less expensive and would have fertilizer value used in irrigation. Recovery processes will become viable with larger scale operations.

However, this proposal is not without problems. Neutral sulfite pulp from the digester usually must be refined (hence called neutral sulfite semi-chemical, **NSSC**). And it has a higher Ka. No. than kraft requiring more bleach. Process conditions should be laboratory pilot plant developed and tested to establish viability and most probable mill conditions. These need to be as near as possible to existing mill conditions. The individual mills can then set about development and tests appropriate their apparatus and conditions. See Exhibit 7 for a proposal in this regard.

Should this prove unacceptable or not viable, Bleached kraft or soda processing is most desirable, as it will eventually be anyway. But initial supplying of sufficient wood for even a very small dedicated mill, would be a severe challenge.

Groundwood, RMP, TMP, CTMP, BCTMP etc. require 1,800-2,400 Kw-hr./ton and yield pulp quality similar to or lower than straw. It is doubtful if the power could be supplied, e.g. 7-10 MW for 100 TPD. It is being considered on a smaller scale by existing mills, but most likely they will, in fact, do NSSC.

STUDY OF TREE FARM WOOD UTILIZATION
FOR WOOD PULP PRODUCTION IN PAKISTAN

SUMMARY

This report is an overview of Pakistan's present and future paper pulp and related fiber requirements and resources; her papermaking industry; and relevant technology. The purpose was to elucidate and recommend appropriate supply and demand options with respect to the traditional fiber supply, tree farm enterprise, and other possible wood fiber supply.

Pakistan is an economically emerging nation. She is amongst the lowest per capita pulp and paper consumers; she must import much of her requirements, about Rs.2.2 billion/yr. Growth of demand will accompany economic growth; this is projected at 894,000 TPA by 1999 compared with 392,000 TPA in 1988-89.

The Pakistani pulp and paper industry was examined. Fourteen paper mills and several other institutions were visited and key personnel interviewed. We estimate present capacity at 273,000 TPA operating; another 192,000 TPA in planned or idle capacity for 465,000 TPA total. 1988-89 reported domestic production was 164,000 tons paper products and about 100,000 tons pulp.

About 30% of pulp used is imported, primarily bleached softwood chemical types. There is no domestic wood pulp production. Most mills are interested in using wood and in position to commence using wood in modest amounts as soon as available and chip preparation apparatus installed.

Three of the largest operators have stated intentions to build new facilities or substantially expand by 25,000 to 50,000 TPA pulp and higher. They will design for and use wood, if it is available in sufficient quantity to justify added investments. These are established, experienced pulp and paper mill operators.

The country is very poor in forest and woodlands. Endeavors are underway to ameliorate this through tree farming, particularly Eucalyptus camaldulensis and Poplar species. A stable market needs be established, remunerating growers of these tree crops, if planting is to continue and aforestation succeed.

Tree farm stands and potential harvest were estimated to be sufficient to support chemical pulp production of about 170 TPD in 1995 and 260 TPD in 2005. The geography ranges from Multan to Pershawar. Smaller groupings indicate wood supply for 90 to 130 TPD. Thus, capturing all of this wood might enable a small Kraft mill. It could support about twice that amount in TMP. This wood is generally within economical transport of existing paper mills. More aggressive planting could substantially increase this.

We estimate capacity for about 20-30 TPD in the Khipro circle vicinity of Sind; less in the the D.M. Jamali circle. This was not further assessed.

A new, 100 TPD market TMP-type mill (minimum economic size) would cost $25-$40 million. Smaller, used equipment mills are possible and could be installed for substantially less. But TMP types are high power consumers, e.g. 240,000 Kw-hr./day for 100 TPD, 10 MW, and much beyond the willingness of WAPDA to service. Power generation facilities costs about $1 million/MW and require fuel.

A 100-150 TPD bleached kraft pulp mill (minimum economic size) will cost $75-100 million. A used equipment mill would be $40-70 million . The Kraft mill would generate 50%-70% of its own power and with supplementary fuel, often biomass, even surplus power.

E. camaldulensis pulp quality was investigated from the standpoint of Pakistani use and processing methods. Bleached kraft, would be most desired and could displace up to 70% of that imported. Satisfactory pulp can be produced from other chemical processes including the soluble base sulfite and soda currently used by the Pakistani industry. Satisfactory TMP-BCTMP could also be produced, but power requirements at over 2000 Kw-hr./ton are problematic, and it would displace straw, not imported pulp.

Pulpwood supply commercial relations, transportation, distribution and wood processing facilities do not currently exist. It will take some time to get this established, especially in volume to support a market pulp mill. The fiber supply to a pulp mill must be dependable for the mill to be viable. Therefore, we conclude that proposals for near term establishment of new Kraft or TMP pulping facilities to be, at best tenuous. Particularly as compared with other opportunities.

Most Pakistani mills desire to use pulpwood as available; initially around 10%-20% of their fiber requirements - 30,000 TPA pulp; 60,000 m3PA wood. This would get supply-demand flow established on a modest, orderly basis. Their potential wood usage capability is 220,000 m3PA for 170 TPD of pulp by 1995.

The use of wood for pulp can be expected to bring the following product, production and cost benefits:

-Pulp yield of 45% vs. less than 30% for straw/Kahi; 36% higher.

-Reduce digester charge time to 20-40 minutes to 4 Hours cover to cover from current 5-6 hours; increase production 25%-50%.

-Packed chip bulk density 200-250 Kg/m3 vs. 130-170 for straw; Increase digester charge 50-90%; comparable production increase.

-Eliminate need for rotating digesters; power and mechanical maintenance saving; speed up charging and dumping.

-Improved runability for the balance of the pulp mill and on the paper machines.

-Product substitution for imported pulp costing Rs.20,000-22,000 per ton vs. ~Rs.9,000-10,000 for straw; higher product quality.

Disadvantages from using wood are possible increase in chemical requirements in both pulping and bleaching, and increased power for defibration. These should be modest.

To the extent gains over straw are achieved, the value of pulpwood will increase. This can be as high as Rs.6,000/OD-ton for full imported pulp substitution. The mill operators will develop and learn the value; competition will bring the price.

The initial wood price would be Rs.800-1200/OD ton (Rs.32-48/mound; Rs.400-600/m3) FIS mill; RS.20-30/mound to the grower. This is competitive or better than straw and bagasse, and somewhat higher than fuel. It is expected that price paid will respond to value and supply, quickly reaching Rs.1,500 and higher. When tree-farm stands, harvest and deliverability are sufficient, a full-scale pulp will become necessary and viable.

Use of wood requires installation of receiving, scaling, chipping and screening facility, preferably at the mill. This will cost Rs.3-5 million ($150,000-300,000). Initially hand debarking can be done, by farmer, middleman or mill. With higher volume mechanical debarking will be more desirable.

All mills visited express willingness to do the following:

-Announce their desire to purchase substantial wood

-Offer a reasonable minimum price, but pay at market

-Install the necessary chip processing and handling apparatus

-Modify their pulping facilities to enable processing chips.

NSSC Processing of Eucalyptus and Poplar could be compatible with their existing processes. However, development work is needed, to find the most promising pulping conditions. This should be on a pilot scale, to minimize mill trial work and production loss. A memo proposal in this regard is in Exhibit 7.

A mill exists in Pakistan capable of bleached kraft pulp production. That is Pakistan Paper Co., Charsadda, NWFP. It is in liquidation, and will come out free of the debilitating debt.

This could be a good paper-making plant, and has most features for a 100-150 TPD bleached Kraft pulp mill. There are evidences it could be in advantageous position to receive a substantial portion of tree-farm hardwood as well as develop some NWFP, North and Kashmir softwood supply. There are problems relating to labor and politics. According to our information, none of the indicated purchase candidates has pulp & paper experience; existing paper industry management stated dis-interest due to the labor and political situation. A feasibility study needs to be made to certify its capabilities, condition and needs.

CONCLUSIONS:

The Pakistan pulp and paper industry consists of small mills, with largely pre-1950 vintage apparatus and methods. They produce pulp from grasses and import chemical pulps. Present papemaking capacity could consume 1.1 million m3PA of pulpwood.

Tree farming is underway, capable of supporting 200-300 tpd chemical pulp, but no pulpwood trade exists today. The existing industry can use wood for 10%-20% of their production quickly and easily; This should be developed to get supply-demand underway. Once supply is established, larger facilities will become viable; as production increases they will be necessary.

Three avenues for increasing wood pulp production and for utilization of tree-farm wood exist:

1. Establish bleached kraft market pulp mills; minimum capacity: 100 TPD; Cost Rs.1-2 billion ($50-100 million). This would displace part of present imports and satisfy papermaking needs.

2. Establish market BCTMP mills; minimum capacity, 100 TPD; cost Rs.50-80 billion ($25-80 million). This would only displace straw pulp and be most useful for newsprint-type papers.

3. Wood utilization by existing industry, essentially within existing plant and process; minimum capacity: 4-8 hr./day, 10%, of current capacity; cost: Rs.2-5 million ($200,000-500,000). This could displace as much imports as would option 1, and enable evolution of the wood supply.

The capital cost and availability of startup wood supply are formidable obstacles to options 1. and 2. They could be reconsidered when the wood supply capability becomes adequate. The viability of Option 3 is dependent upon development of conditions satisfactory for producing the pulp. There is historical precedence for this, although it is not fashionable in the current industrialized world. However, technical assistance in developing satisfactory conditions for pulping the E. Camaldulensis is necessary, at both pilot and mill scale.

The existing Pakistani pulp and paper industry is in good position to develop viable methods of wood supply and pulp production. However, no prior experience exists in the country. Therefore assistance as recommended above will catalyze getting this going and established. Technical and financial assistance in developing methods of harvest, transport and preparation of the wood will further facilitate getting this underway.

As the volume of pulp production increases, processes for chemicals recovery, energy production, environmental preservation, etc. can be considered as appropriate to economics and other circumstances. This will lead to Option 1., above. The market and cost savings will make it financially feasible; the wood supply and pulp market should then be in place.

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1. Encourage the existing industry to commence purchase and utilization of tree farm wood.

2. Assist organizing meetings between the pulp industry and farmers. These would be to familiarize farmers with mill pulpwood requirements, familiarize mills with farmers needs and concerns, and establish initial lines of supply-demand. This would include presentation of our findings, mill/farm visits and announcement of purchase agreements. The mills are willing to sponsor the meetings at their premises.

3. Organize technical and business meetings for each group, pulpwood supplier and user. For the mills, this would include technical presentations as to utilization methods: preparation, handling, pulping, paper-making, etc. Also procurement and contracts. For the farmers, experience of others in planting, harvesting, debarking, and delivery.

4. Assist formation of supplier-user co-operative or trade organization. This will strengthen the buyer-user marketplace circumstance vis a vis middleman traders. This is not to preclude them, but create a better competition. It will also assist technical and commercial communications.

5. Sponsor and fund the "neutral" sulfite pilot research and development to find the conditions satisfactory for pulping wood and compatible with those for existing fiber. Subsequent work should seek to find the best quality conditions.

6. Sponsor and fund design of wood handling, transport and most particularly chip processing apparatus; fund or assist funding purchase and installation of these.

7. Sponsor and assist education programs. There is great need for pulp and paper technology education at all levels. Particularly the entry professional and vocational level for operators, technical, supervisory and management personnel. This could be through the above trade/technical organization via, e.g. Punjab University Chemical Engineering School, PFI and other appropriate institutions.

8. Conduct a pulpwood supply projection: stands, growth, optimum and probable harvest; determine and recommend optimum pulpwood rotation, i.e. young wood and maximum, rapid returns.

9. Investigate tree farm planting of conifers; these are most desirable and valuable for both solid wood and pulp products. Are there not robust, fast growing species available?

10. Encourage and facilitate takeover and operation of Pakistan Paper Corp., Charsadda by one of the leading Pakistani pulp & paper firms. Before this can happen the counter-productive government, political and labor situations must be remedied.

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E. CAMALDULENSIS VOLUME AND YIELD DATA

Per G. Naughton
for partial planting & partial harvest

AGE YEARS	VOLUME m3/H	YIELD m3/H/Yr	PULP @ 330 DPY T/H	H/TPD
1	10.0	10.0	6.3	52.8
2	32.2	16.1	10.1	32.8
3	40.8	13.6	8.5	38.8
4	56.9	14.2	8.9	37.1
5	60.3	12.1	7.5	43.8
6	65.0	10.8	6.8	48.7
3-4	48.9	13.9	8.7	38.0

E. CAMADULENSIS VOLUME YIELD DATA

Per T.A. Ansari & PFI
for dedicated planting and total harvest

	PLANTING SPACING					
	1.5m X 1.5m		1.8m X 3.0m		3.m X 3.m	
AGE	VOLUME	MAI	VOLUME	MAI	VOLUME	MAI
2	97.7	9748.9	60.6	30.3	33.1	16.6
3	124.5	2441.5	71.9	24.0	59.9	20.0
4	143.2	4335.8	114.1	28.5	85.4	21.4
5	159.4	5931.9	129.9	26.0	93.7	18.7
6	182.1	8230.3	146.6	24.4	106.0	17.7
7	202.5	0228.9	119.6	17.1	151.9	21.7
8	222.8	2227.9	132.2	16.5	140.2	17.5

E. CAMADULENSIS BASIC WOOD DATA

Basic Density 620-700 Kg/m3
Typical Moisture: 70.0% H2O/OD WOOD ---> 41.2% H20/WET WOOD
Bark:10-15%
Chips: --->2.8-3 m3/m3 solid wood; 210-250 Kg/m3

Ref.: GWA1-L0081101

ESTIMATES OF PULPWOOD AVAILABILITY ROM TREE-FARM HARVEST

G. NAUGHTON & G. WIRE

	CIRCLE	KOHAT	PINDI	LAHORE	MULTAN	JAMALI	KHIPRO	TOTAL
1991	HECTARES	1,264	3,298	2,247	3,222	750	2,564	13,345
	CM/H	10.3	11.2	11.1	11.2	9.3	11.3	11.0
	1000CM	13	37	25	36	7	29	147
	TPD KRAFT	10	28	19	28	5	22	113
1995	HECTARES	1,264	8,878	5,417	4,639	750	2,564	23,512
	CM/H	10.3	11.2	11.1	11.2	9.3	11.3	11.1
	1000CM	13	99	60	52	7	29	260
	TPD KRAFT	10	76	46	40	5	22	200
2000	CM/H	15.0	16.2	16.1	16.4	16.0	16.4	16.2
	1000CM	19	144	87	76	12	42	380
	TPD KRAFT	14	104	63	55	9	30	274
2005	CM/H	15.8	16.9	16.8	17.0	16.0	16.8	16.8
	1000CM	20	150	91	79	12	43	395
	TPD KRAFT	15	116	70	61	9	33	304

PER PFI: 1.5m X 1.5m, 3-4 YEAR HARVEST, m3/Hec YIELD = 38.574

YEAR	CIRCLE	KOHAT	PINDI	LAHORE	MULTAN	JAMALI	KHIPRO	TOTAL
1991	HECTARES	1,264	3,298	2,247	3,222	750	2,564	13,345
	1000CM	49	127	87	124	29	99	515
	TPD KRAFT	28	73	50	71	17	57	296
1995	HECTARES	1,264	8,878	5,417	4,639	750	2,564	23,512
TO	1000CM	49	342	209	179	29	99	907
2005	TPD KRAFT	28	197	120	103	17	57	521

Ref.: GWA1-L0060903

ESTIMATING METHODOLOGY

G. NAUGHTON

1. Using available project reports and statistics, plus some additional records of on-farm and government lands tree planting since 1985, I tabulated the data for eucalyptus planting by year and by district, making downward adjustments in actual acreage reported on all stands which were reported as less than 85% survival. A table was developed for the per year plantation by district through 1990.

2. Based on the known acreages planted and the trend reflected by the past years' activity, I took a conservative projection of the number of acres which would be planted, by district, in the years 1991-1995. I then assumed that no additional new plantings would be done past 1995, and that all future harvest would be done on a coppice rotation of 5 years for the first cut and recurring at 4 year intervals.

3. The first year for available harvest under this scheme would have been 1990, but because the market is not yet developed, the first harvest was postponed until 1991. This gave a slightly larger total resource volume available through the first rotation.

4. Yield data for Eucalyptus plantations, as reported in the Pakistan Journal of Forestry, were modified by reducing the yields to 65% to account for volume losses due to stick sizes of less than 1.5 inches in diameter, and to account for less than perfect performance and management conditions. The plantation yields for stands planted at 3 X 1.8 meters were used. These gave average yields 65 cu.m/ha at age 6, 60.4 cu.m/ha. at age 5, and 56.9 cu.m at age 4. It can be argued that these figures underestimate the potential yields, but I didn't want to stretch the estimates because we are working at a macro scale which covers widely divergent site, climatic, edaphic, and management regimes. Harvest at age 3 was considered premature because of material size at that age.

5. Working from the Atlas of Pakistan, prepared by the Survey of Pakistan in 1985, all districts which are actively growing eucalyptus were grouped together into 6 working circles of contiguous districts, making some judgments based upon political subdivisions, road and rail networks, etc. This will provide potential users information about the approximate production capability in different areas.

6. To check the reality of the estimates and the relative potential for further planting, the Atlas was used to derive total area, total arable area, total productive cropland, and potential additional tree plantation land, by district and

working circle. These calculations assumed that there is no productive cropland available for farm forestry, and that any expansion of tree planting on farms will necessarily be limited to :

1. waterlogged soils (212,000 ha) WAPDA map, 1989
2. saline soils (unknown amount)
3. eroded (non-tillable) areas (425,000 ha.) based on 5% of the uncultivated arable lands -- the balance to remain in pasture
4. field borders on croplands (187,000 ha.) @ 1.3% of tillable land area

These figures total 824,000 ha. of farmlands available for tree planting, as against an estimated 24,000 ha. already planted, for a potential remaining area of 800,000 ha. If the market demand is sufficient to make tree growing profitable to farmers, most of this land will find its way into the farm forestry system, at least temporarily. On a country-wide basis, it shows that Pakistan can easily expand its forested area to 5% of the total land base. About 21% of the total forested area would be on private lands, complementary to and not conflicting with agriculture.

7. Annual potential pulp tonnage was derived on the basis of the step-wise projections of stand ages and areas, by district and working circle. An erratic flow of product resulted because of the uneven area planted per year. However, this gives the growers a chance to postpone harvest for up to two years to take advantage of market price fluctuations.

8. Finally, using these data, the projected plantation area through 1995, and the lumpiness of the year-to-year outputs, we derived a 3-year rolling average of potential production for the base years of 1995, 2000, and 2005 as estimator points. By using the rolling averages, the production figures provide a more consistent forecast of future supply.

E. CAMADULENSIS VOLUME YIELD DATA

CHEMICAL CONSULTANTS (PAKISTAN) LTD.

TABLE - 3.1.

Punjab - Availability of Eucalyptus

Name of Division	Area in acres.	Volume in M^3	Weight in tons.
1. Lal Sohanra National Park (Bahawalpur).	872.50	8959.191	6316
2. Bahawalpur Forest Divn.	1475.00	78975.486	55678
3. Sahiwal Forest Divn.	5.50	58.989	42
4. Multan Forest Divn.	185.50	11955.349	8428
5. Chichawatni Forest Divn.	310.00	32080.933	22617
6. Muzaffargarh Forest Divn.	63.00	2152.941	1518
7. Mianwali Forest Divn.	207.00	2870.518	2023
8. Faisalabad Forest Divn.	879.17	21640.210	15961
9. Bhakkar Forest Divn.	45.70	2205.183	1555
10. Shahpur Forest Divn.	393.25	2351.070	1658
11. Jhang Forest Division	732.10	36283.314	26580
12. Kasur Forest Division	139.50	10735.308	7561
13. Rawalpindi Forest Divn.	100.00	5813.245	4098
	5448.22	216073.737	152035

BEST AVAILABLE DOCUMENT

E. CAMADULENSIS VOLUME YIELD DATA

CHEMICAL CONSULTANTS (PAKISTAN) LTD.

TABLE - 3.2.

Punjab- Current Availability of Eucalyptus by age of trees.

Current age:-	1-3 years Weight(Tons)	4-6 years Weight (Tons)	7 years and above Weight (Tons)
Lal Sohanra National Park, Bahawalpur.	6316	-	-
Bahawalpur Forest Divn.	4475	12351	38851
Sahiwal Forest Division.	41.5	-	-
Multan Forest Division.	-	-	8428.5
Chichawatni Forest Division.	-	-	22617
Muzaffargarh Forest Division.	183	1140	195
Mianwali Forest Division.	1434	-	-
Faisalabad Forest Division.	10089	1009	4863
Bhakkar Forest Division.	226	733	596
Shahpur Forest Division, (Jauharabad)	1658	-	-
Jhang Forest Division.	3098	6776	16706
Kasur Forest Division, (Changa Manga).	-	3884	3678
Rawalpindi North Forest Division.	-	335	3764
	27111	26228	99699

BEST AVAILABLE DOCUMENT

not in substantial form. The Forest Department reports that the area can be extended immediately when the Department knows that there is ready market for disposal of Eucalyptus wood. Moreover, the farmers will also start planting Eucalyptus if they come to know that ready market is available for this species.

3.4. Yield of Eucalyptus Camaldulensis.

The per hectare yield of Eucalyptus Camaldulensis has been worked out on the basis of following yield table prepared by Pakistan Forest Institute, Peshawar :-

Age in years	Volume in M^3	Mean Annual Increment (M^3)
1	16.531	16.531
2	33.063	16.531
3	71.943	23.981
4	114.128	28.532
5	129.901	25.980
6	146.640	24.440
7	119.604	17.086
8	132.174	16.522
9	171.134	19.015
10	164.638	16.464
11	170.437	15.494

It would appear from the above Table that the best rotation for working of Eucalyptus Camaldulensis is 5 to 6 years. However, from data available from Brazil and Portugal, a 8-year period is considered best for pulp and paper.

3.5. Future Availability of Eucalyptus Camaldulensis.

The total requirements for producing 100, 120 and 200 tons per day of pulp (at 45 % recovery) at full capacity are as given below after accounting for 15% barki-

BEST AVAILABLE DOCUMENT

E. CAMADULENSIS VOLUME YIELD DATA

CHEMICAL CONSULTANTS (PAKISTAN) LTD.

	Tons of wood/year
100 tons/day pulp (330 days/year)	86,300
120 tons/day pulp (330 days/year)	103,500
200 tons/day pulp (330 days/year)	172,600

From the Table given above, the yield per hectare at 6 years is 135.995 cubic metres per hectare, or 95.2 tons per hectare per year. To meet the demands above, therefore, the requirement of area is :-

100 tons/day plant	-	907 hectares or 2,220 acres.
200 tons/day plant	-	1811 hectares or 4,440 acres.

In actual practice, as can be seen from the data in Table 3. the current yields in good plantations (See Bahawalpur) reaches 90 tons/hectare. However, to be on the safe side, areas of 2500 acres and 5000 acres per year would have to be considered to account for parts of the forest which would not coppice well. For 120 tons/day plant 3000 acres per year will be required.

On the basis of the 6-year cycle, therefore, the total area required would be 15,000 acres for the 100 ton plant and 30,000 acres for the 200 ton plant. The 120 tons per day plant would require 18,000 acres.

If the 8-year cycle is considered, then the actual yield would increase to 169.6 cubic metres per hectare or 118.7 tons/hectare or nearly 25 % above the 6-year yield. The area of forest land required would thus be proportionately less per year, but since the cycle would be 8-years, the total required would be slightly more (about 6 % more).

From the areas of the plantation given above, it is clear that this area could be made available, basically in two areas : Bahawalpur Forests or the forests in the Pirawala - Chichawatni - Kamalia - Shorkot area, with the latter area being preferred (availability of forest land is 50,390 acres in the four plantations).

BEST AVAILABLE DOCUMENT

EXHIBIT 2

PAKISTAN PULP AND PAPER INDUSTRY

TABLE E2.1: PAKISTAN PULP AND PAPER INDUSTRY DATA - SUMMARY

	METRIC TONS PER YEAR				
	FIBER	PULPING		PAPER	PULPWOOD
COMPANY	SOURCE	PROD.	DIG.	PROD	POTENTIAL
NWFP OPERATING	30,357	8,500	11,500	30,000	66,660
NWFP IDLE	89,286	25,000	25,000	30,000	66,660
NWFP PLANNED	0	0	0	0	0
NWFP TOTAL	119,643	33,500	36,500	60,000	133,320
PUNJAB OPERATING	437,500	135,300	234,300	211,900	447,971
PUNJAB IDLE	35,714	10,000	16,000	16,500	36,663
PUNJAB PLANNED	262,521	86,750	132,500	109,300	342,891
PUNJAB TOTAL	735,736	232,050	382,800	337,700	827,525
TOTAL SIND OPERATING	73,429	21,500	35,500	31,000	68,820
TOTAL SIND IDLE					
TOTAL SIND PLANNED	17,857	5,000	7,500	37,000	82,140
TOTAL SIND	91,286	26,500	43,000	68,000	150,960
TOTAL PAKISTAN OPERATING	541,286	165,300	281,300	272,900	583,451
TOTAL PAKISTAN IDLE	125,000	35,000	41,000	46,500	103,323
TOTAL PAKISTAN PLANNED	280,379	91,750	140,000	146,300	425,031
TOTAL PAKISTAN	946,664	292,050	462,300	465,700	1,111,805

REF.: GWA.1-L0051704, 13-Aug-90

TABLE E2.2: PAKISTAN PULP AND PAPER INDUSTRY DATA - NWFP

*IDLE; **PLANNED

			METRIC TONS PER YEAR						
			FIBER		PULPING			PAPER	PULPWOOD
NO.	COMPANY	LOCATION	TYPE	SUPPLY	PROD.	TYPE	DIG.	GRADE	PROD.	POTENTIAL
1	PAKISTAN PAPER CORP.**	CHARSADDA	B	89,286	25,000		25,000	FINE	30,000	66,660
2	ADAMJEE	NOWSHERA	S,K,C	30,357	8,500	N	11,500	P/W,D	30,000	66,660
3	ADAMJEE**	?								
	NWFP OPERATING			30,357	8,500		11,500		30,000	66,660
	NWFP IDLE			89,286	25,000		25,000		30,000	66,660
	NWFP PLANNED									
	NWFP TOTAL			119,643	33,500		36,500		60,000	133,320

REF.: GWA.1-L0051704, 13-Aug-90

TABLE E2.3: PAKISTAN PULP AND PAPER INDUSTRY DATA - PUNJAB

*IDLE; **PLANNED

NO.	COMPANY	LOCATION	FIBER TYPE	FIBER SUPPLY	PULPING PROD.	PULPING TYPE	PULPING DIG.	PAPER GRADE	PAPER PROD.	PULPWOOD POTENTIAL
					METRIC TONS PER YEAR					
4	THAL PAPER IND.**	JAUHARABAD				M		NEWS	17,000	21,250
5	INT'L FIBROUS PROD.**	KHUSHAB						P/W	10,500	23,331
	TOTAL								27,500	44,581
6	FAROOKI PULP MILLS**	GUJRAT	W	77,700	35,000		52,500			116,550
7	FIRDAUS PAPER IND.	GUJRANWALA	S					C	3,000	6,666
8	GHULUM QADIR STRAW BD	GUJRANWALA	S					C		
9	JUBILEE P'BOARD MILLS*	GUJRANWALA	S	35,714	10,000	L-S	20,000	C,L,FB	15,000	33,330
10	LASANI STRAW BOARD*	GUJRANWALA	S	10,714	3,000	L-S	6,000	C	3,300	7,333
11	SETHI STRAW BOARD	GUJRANWALA	S	21,429	6,000	L-S	12,000	C	8,000	17,776
12	SULTAN P'BOARD MILLS*	GUJRANWALA	S	2,679	750	L-S	2,000	C	1,500	3,333
	TOTAL			70,536	19,750		40,000		30,800	68,438
13	ALI PAPER BOARD*	SHEIKHUPURA		21,429	6,000	N	10,000	FB	10,500	23,331
14	ARSHAD KHURSHID PAPER**	SHEIKHUPURA		28,571	8,000	N	12,000		12,000	26,664
15	BAHAWALPUR BOARD MILLS*	SHEIKHUPURA	S	14,286	4,000	N	6,000	P/W,F	6,000	13,332
16	FLYING PAPER IND.	SHEIKHUPURA	S	52,143	14,600	N	18,000	P/W	24,000	53,328
17	GHAZI PAPER*	SHEIKHUPURA	S	21,429	6,000	N	12,000	P/W	10,200	22,664
18	PAKISTAN BOARD MILLS	SHEIKHUPURA	S	8,929	2,500	N	4,500	F,L,M	4,500	9,999
19	PAKISTAN PAPER PROD.	SHEIKHUPURA	S	7,857	2,200	N	4,000	F,M	5,400	11,999
20	PREMIER PAPER MILLS	SHEIKHUPURA	S	25,000	7,000	N	8,400	P/W	10,500	23,331
21	PUNJAB BOARD MILLS	SHEIKHUPURA	S	0						
22	QADRIA BOARD MILLS	SHEIKHUPURA	S	7,143	2,000	N	6,000	F/L	4,800	10,666
23	SAMPAK PAPER & BOARD	SHEIKHUPURA	S	17,857	5,000	N	8,000	F	21,000	46,662
24	SAYID PAPER MILLS	SHEIKHUPURA	S	7,143	2,000	N	4,000		3,000	8,888
	TOTAL			211,786	59,300		92,900		111,900	250,864
25	AL-QURESH	LAHORE	S	10,714	3,000	N	4,000		3,000	6,666
25	BABAR PAPER MILLS	LAHORE	S			N				
27	PACKAGES LTD.	LAHORE	S	64,286	18,000	N	45,000	T,P/W,F	42,500	94,435
28	PACKAGES LTD.**	LAHORE	S	107,143	30,000	N	40,000	T,P/W,F	50,000	111,100
29	SHALIMAR PAPERS	LAHORE	S	25,000	7,000	N	8,400		12,000	26,664
	TOTAL			207,143	58,000		97,400		107,500	238,865
30	CENTURY PAPER & BOARD	CHUNIAN, KASUR	S,B	128,571	36,000		50,000	T,P/W,F	36,000	79,992
31	CRESCENT HARDBOARD	FAISALABAD	B,W	40,000	24,000		50,000	HB,PB	24,000	28,235
32	INDUS PAPER MILLS**	RAJHUNPURA								
	PUNJAB OPERATING			437,500	135,300		234,300		211,900	447,971
	PUNJAB IDLE			35,714	10,000		16,000		16,500	36,663
	PUNJAB PLANNED			262,521	86,750		132,500		109,300	342,891
	PUNJAB TOTAL			735,736	232,050		382,800		337,700	827,525

REF.: GWA.1-L0051704, 13-Aug-90

TABLE E2.4: PAKISTAN PULP AND PAPER INDUSTRY DATA - SIND

*IDLE; **PLANNED				HETRIC TONS PER YEAR					
			FIBER	PULPING			PAPER		PULPWOOD
NO.	COMPANY	LOCATION	TYPE	SUPPLY	PROD.	TYPE	DIG.	GRADE	PROD.	POTENTIAL
33	DADABHOOY PAPER MILLS	KARACHI		2,000	1,000		1,500	P/W	3,500	7,770
34	SECURITY PAPERS	KARACHI	C		500		2,000	Rs.	1,500	3,330
	TOTAL			2,000	1,500		3,500		5,000	11,100
35	DAWN PAPER MILLS**	HYDERBAD								
36	ORIENT PAPER MILLS	KOTRI	S	10,714	3,000		5,000		2,500	5,550
37	STAR PAPER MILLS	KOTRI	S	7,143	2,000		6,000	L,H	5,000	11,100
	TOTAL			17,857	5,000		11,000		7,500	16,650
				35,714	10,000		22,000		15,000	33,300
38	ALLIED PAPER IND.**	THATTA	S?	17,857	5,000	K?	7,500	P/W	7,000	15,540
39	CHILYA	THATTA	S,B	17,857	5,000		10,000	L,H	6,000	13,320
40	PAKLAND PAPER LTD.**	THATTA	S?					P/W	30,000	66,600
	TOTAL THATTA			35,714	10,000		17,500		43,000	95,460
41	CITY PAPER & BOARD	NORIABAAD,	S?	17,857	5,000			P/W	5,000	11,100
	TOTAL SIND OPERATING			73,429	21,500		35,500		31,000	68,820
	TOTAL SIND IDLE									
	TOTAL SIND PLANNED			17,857	5,000		7,500		37,000	82,140
	TOTAL SIND			91,286	26,500		43,000		68,000	150,960

REF.: GWA.1-L0051704, 13-Aug-90

EXHIBIT 3

PULP & PAPER INDUSTRY AND RELATED VISITS

EXHIBIT 3: PAKISTAN PAPER MILLS & RELATED VISITS

ORGANIZATION	LOCATION	PERSON	TITLE/POSITION
PULP & PAPER INDUSTRY			
Adamjee Paper & Board Mills	Nowshera	M. Rafiuddin	General manager
Adamjee Paper & Board Mills	Nowshera	Mohammad Rafoq	Chief Chemist
Adamjee Paper & Board Mills	Nowshera	Rahat-Ullah-Khattak	Commercial Manager
Century Paper & Board Mills	karachi	M. Rafi Chawla	managing Director
Century Paper & Board Mills	Kasur	Khalid Saleem	General Manager
Century Paper & Board Mills	Kasur	Aftab Ahmad	Technical Mgr.
Century Paper & Board Mills	Lahore	Asif Hassan	Marketing Manager
Crescent Boards Ltd.	Faisalabad	M. Asghar Qureshi	Director
Farooki Kraft Pulp Mill	Lahore	Salim A. Farooki	Managing Director
Flying Paper Mills	Lahore		
Ghazi Paper Mills Ltd.	Sheikhupura	Hameed Akhtar Khokhar	Factory Manger
Jubilee Paperboard Mills	Gujranwalla	Shiekh Aijaz	Resident Director
Jubilee Paperboard Mills	Gujranwalla	Hafiz Maqsood Ahmed	Gen. Manager
Jubilee Paperboard Mills	Gujranwalla	Sheikh Munndoz	Chief Executive
Kashmir Dev. Corp.	Jhelum	M. Naeem Bashir	Director
Lasani Board Mills	Gujranwalla	Anwar Pasha	Director
Packages Ltd	Lahore	Tariq Hamid	Gen. Manager
Packages Ltd	Lahore	Iqbal Saeed	Advisor
Packages Ltd	Lahore	M. Fasih-Uz-Zamid	Production Mgr.
Packages Ltd	Lahore	M. Mubshan	Process Manager
Packages Ltd	Lahore	Syed Babar Ali	Founder, Maj. Owner
Packages Ltd	Lahore	S. Mighis Asghar	Tech. Manager
Pakistan Paper Corp.	Charsadda	Moiz-ud-Din	Production Manager
Pakistan Paper Corp.	Charsadda	Aman Ullah Khan	Dep. Gen. Manager
PICIC (Pakistan Paper)	Karachi	Tahir Abbas	Deputy Chairman
PICIC (Pakistan Paper)	Pershawra	Iftikhar Uddin	Vice President
Premier Paper Mills	Sheikhupura	Sheikh Mohammad Saeed	Director
Premier Paper Mills	Sheikhupura	Muhammad Hanif Malik	Process Manager
Premier Paper Mills	Sheikhupura	Altaf-Ur-Rehman Qureshi	Commercial Manager
Sampak Paper & Board Mills	Sheikhupura	Mahboob Ali	General Manager
Sultan Paperboard Mills	Gujranwalla	M. Salim	Process Engineer
Sultan Paperboard Mills	Gujranwalla	Ch. Mohammad Shabbir	Director
OTHER			
Consultant	Karachi	T.A. Ansari	Ch. Forester (Ret.)
GOP, Forest Dept.	Islamabad	Abedullah Jan	Inspector General
GOP, Water & Power Ministry	Islamabad	Fayyaz Elahi	Dep. Secretary
Pakistan Forestry Institute	Pershawra	Nadeem Kauser	Pulp & Paper
Pakistan Forestry Institute	Pershawra	K. M. Suleman	Sr. Pulp & Paper
Pakistan Forestry Institute	Pershawra	K. M. Saddiqui	Director General
Punjab Indust. Dev. Board	Lahore	Dr. Pirzada	Pulp & Paper
Punjab University	Lahore	Ijaz Hussain Khan	Engineering Prof.
Punjab University	Lahore	Zafrullah Sheikh	Engineering Dean
Tree Farmer	Faisalabad	Mian M. Aslam	
Winrock Int'l	Islamabad	Chas. Hatch	Chief of Party
Winrock Int'l	Islamabad	Gary Naughton	Chief, Tree Farming
Winrock Int'l	Islamabad	George Blake	Chief, Research
Winrock Int'l	Islamabad	William Beaufait	Chief, Research
Winrock Int'l	Islamabad	Wendell Clark	Consultant
Winrock Int'l	Islamabad	Chas. McKetta	Consultant

EXHIBIT 4

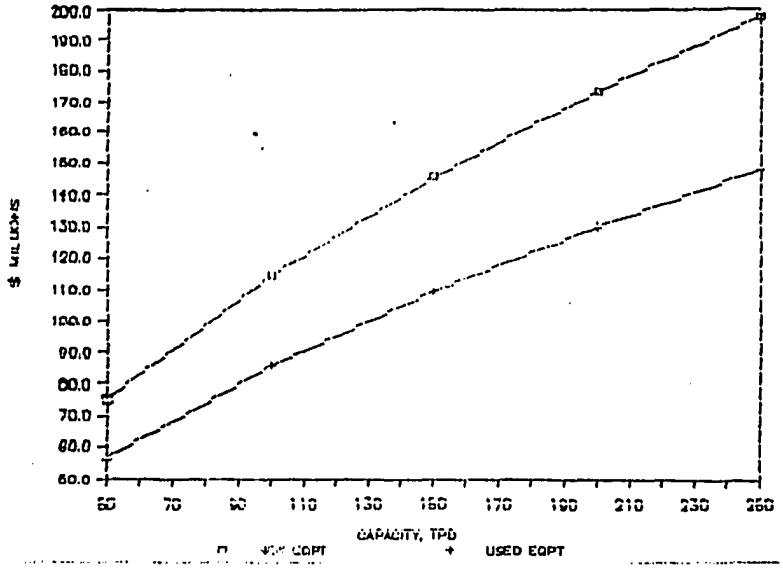
PULP & PAPER CAPITAL PROJECTS

FIGURE E4.1

C A P I T A L C O S T

B L E A C H E D K R A F T M A R K E T P U L P M I L L

COST PER TPD CAPACITY



TOTAL INSTALLED COST VS. TPD CAPACITY

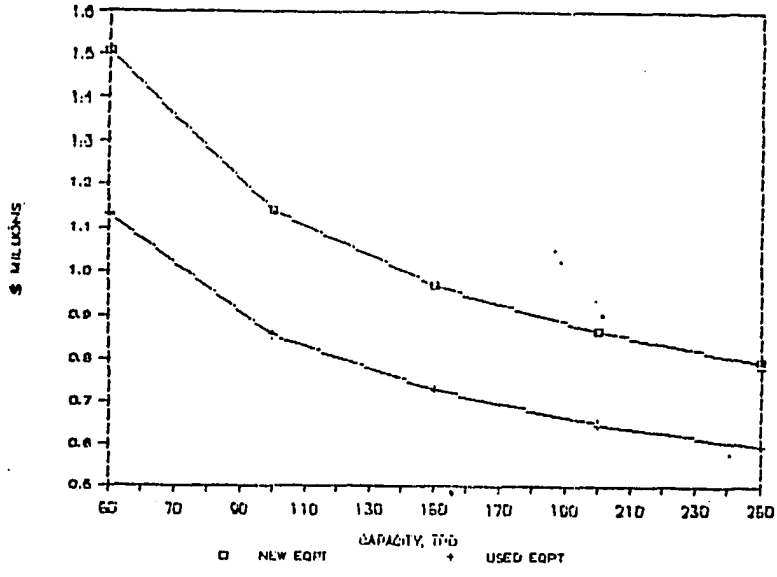
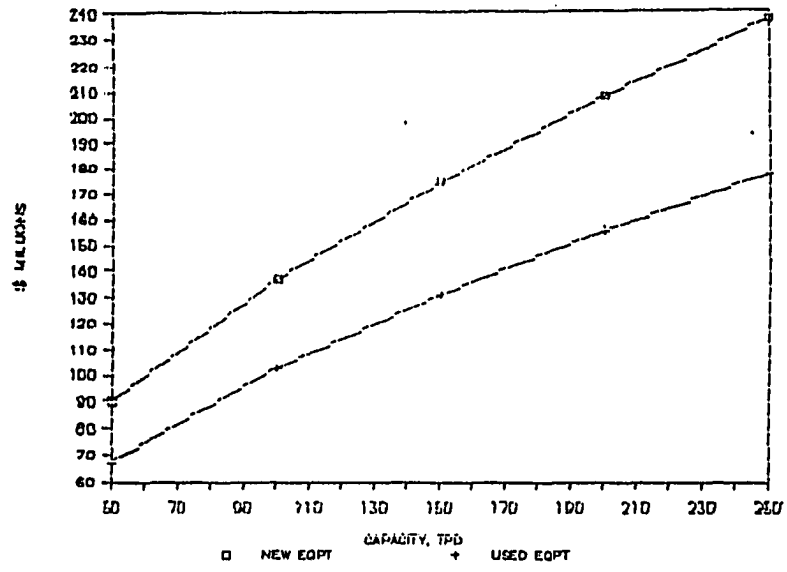


FIGURE E4.2

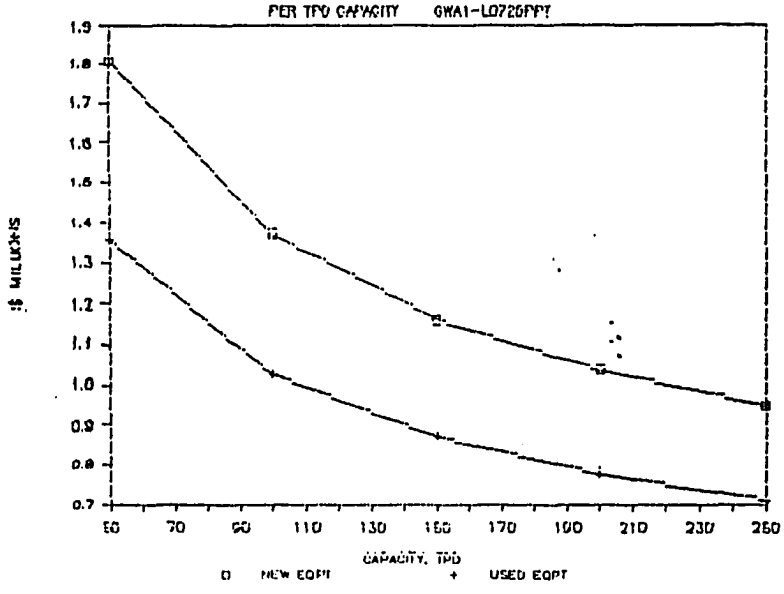
C A P I T A L C O S T

P A C K A G I N G P A P E R S M I L L

TOTAL INSTALLED COST VS. TPD CAPACITY



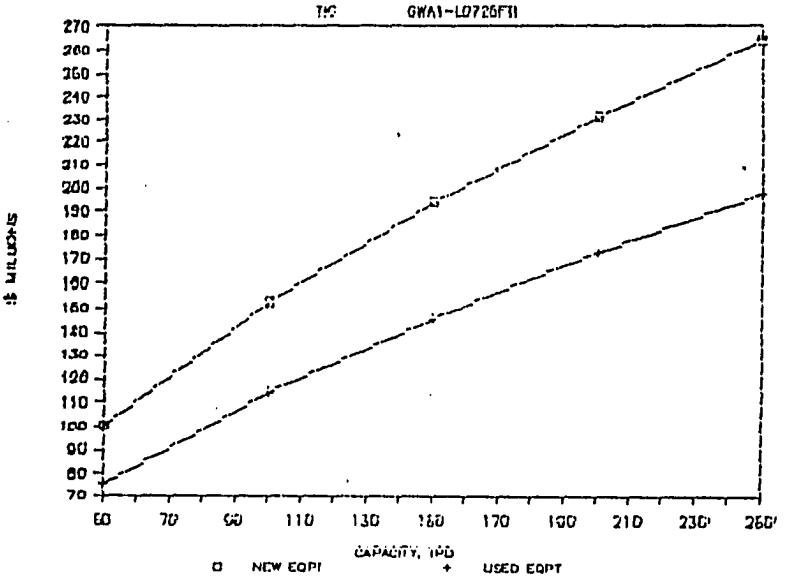
COST PER TPD CAPACITY



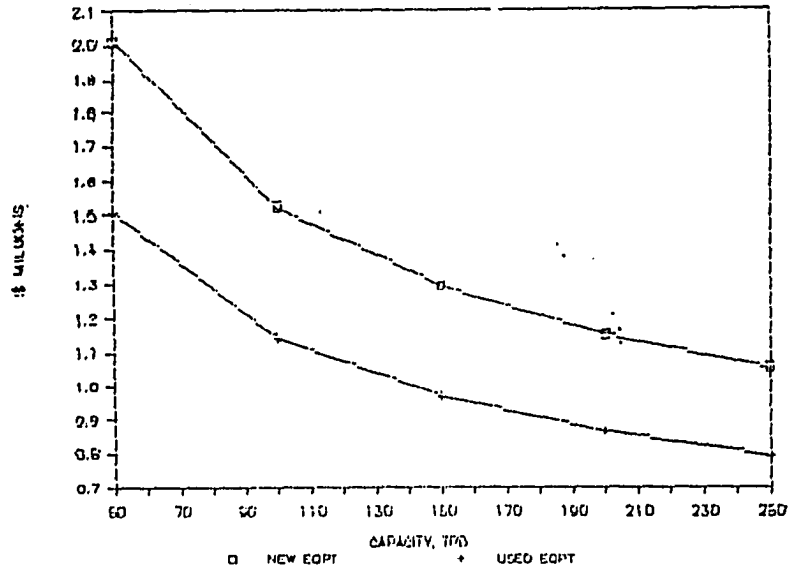
C A P I T A L C O S T

F I N E P A P E R M I L L S

TOTAL INSTALLED COST VS. TPD CAPACITY



COST PER TPD CAPACITY



..1: PULP &

REF. NO	PROJECT	TYPE	ID	YR	CAPACITY TPD	CAPACITY KTPA	TIC US$MM	US$1000/TPD
	BLEACHED KRAFT							
37	FARODKI, PAK	BHKMP	B	90	100		24	238
58	GULF, AL	BSKP	B	90	750		250	333
59	RAUMA, FIN	BSKP	B	90	1,000	350	420	420
3	DAISHOWA CAN.	BHMKP	B	90	1,000		425	425
64	P&G, ALB	BSMKP	B	90	857	300	365	426
68	STONE, GA	BHMKP	B	90	740		335	453
65	WEYCO, MS	BKMP	B	90	1,023	358	500	489
70	WTD IND, OR	BSMKP	B	90	857	300	420	490
30	GUAAXI	GBSK	B	88	143	50	70	490
66	BOWATERS, TN	BKP	B	90	406	142	205	505
61	DAISHOWA, ALB	BSKP	B	90	971	340	500	515
15	SIAM CEL.	BKP	B	90	143	50	75	525
48	SIAM KRAFT	B&EBK	B	90	143	50	75	525
67	P&W, AL	BSMKP	B	90	1250		700	560
43	CHAMPION, BRA	BEKP	B	90	1,429	500	850	595
60	CRESTBROOK. AL	BSKP	B	90	1,417	496	850	600
52	SPAIN	BEKMP	B	90	714	250	430	602
54	STORA, PORT.	BKMP	B	90	1,000	350	650	650
7	REPAP, MAN.	GFBK	B	90	1,200	420	800	667
50	REPAP	GFBK	B	90	1200		800	667
55	ARACRUZ	BEKP	B	90	1,500	525	1000	667
44	ALBERTA PAC.	BMKP	B	90	1,429	500	1100	770
62	HOWE SOUND	BSKP	B	90	357	125	280	784
42	POTLATCH, MN	BKP	B	90	550		450	818
46	MICHIGAN PULP	BMKP	B	90	1200		1200	1,000
69	UNION CAMP, SC	BMKP	B	90	300	105	675	2,250
	AVERAGE				834		$517	$633
	MECHANICAL							
33	NIAGARA, WI	PGW	M	88	280		48	171
10	BOISE, KENORA	TMP	M	90	400		72	181
31	MB. ALB	TMP	M	88	350		77	219
11	MILLER WEST, SASK	BCTMP	M	90	686	240	170	248
34	BALAKHNA, USSR	CTMP	M	88	571	200	170	298
36	TEMBEC	BCTMP	M	88	286	100	85	298
35	TAKEMA, BC	BCTMP	M	88	543	190	166	305
13	SCOTT, PQ	BCTMP	M	90	300		94	312
12	ASITKA, BC	TMP	M	90	714	250	255	357
56	MILLER WEST., ALB	BCTMP	M	90	686	240	250	365
32	ASITKA, BC (12)	CPGW	M	88	300		122	408
1	ALBERTA ENERGY	CTMP	M	90	314	110	145	460
23	MEERSON. BELG	CTMP--LWC	M	90	571	200	300	525
24	TENCEL	BCTMP	M	86	150		102	680
21	IMPACEL. BRAZ	CTMP	M	90	371	130	338	910
27	DONAHUE, MAT.	CTMP	M	88	543	190	247	454
5	QUEB & ONT	TMP	M	90	600		111	184
	AVERAGE				451		$162	$375

BEST AVAILABLE DOCUMENT

METRIC TONS PER DAY CAPACITY

REF. NO	PROJECT	TYPE	ID	YR	CAPACITY TPD	CAPACITY KTPA	TIC US$MM	US$1000/TPD
	NEWSPRINT							
26	ORINOCO PULP	NEWS	N	88	571	200	213	372
14	CP	NEWS	N	90	671	235	272	405
41	KENAF PAPER	NEWS	N	90	86	30	35	408
4	KRUGER	NEWS	N	90	466	163	196	422
28	CP, T'BAY	TMP, NEWSN		88	657	230	298	453
29	SCA, CELUDUPIN	NEWS	N	88	600	210	275	458
2	ALBERTA NEWS	NEWS	N	90	629	220	322	513
25	CEL Y PAP, MX	NEWS	N	86	214	75	110	513
40	KENAF PAPER	NEWS	N	90	614	215	400	651
63	HOWE SOUND	NEWS	N	90	543	190	355	654
8	NORSKSKOG, FR	NEWS	N	90	571	200	420	735
16	WILBERT, AZ	GWS	N	90	517	181	400	773
57	PAPELERO ESP.	NEWS	N	90	571	200	450	788
	AVERAGE				516		$288	$550
	UNBLEACHED KRAFT							
53	PANJOPOL, THAI	UK	U	90	250		78	312
45	DAISHOWA, OR	UK	U	90	1000		425	425
39	PIDB, USED	UKP	U	85	100		48	482
38	PIDB, NEW	UKP	U	85	100		61	610
49	REPAP, MAN	UBK	U	90	286	100	200	700
	AVERAGE				347		$162	$506
	STRAW, NEC							
51	UK	STRAW	V	90	857	300	275	321
9	AUST-ANKEL	SA KENAF	V	90	286	100	175	613
22	NEPAL PI	STRAW	V	90	29	10	38	1,330
	AVERAGE				390		$163	$754
20	TAIWAN PULP	FINE	P	90	200		47	235
19	KARAN, IRAN	BAG. FINEP		90	257	90	100	389
18	MAZANDARAN, IRAN	?	P	90	243	85	120	494
	AVERAGE				233		89	373

CAPITAL COST, BASIS GWC AVG TPD * (TPD/AVG)^.6

	US$1,000 PER TON PER DAY				MILLION US$			
TPD	BKP	NEOL	NEWS	UBK	BKP	NEOL	NEWS	UBK
50	1,912	865	1,420	1,016	96	43	71	51
100	1,449	655	1,076	770	145	66	108	77
150	1,232	557	915	655	185	84	137	98
200	1,098	497	816	583	220	99	163	117
250	1,004	454	746	534	251	114	186	133
300	934	422	693	496	280	127	208	149
350	878	397	652	466	307	139	228	163
400	832	376	618	442	333	151	247	177
450	794	359	590	422	357	162	265	190
500	761	344	565	404	381	172	283	202

BEST AVAILABLE DOCUMENT

TYPICAL MINIMUM ECONOMIC SIZE OF PULP AND PAPER MILLS

(In Metric Tons Per Day)

	Type of Mill	International Market	Regional Market	LDC In-Country Market
1.	Bleached softwood or hardwood chemical market pulp	700 - 800	300 - 400	150 - 200
2.	Bleached bagasse market pulp mill		250 - 350	120 - 180
3.	Bleached straw pulp mill		200 - 300	120 - 180
4.	Bleached CTMP market pulp	300 - 400	150 - 250	60 - 100
5.	Bleached specialty pulp mill*	50 - 200	30 - 100	10 - 20
6.	Mechanical (groundwood) market pulp	250 - 300	80 - 120	10 - 30
7.	Sack kraft or kraft liner (integrated with pulp mill)	600 - 700	300 - 400	100 - 150**
8.	Corrugating medium (integrated with pulp mill)	350 - 500	200 - 300	80 - 120
9.	Newsprint (integrated with groundwood mill)	800 - 1000	500 - 750	150 - 200
10.	Woodfree fine papers - printing, writing, offset and bonds (integrated with pulp mill)	250 - 350	150 - 200	60 - 100***
11.	Multiply board (integrated with wastepaper plant)	100 - 200	80 - 120	30 - 60
12.	Tissue (no pulp mill, but integrated with converting plant)	100 - 200	50 - 100	15 - 30

NOTES:
- * Flax, hemp, sisal, abaca, and cotton linters.
- ** Lower quality when using non-wood fibers.
- *** With pulp mill using non-wood fibers.

EXHIBIT 5

PAKISTAN PULPWOOD VALUE

FIGURE E5.1a: INCLUDING IMPORTED PULP AT Rs.20,000/TON

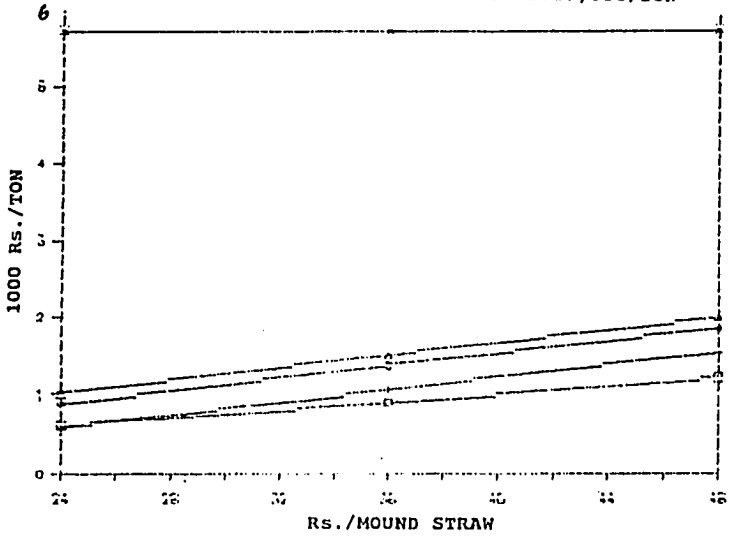
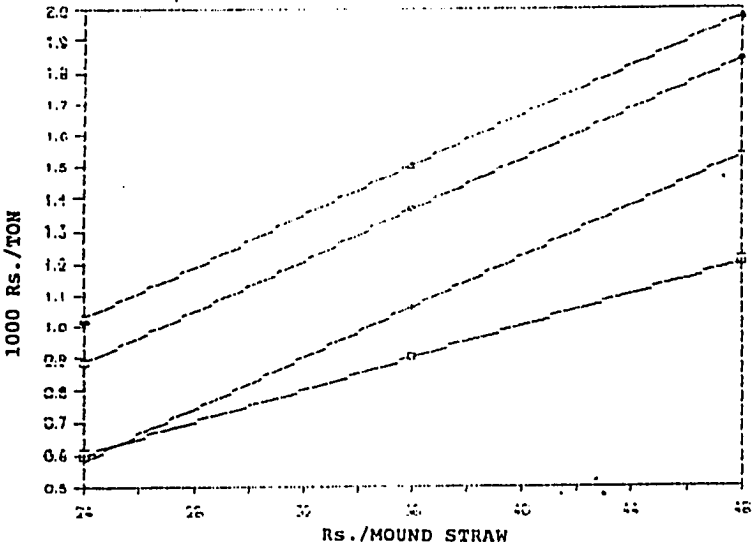


FIGURE E5.1b: EXCLUDING IMPORTED PULP



- ▫ STRAW/KAHI
- + WOOD REPLACEMENT FOR STRAW/KAHI
- ◇ PLUS YIELD BENEFIT @ 137%
- △ PLUS YIELD AND BULK BENEFIT @ 187%
- X REPLACING IMPORTED BLEACHED CHEMICAL PULP @ Rs.20,000/TON

TABLE E5.1: PULPWOOD VALUE vs. STRAW/KAHI COST AT Rs.24/MOUND

COST PER TON PULP			WHEAT STRAW		EUCALYPTUS CAMALDULENSIS BLEACHED NSSC							
		Rs./	@ Rs.24/MOUND		FOR WHEAT STRAW		W/YIELD BENEFIT		W/YIELD + BULK		REPLACE IMPORT	
DESCRIPTION	UNIT	UNIT	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./T
TONS PER YEAR			30,000		30,000		47,700		65,190		89,093	
KAPPA NO.	NO.		20		20		20		20		20	
YIELD	%		28.3%		45.0%		45.0%		45.0%		45.0%	
FIBER VALUE	MOUND			24		23		35		41		2
FIBER VALUE	TON			600		582		887		1,026		5,7
FIBER	TON		3.53	2,120	2.22	1,294	2.22	1,971	2.22	2,279	2.22	12,7
OTHER MATERIALS												
SULFUR	Kg	4.50	98.67	444	125.00	563	125.00	563	125.00	563	125.00	5
SODA ASH	Kg	5.50	392.36	2,158	500.00	2,750	500.00	2,750	500.00	2,750	500.00	2,7
CAUSTIC SODA	Kg	14.00	47.36	663	50.00	700	50.00	700	50.00	700	50.00	7
CHLORINE	Kg	3.30	79.39	262	80.00	264	80.00	264	80.00	264	80.00	2
SUBTOTAL				3,527		4,277		4,277		4,277		4,2
TOTAL MATERIALS				5,647		5,571		6,248		6,556		17,0
DIRECT LABOR				250		250		157		115		
VARIABLE OVERHEADS												
STEAM (F. OIL)	TON	2300	0.62	1,418	0.62	1,418	0.62	1,418	0.62	1,418	0.62	1,4
ELECTRICITY	KWH	1.09	780.00	850	850.00	927	850.00	927	850.00	927	850.00	9
WATER	m3	0.23	0.00	0	0.00	0	0.00	0	0.00	0	0.00	
MAINT. & REPAIR				174		174		109		80		
SUBTOTAL				2,442		2,519		2,454		2,425		2,4
FIXED OVERHEAD				385		385		242		177		1
DEPRECIATION				1,016		1,016		639		468		3
TOTAL NON-FIBER COST				7,620		8,446		7,769		7,461		7,2
TOTAL COST				9,740		9,740		9,740		9,740		20,0

Ref.: GWA2-L0070202

TABLE E5.2: PULPWOOD VALUE vs. STRAW/KAHI COST AT Rs.36/MOUND

COST PER TON PULP			WHEAT STRAW		EUCALYPTUS CAMALDULENSIS BLEACHED NSSC							
		Rs./	@ Rs.36/MOUND		FOR WHEAT STRAW		W/YIELD BENEFIT		W/YIELD + BULK		REPLACE IMPORT	
DESCRIPTION	UNIT	UNIT	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TO
TONS PER YEAR			30,000		30,000		47,700		65,190		89,093	
KAPPA NO.	NO.		20		20		20		20		20	
YIELD	%		28.3%		45.0%		45.0%		45.0%		45.0%	
FIBER VALUE	MOUND			36		42		55		60		2
FIBER VALUE	TON			900		1,059		1,364		1,503		5,7
FIBER	TON		3.53	3,180	2.22	2,354	2.22	3,031	2.22	3,339	2.22	12,7
OTHER MATERIALS												
SULFUR	Kg	4.50	98.67	444	125.00	563	125.00	563	125.00	563	125.00	5
SODA ASH	Kg	5.50	392.36	2,158	500.00	2,750	500.00	2,750	500.00	2,750	500.00	2,7
CAUSTIC SODA	Kg	14.00	47.36	663	50.00	700	50.00	700	50.00	700	50.00	7
CHLORINE	Kg	3.30	79.39	262	80.00	264	80.00	264	80.00	264	80.00	2
SUBTOTAL				3,527		4,277		4,277		4,277		4,2
TOTAL MATERIALS				6,707		6,631		7,308		7,616		17,0
DIRECT LABOR				250		250		157		115		
VARIABLE OVERHEADS												
STEAM (F. OIL)	TON	2300	0.62	1,418	0.62	1,418	0.62	1,418	0.62	1,418	0.62	1,4
ELECTRICITY	KWH	1.09	780.00	850	850.00	927	850.00	927	850.00	927	850.00	9
WATER	m3	0.23	0.00	0	0.00	0	0.00	0	0.00	0	0.00	
MAINT. & REPAIR				174		174		109		80		
SUBTOTAL				2,442		2,519		2,454		2,425		2,4
FIXED OVERHEAD				385		385		242		177		1
DEPRECIATION				1,016		1,016		639		468		3
TOTAL NON-FIBER COST				7,620		8,446		7,769		7,461		7,2
TOTAL COST				10,800		10,800		10,800		10,800		20,0

Ref.: GWA2-L0070202

TABLE E5.3: PULPWOOD VALUE vs. STRAW/KAHI COST AT Rs.48/MOUND

COST PER TON PULP			WHEAT STRAW		EUCALYPTUS CAMALDULENSIS BLEACHED NSSC							
		Rs./	@ Rs.48/MOUND		FOR WHEAT STRAW		W/YIELD BENEFIT		W/YIELD + BULK		REPLACE IMPORT	
DESCRIPTION	UNIT	UNIT	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./TON	AMOUNT	Rs./T
TONS PER YEAR			30,000		30,000		47,700		65,190		89,093	
KAPPA NO.	NO.		20		20		20		20		20	
YIELD	%		28.3%		45.0%		45.0%		45.0%		45.0%	
FIBER VALUE	MOUND			48		61		74		79		2
FIBER VALUE	TON			1,200		1,536		1,841		1,980		5,7
FIBER	TON		3.53	4,240	2.22	3,414	2.22	4,091	2.22	4,399	2.22	12,7
OTHER MATERIALS												
SULFUR	Kg	4.50	98.67	444	125.00	563	125.00	563	125.00	563	125.00	5
SODA ASH	Kg	5.50	392.36	2,158	500.00	2,750	500.00	2,750	500.00	2,750	500.00	2,7
CAUSTIC SODA	Kg	14.00	47.36	663	50.00	700	50.00	700	50.00	700	50.00	7
CHLORINE	Kg	3.30	79.39	262	80.00	264	80.00	264	80.00	264	80.00	2
SUBTOTAL				3,527		4,277		4,277		4,277		4,2
TOTAL MATERIALS				7,767		7,691		8,368		8,676		17,0
DIRECT LABOR				250		250		157		115		
VARIABLE OVERHEADS												
STEAM (F. OIL)	TON	2300	0.62	1,418	0.62	1,418	0.62	1,418	0.62	1,418	0.62	1,4
ELECTRICITY	KWH	1.09	780.00	850	850.00	927	850.00	927	850.00	927	850.00	9
WATER	m3	0.23	0.00	0	0.00	0	0.00	0	0.00	0	0.00	
MAINT. & REPAIR				174		174		109		80		
SUBTOTAL				2,442		2,519		2,454		2,425		2,4
FIXED OVERHEAD				385		385		242		177		1
DEPRECIATION				1,016		1,016		639		468		3
TOTAL NON-FIBER COST				7,620		8,446		7,769		7,461		7,2
TOTAL COST				11,860		11,860		11,860		11,860		20,0

Ref.: GWA2-L0070202

EXHIBIT 6

PROPOSAL: G.WIRE CO./UNIVERSITY OF WASHINGTON

NSSC PULPING CONDITIONS DEVELOPMENT

TESTING AND EVALUATION FACILITIES & METHODS

EDUCATION AND TRAINING

EXHIBITS

STUDY OF TREE FARM WOOD UTILIZATION FOR WOOD PULP PRODUCTION IN PAKISTAN

by

GERALD G. WIRE

PULP & PAPER CONSULTANT
BELLEVUE, WASHINGTON 98006

FOR THE

FORESTRY PLANNING AND DEVELOPMENT PROJECT

GOVERNMENT OF PAKISTAN - USAID

16 AUGUST 1990

EXHIBITS

PRELIMINARY FEASIBILITY STUDY OF
TREE FARM WOOD UTILIZATION
FOR
WOOD PULP PRODUCTION IN PAKISTAN

EXHIBIT	SUBJECT
1	PAKISTAN TREE-FARM STANDS AND PROJECTED PULPWOOD YIELD
2	PAKISTAN PULP AND PAPER INDUSTRY
3	PULP & PAPER INDUSTRY AND RELATED VISITS
4	PULP AND PAPER CAPITAL PROJECTS
5	PAKISTAN PULPWOOD VALUE
6	PROPOSAL: G.WIRE CO./UNIVERSITY OF WASHINGTON a. NSSC PULPING CONDITIONS DEVELOPMENT b. TESTING AND EVALUATION FACILITIES & METHODS c. EDUCATION AND TRAINING
7	PROPOSAL: PULPWOOD CHIPPING, DEBARKING AND SCREENING
8	PROPOSAL: PULPWOOD SUPPLIERS-USERS CONFERENCE EXAMPLE AGENDA

EXHIBIT 1

PAKISTAN TREE-FARM STANDS AND PROJECTED PULPWOOD YIELD

ESTIMATES OF PULPWOOD AVAILABILITY ROM TREE-FARM HARVEST
G. NAUGHTON & G. WIRE

ESTIMATING METHODOLOGY
G. NAUGHTON

YIELD DATA
PFI

BASIC DATA
T.A. ANSARI; PFI

AVAILABILITY OF E. CAMALDULENSIS IN PUNJAB
CHEMICAL CONSULTANTS (PAKISTAN) LTD.

SUBJECT: Pakistani Wood Pulp Industry
1. Processing Conditions
2. Testing & Evaluation Facilities
3. Technical Training

BY: Gerald G. Wire
Pulp & Paper Consultant
Winrock International

Ref.: GWA1-W0060301.M

There are 36 firms identified as producing paper within Pakistan; most of these make some pulp from straw and grasses employing a "neutral sulfite" process as well as useing imported wood pulp. Most are desireous of producing wood pulp and might employ Eucalypt, poplar and other hardwoods for this using process and chemistry similar to their existing operation. If shown practicable, such procedure could enable commencing production on a modest scale immediately, enabling evolvment of wood supply-demand commerce as well as the learning of most satisfactory pulp and paper making techniques. However there are certain needs to establishing operational practice, as well as providing for developmental and technical needs of a growning industry.

1. Although the process conditions for this pulping scheme may be similar to that of current practice, very specific conditions must be established. Although the mills probably are willing to experiment themselves, they cannot carry out extensive hunt and search for the conditions; if after a few tries the pulp is not useable, they will quit, and gaining their interest for renewed attempts will be difficult. Therefore, there needs to be laboratory "pilot scale' study & evaluation of probably most satisfactory conditions:

1.1 Concentration, time & temperature to produce 15-18 Ka No. (10-12 K No.) pulp, preferably without need for defibration; affect of replacing Na with NH_3 on cost & quality.

1.2 Bleach conditions to produce 75%-80% GEB pulp (CEH).

1.3 Beater test characteristics of resulting pulps: refining energy, freeness, tear, tensile, burst & density relationships.

There are probably two laboratories in Pakiston capable of the required procedures, PFI and Packages (PVT) Ltd. However, the cabability is limited and marginal. Therefore, it is recommended that this be carried out, at least in duplication, by another established and qualified laboratory. The pilot plant facilities of these are marginal, and the testing facilities even more so, particularly at PFI.

BEST AVAILABLE DOCUMENT

It is proposed that this work be carried out at the Department Of Pulp & Paper Science & Engineering, College of Forestry, University of Washington, Seattle Washington. The director of the work would be Dr. Wm. T. McKean, Chairman, in close association with Gerald G. Wire. We have a close working relationship and can bring the highest level of scientific and operationally practical knowhow to the work. This could include pilot papermaking.

The results of this work will be definition of process conditions closely matched to Pakastani mill facilities and abilities. This information would pe presented at an industry meeting in Pakistan, following work completion. At such time, we also propose to carry out the following:

2. Specific recommendations and training regarding equipment, apparatus and techniques for evaluation and testing by and within PFI. Punjab University Dept. of Chemical Engineering and other identified locations. This would be for institution, industry, student and other (supply industry) personnel. Pulp and paper technology seminars coincident with this is recommended.

3. Dr. McKean would evaluate and recommend courses of study, curricula, references and texts relative to technical (short course and 2-yr), baccalaureate and graduate level programs for the above and other appropriate, designated institutions, government and private.

If this proposal can be acted upon quickly, now is the right time to carry out the pilot work. This could be completed in time for presentation in the late fall, at which time items 2. and 3. would be done, in conjunction with a pulp wood user-supplier conference, including purchase price/volume announcements.

The pilot work and in-U.S. prepararion is estimated to require 200 man-days and two months elapsed time; the presentation and in-Pakistan work will require 50 man-days and 3 weeks elapsed time. The cost on this basis would be:

Labor:	2 persons, 100 MD	@	$300.	=	$30,000.
	2 persons, 250 MD	@	$100.	=	25,000.
Travel:	2 Round trips	@	$2,500.	=	5,000.
Per Diem:	50	@	$100.	=	5,000.
Total					$65,000.

Dr. McKean earned a BS from the University of Colorado and PhD from the University of Washington in Chemical Engineering. He has been an associate Professor in the Pulp & Paper Technology Department at Nort Carolina State University and is Professor of Pulp and Paper Science & Technology as well as Chemical Engineering at the University of Washington. He has prior employment as a Senior Researcher with the Batelle Institute and Weyerahauser Paper Company. He currently engages in substantial consulting for government and industry along with his department head and teaching duties. He is a dedicated educator and researcher.

BEST AVAILABLE DOCUMENT

EXHIBIT 7

PROPOSAL: PULPWOOD CHIPPING, DEBARKING AND SCREENING

KIC INTERNATIONAL
CORPORATION

FAX TO: JERRY WIRE
FROM: MIKE REVORD
KIC INTERNATIONAL
DATE: 7-31-90
REF: CHIP-PAC

THE ATTACHED QUOTATIONS ARE FOR ONE (1) 48 INCH CHIP-PAC, AS PER THE SPECIFICATIONS AND ONE (1) 58 INCH CHIP-PAC, AS PER THE SPECIFICATIONS. THE 48 INCH MACHINE WILL HANDLE UP TO 10 ROUND DIAMETER AND THE 58 INCH WILL HANDLE UP TO 15 INCH ROUND DIAMETER MATERIAL.

I HAVE INCLUDED COPIES OF OUR CHIP-PAC BROCHURE FOR YOUR REVIEW. THE ONLY INFORMATION NOT GIVEN ON THE SPEC SHEET IS PRODUCTION. THE 48 INCH UNIT HAS A 5FT.X5FT. SCREEN AND IS CAPABLE OF CHIPPING AND SCREENING 6 TONS PER HOUR. THE 58 INCH MACHINE HAS A 6FT.X6FT. SCREEN AND IS CAPABLE OF CHIPPING AND SCREENING 8 TONS PER HOUR.

DUE TO YOUR PRODUCTION REQUIREMENT, I WOULD SUGGEST THAT YOU LEAN TOWARD THE 58 INCH UNIT. I REALIZE THE 15 INCH CAPACITY IS MORE THAN YOU REQUIRE BUT FOR THE DIFFERENCE IN PRICE THE MACHINE WOULD BE UNDER LITTLE STRESS AND THE LIFE OF THE MACHINE WOULD THEREFORE BE PROLONGED.

PLEASE REVIEW THE MATERIAL AND CONTACT ME IF YOU HAVE ANY QUESTIONS OR CONCERNS. I WILL BE OUT OF THE OFFICE FROM JULY 31, 1990 UNTIL AUGUST 8, 1990. MY SECRETARY WILL BE ABLE TO REACH ME BY PHONE.

SINCERELY,

Mike Revord

MIKE REVORD
KIC INTERNATIONAL

4109 FRUIT VALLEY ROAD, VANCOUVER, WASHINGTON 98660-1290, U.S.A.

VANCOUVER, WA (206) 696-0561 PORTLAND, OR (503) 283-3118 TELEX 4742023 (ITT) FAX (206) 696-3132

MORBARK MODEL 586 SERIES "D" CHIP-PAC

STANDARD EQUIPMENT:

-MORBARK Model 58", 3-Knife, Drop Feed, End Discharge Chipper (3/4 inch chip size)
-6'x6' Chip Screen with Punch Plates (DESIGNATE screen size top and bottom), and 2-HP hydraulic screen drive
-Blowpipe and Cyclone
-Overs Return to Spout
-Diesel Engine Base (SPECIFY make and model of diesel)
-Double Pump Hydraulic System

PRICE EX-FACTORY (USD)..... $40,680.00

-Hydraulically driven 30-HP Super Blower mounted on a standard or swivel base, with "S" pipe..... $ 4,311.00

-3208 Cat 250-HP including fuel tank, battery & cable, drive (motor sheaves, bushings & belts)..... $21,878.00

TOTAL PRICE EX-FACTORY (USD)..... $66,869.00

MORBARK MODEL 485 SERIES "D" CHIP-PAC

STANDARD EQUIPMENT:

-MORBARK Model 48", 3-Knife, Drop Feed, End Discharge Chipper (3/4 INCH CHIP SIZE)
-5'x5' Chip Screen with Punch Plates (DESIGNATE screen size top and bottom), and 2-HP hydraulic screen drive
-Blowpipe and Cyclone
-Overs Return to Spout
-Diesel Engine Base (SPECIFY make and model of diesel)
-Double Pump Hydraulic System

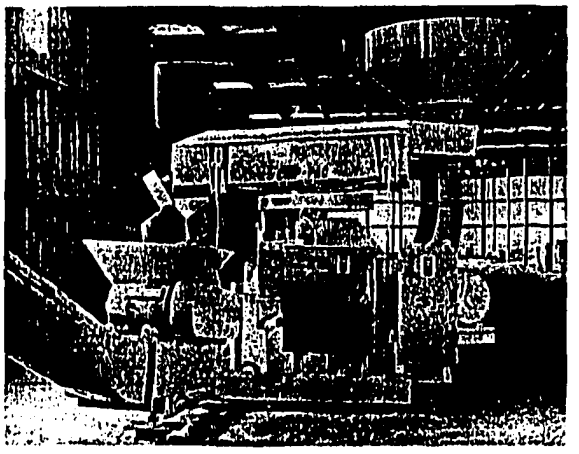
PRICE EX-FACTORY (USD).....$34,533.00

-Hydraulically driven 30-HP Super Chip Blower mounted on a standard base (SPECIFY) with "S" pipe.....$ 5,278.00

-6BTA5.9 Cummins (177-HP) including fuel tank, battery & cable, drive (motor sheaves, bushings & belts).....$17,550.00

TOTAL PRICE EX-FACTORY (USD).....$57,361.00

48 Chip Pac



GENERAL

Width . . . . . 76"
Depth . . . . . 70"
Height . . . . . 92"
w/Cyclone Approx. 120"
Weight . . . . . 11, 200 lbs.
w/75 H.P. Motor, Blower & Cyclone
Overall Floor Space Required . . . . 123" x 110"

CHIPPER

Chipper . . . . . 48"
Knife Option . . . . 2,3 & 6 Knives in Round Disc
Woodsize . . . . . 11" Diameter

POWER UNIT

Engine Type . . . . . Most Electric or Diesels
Horsepower . . . . . 75 H.P. to 150 H.P.
RPM . . . . . 1750 w/U Frame

SCREEN

Punch Plates. . . . . 1/8" to 2½"
Screen RPM . . . . . 220 RPM
Screen Size . . . . . 5' x 5'

BLOWERS

Chip Blower(Optional). . . . . 10 or 25 H.P.
Fines Blower(Option in Electric Only). . . . 3 H.P.

Width . . . . . 88"
Depth . . . . . 87"
Height . . . . . 104"
Weight . . . . . 15,640 lbs.
w/125 H.P. Motor, Blower & Cyclone
Overall Floor Space Required . . . . 155" x 110"

CHIPPER

Chipper Disc . . . . . 58"
Knife Option . . . . 2,3 & 6 Knives in Round Disc
Woodsize . . . . . 15" Diameter

POWER UNIT

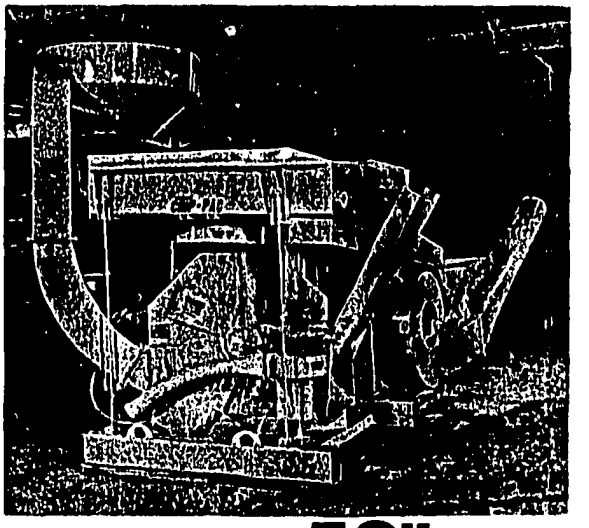
Engine Type. . . . . Most Electric or Diesels
Horsepower . . . . . 75 H.P. to 250 H.P.
RPM. . . . . 1750 w/U Frames

SCREEN

Punch Plates. 1/8" to 2½" Holes — Round or Square
Screen RPM . . . . . 220 RPM
Screen Size . . . . . 6' x 6'

BLOWERS

Chip Blower(Optional). . . . . 10 or 25 H.P.
Fines Blower(Option on Electric only). . . . 3 H.P.



58" Chip Pac

MORBARK INDUSTRIES, INC.

WINN, MICHIGAN 48896 • 517-866-2381 • TELEX 227 443 (MORBARK WINN)

EXHIBIT 8

PROPOSAL: PULPWOOD SUPPLIERS-USERS CONFERENCE

EXHIBIT 8: PROPOSAL: PULPWOOD SUPPLIERS-USERS CONFERENCE

PURPOSE

It is proposed that a pulpwood suppliers-user conferences be held. The purposes are several, including-

1. Bring suppliers including farmers, growers, transporters and merchandisers together with prospective pulpwood users, i.e. the pulp and board industry.

2. Enable them to come to know each other personally; enable the various sectors of interest to both express its needs and concerns, and learn those of their counterparts.

3. Present the objectives and facts of tree-farming, harvest, delivery and other related information to all in common meeting.

4. Disseminate specific technical information relative to growing, harvest, delivery and utilization to the specific sectors interested. This both by their peers, and by outside experts.

5. Provide examples of successful practices by their peers.

6. Provide example methods and agreements of commerce.

7. Facilitate trade/technical organization formation.

8. Provide a forum for announcement of offers to sell and buy.

It is proposed that two types of meeting be held:

A. A general, 3-5 day, national conference be held at Lahore (being most central to most growers and users).

B. Mini-conferences at mill locales, e.g. Nowshera, Sheikhupura, Gujranwalla, Kasur, Faisalabad, Karachi, Thatta, etc. These to enable smaller farmers and merchants to attend. They would be hosted by a local user.

The principal participants should be suppliers, users and selected consultants. It is recommended that apparent government and institution participation be to show sanction and support; otherwise be kept to the background. They should be as guests.

The local meetings can and should be user sponsored; also they can probable bear substantial meeting cost including meals. Likewise extents of the national meeting, e.g. mill-site proceedings, some meals, etc.

However, organization, organizers, promotion, speakers and meeting place costs will need to be covered. It is proposed that USAID underwrite this.

Day 1

To 1000: Registration; Continental breakfast

1000-1230: Session 1
- 1.1 Opening ceremonies; introductions
- 1.2 Chief Guest
- 1.3 Keynote: Overview, world and Pakistan pulpwood; woodpulp; paper

1230-1330: Lunch break

1330-1730: Session 2
- 2.1 GWC/Winrock report presentation
- 2.2 General fiber use and need; wood & non-wood; Pakistan supply situation
- 2.3 Non-tree farm supply
- 2.4 Tree farm cultivation and supply; present; future
- 2.5 Pulp from wood potential in Pakistan

1830-2200 Session 3
Packages Ltd.: tour, dinner, panel discussion.

Day 2

0800-1200: Session 4A, Suppliers
- 4A.1 Establishing tree farms; benefits; problems.
- 4B.2 Methods: species, cultivation, fertilizing., etc.
- 4B.3 Harvest; preparation for delivery
- 4B.4 Merchandising, sales, shipping; contracts.

0800-1200: Session 4B, Users
- 4B.1 Use of pulpwood vs. traditional fiber; processing.
- 4B.2 Pulpwood value to the mill.
- 4B.3 Preparation & handling of wood chips.
- 4B.4 Pulpwood procurement; contracts; involvement with growers and suppliers.

1200-1330: Lunch break; exhibits

1330-1600: Session 5, Panel/Workshop Format
- 5.1 Supplier needs; announce desire to sell and deliver.
- 5.2 User needs; Announce desire to purchase; price
- 5.3 Merchant & middleman functions; value.
- 5.4 Agreements & contracts; methods of trade Scaling; weight, volume, moisture, bark & dirt, etc.
- 5.5 Educational need; methods
- 5.6 Government involvement, assistance, requirements.
- 5.7 Questions & answers.
- 5.8 Closing remarks; ceremony.

DAYS 3 to 5, Optional
- A: Tree farm technology and methods seminar (Winrock)
- B: Pulp & Paper Technology Seminar (G. Wire & Assoc.)

PULP AND PAPER TECHNOLOGY, OPERATIONS AND CONTROL SEMINAR AGENI

DAY DESCRIPTION

1 - Introduction
- Pulp and paper industry overview and general characteristics
A synopsis of the following

2 - Fibre sources, harvesting, transportation, competition
- Fibrous raw material preparation: wood, non-wood
- Mechanical pulping: groundwood, RMP, TMP, CTMP, others
- Chemical pulping: overview, wood chemistry aspects
- Sulphite process: acid, NSSC
- Kraft process: general process and digester operations

3 - Brown stock washing
- Recovery operations; evaporation, recovery process, chemicals preparation
- Screening/cleaning
- Bleaching: O,C,E,H,D and variants; equipment; chemicals prep.
- Pulping operations wrapup; new developments

4 - Paper making - overview
- Stock preparation
- Paper machine: wet end, dry end, finishing
- Paper making other operations, facilities
- Paper coating
- Energy requirements, heat and power system; cogeneration; emissions
- Water, effluent and treatment systems

5 - Instrumentation and Control
- Operations, Production and Quality Control Objectives
- General test, measurement and sensor characteristics
- Special test and sensor needs
- Programmed Logic Control
- Regulatory Control
- Advanced Control and Optimization
- Information and Control Systems

The program is based on 6hr/day seminar sessions. Presentation is paced to provide question and answer time. Depending on client and audience interests, some areas may be strengthened in coverage while others are given more cursory treatment.

Format: Lecture/discussion; slides, flip charts and overhead projection presentation aids; VCR's also available, RPQ.

Notes: Each participant will receive a set of seminar notes.

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PULP BLEACHING OPERATION AND ADVANCED CONTROL SEMINAR

DAY DESCRIPTION

1. -INTRODUCTION:
   Welcome; statement of purpose, announcements.

   -PURPOSES OF PULP BLEACHING AND CONTROL - OVERVIEW
   Delignification; whitening; shieve removal; strength

   -CHEMISTRY AND PROCESSING REVIEW - THEORY AND PRACTICE
   O-Stage; C-Stage: C, C+D; E-Stages: E1, E2, E+O, E+H, E+P
   H-Stage; D-Stage; peroxide and other chemistries.

   -PROCESS EQUIPMENT, OPERATIONS, SENSORS AND CONTROL
   Feedstocks; pumping, mixing, heating, reaction, washing;
   Stock processing consistency, rate, level, etc.
   Equipment arrangements. Water reuse; corrosion.

   Variables: affects on quality and control: measurements, sensors and control systems requirements. Pulp quality, productivity; operating and environmental factors; costs.

2. -ADVANCED CONTROL CONCEPTS, REQUIREMENTS AND BENEFITS
   A review of Day 1 material in advanced control context.
   Applications strategy; why digital systems are needed.

   -PROCESS, INSTRUMENTATION AND CONTROLS AUDIT
   Reasons, methodologies and procedures; special sensors.

   -DIGITAL CONTROL SYSTEM REQUIREMENTS, EVALUATION AND SELECTION
   Hardware facilities: Compute capabilities and memories;
   Peripherals; printers, plotters, dislays, etc.
   Process input and output; communications and networks;

   Software Facilities: Operating and general facilities;
   Configuration and programming; hardware integration;
   Data acquisition, regulatory and advanced control;
   Human interface: operator, management, maintenance
   Displays and reports; management information; communications

   -PLANNING, ENGINEERING, DESIGN AND PROJECT MANAGEMENT
   Modeling and customizing: process, plant and operation;
   Control room design: layout, equipment placement, etc;
   Instrumentation, cabling, electrical, mechanical and HVAC;
   Simulation, testing, installation, commissioning, checkout;
   Documentation; engineering, design and maintainance aides;
   Training: operator, maintenance, management/technical

3. -INSTALLATION AND IMPLEMENTATION REQUIREMENTS
   Contracting, contract management; installation planning
   Fast track, zero production time loss requirements
   Calibration, process identification, algorithm tuning,
   Control tuning, and continuing maintenance

   -CONCLUSIONS AND WRAPUP

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GWC-WINROCK-USAID

STUDY OF TREE FARM WOOD UTILIZATION FOR WOOD PULP PRODUCTION IN PAKISTAN

APPENDIX A

PULP AND PAPER TECHNOLOGY

A REVIEW

BY

G.WIRE CO.
PULP AND PAPER PROCESS & CONTROL TECHNOLOGY
6529 121st Pl. S.E.
BELLEVUE, WASHINGTON 98006 USA

REF.:GWA2-W00727A1

APPENDIX A: PAPER PULP TECHNOLOGY

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4. GENERAL PULPING TECHNOLOGY	A10
5. PULP QUALITY AND CHARACTERISTICS	A13
6. MECHANICAL PULP MANUFACTURE STONE GROUNDWOOD (SGW) REFINER MECHANICAL PULP (RMP, GRW) CHEMI- & THERMO-MECHANICAL PULP (TMP, CMP, CTMP)	A15
7. CHEMICAL PULP MANUFACTURE ALKALINE; KRAFT, SODA SULFITE; NEUTRAL & ACID OTHER PROCESSES	A19
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PULP & PAPER OVERVIEW

Paper products are pervasive to modern society--sanitary and hygienic products; writing, printing and publishing; packaging and wrapping; and hosts of industrial products such as wallboard, insulation board, formica, etc Paper is one of the basic commodities of modern civilization; per capita consumption is a common index of cultural and economic achievement. Worldwide it ranges from less than 1 Kg to 311 Kg in the U.S.; Pakistan is 2.7 Kg.

The pulp and paper industry is a virtual microcosm of modern chemical and manufacturing industry. Most cellulose pulp is manufactured from wood, and thus, is a major forest products industry. Its processing and manufacture involve complex chemistries, apparatus and procedures. It is a major consumer of energy and power, but also may be a net producer as well. It is capital intensive, typically requiring $0.3 to 1. million per ton per day of capacity, depending on nature and extent of facility.

In 1988 the world produced over 225 million tons. Most of this is made from vegetation fiber. There is a very small but growing synthetic fiber usage. This is mainly for specialized products. The predominant vegetation fiber source is of wood origin; however in some areas of the world annual crop fiber such as bagasse, straw, grasses, bamboo, and Kenaf are used.

Annual crop fiber sources yield pulp inferior to wood in terms of world market expectations; however, where used, products satisfactory for the market served have obviously been developed, but usually with substantial price reduction or tariff and customs protection from competition. Cotton and hemp (linen) also are used for papermaking. These produce superior quality papers and are primarily used for bond and very long lasting papers.

Paper is a construction, made by "forming" a sheet from a very dilute (0.3%-0.8%) suspension of pulp in water. Depending upon the grade of paper and the mill situation, it may contain one or more fiber types along with chemicals, pigments and dyestuffs, to render the desired sheet characteristics. After formation on a wire mesh arrangement, the water is further removed, first by pressing then by drying. Finally the sheet is finished by calendering to make it smooth, and may be coated with a pigment-binder "paint" for improved printing or other application purpose.

Cellulose pulps have a wide variety of characteristics depending upon the fiber source and the pulping process employed. These properties are further developed by mechanical and chemical treatment in the papermaking process.

Table A1 lists a typical printing paper composition, Table A2 typical pulp furnishes for a variety of paper types; Table A3 shows important properties values for a variety of pulp types. Figure 1 shows pulp and paper manufacture functions.

The following are typical of the ingredients necessary for an average ton of paper and represents a variety of grades.

DESCRIPTION	UNITS	PER TON
Labor	Man-hr.	11
Fiber @ 45% yield	OD Kg	2,222
Water	m3	128
Power	Kw-hr.	1,200
Fuel Oil	Liters	650
Sulfur	Kg	14
Salt cake	Kg	30
Lime	Kg	160
Caustic Soda	Kg	26
Chlorine	Kg	50
ALum	Kg	13
Rosin	Kg	6
Clay	Kg	60
Talc	Kg	25
Synthetic Filler	Kg	10
Starch	Kg	50
Dye & Pigment	Kg	7

TABLE A2: EXAMPLE PAPER FURNISHES

	PERCENT BY WEIGHT				
PULP GRADE-->	MECHANICAL PULP		CHEMICAL PULP		CLAY/FILLER
PAPER GRADE	SGW/RMP	TMP/CMP	UNBL	BLEACH.	
NEWSPRINT	75-80			20-25	
NEWSPRINT		100			
BOOK	60-80			20-40	10
BOOK		80-100		0-20	10
LIGHT WT. COAT.	20-30			70-80	40-50
LIGHT WT. COAT		50-60		40-50	40-50
MAGAZINE	40-50			50-60	50-60
MAGAZINE		50-70		30-50	50-60
REG. BOND		50-70		30-50	
FINE				100	10-15
TISSUE				100	
TOWEL		80		20	
FOODBOARD*				100	10-15
CARRIER*			70	30	7-12
FOLDING BOX	80 % RECYCLE			20	10
LINERBOARD			100		
COR. MEDIUM			NSSC OR WASTE PAPER		

TABLE A3: PULPING PROCESSES & PULP CHARACTERISTICS

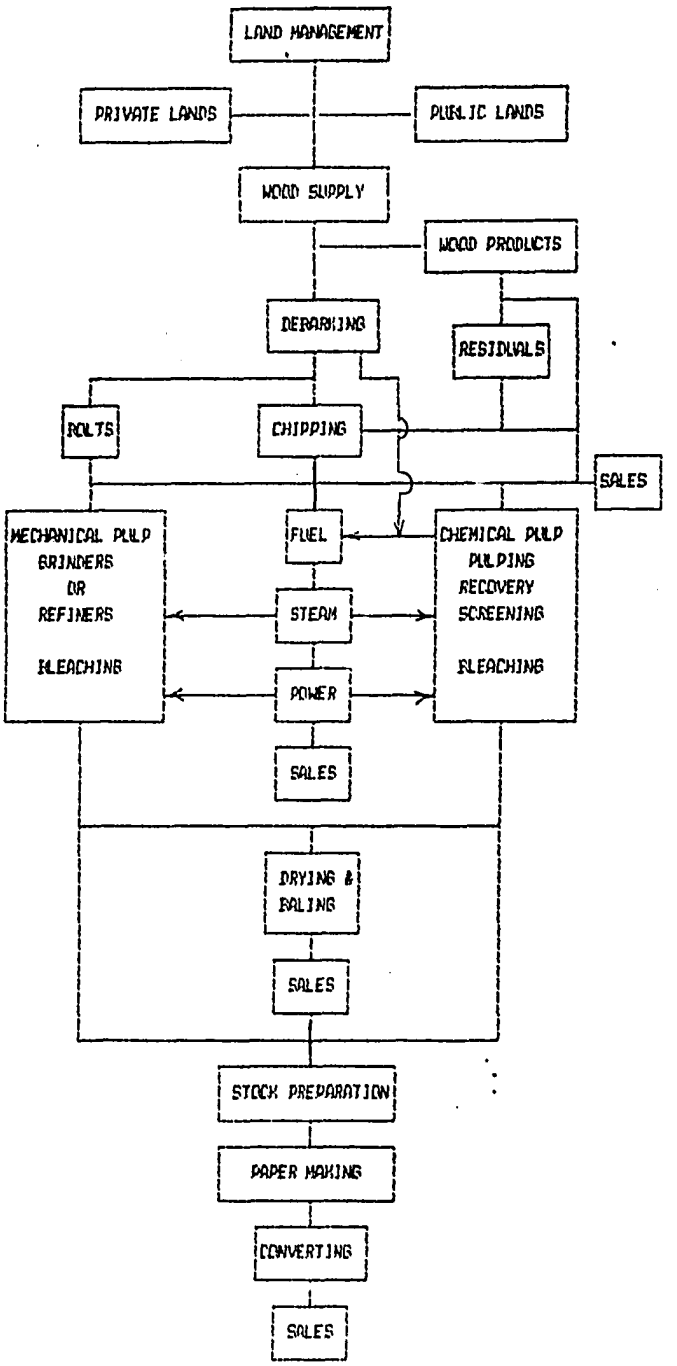
```
PROCESS TYPE-----------> MECHANICAL------------------------>CHEMICAL
PROCESS        YIELD----> 92%---------------------------------->40%
  GROUNDWOOD              *--*
  RMP                     *--*
  TMP                       *---*
  CTMP                       *----*
  BCTMP                      *------*
  NSCM                         *-------*
  NSSC                                *--------------------*
  KRAFT                                                  *------------*
  SODA                                                          *-----*
  SULFITE                                             *---------------*

CHARACTERISTICS
  BRIGHTNESS, Unbl./Bl.   55-65/60-75                        40/70--94
  TEAR STRENGTH           LOW                                     HIGH
  TENSILE STRENGTH        LOW                                     HIGH
  BULK                    HIGH                                     LOW

FIBER SOURCES:
  SOFTWOOD                YES                                      YES
  HARDWOODS               ??-->                                    YES
  BAGASSE                                 *------------------------>YES
  STRAWS & GRASSES        NO                                       YES
POWER REQUIRED, per ODT   >2,000 Kw <------------------------700 Kw
ENERGY & POWER COGEN.     NO--------------------------->           YES
CHEMICALS RECOVERY        NO----------------->   ------------->YES
MILL COST, MM$/TPD        0.3-0.6<------------   --------->0.7-1.2

PAPER GRADE EXAMPLES:     NEWSPRINT                 PRINTING/WRITING
                          CATALOG, BOOK             TISSUE, SANITARY
                          PUBLISHING, LABEL        BOXES; CONTAINERS
OTHER USE EXAMPLES        MOLDED PULP                  RAYON & FILMS
                                                 PLASTICS & LAMINATES
                                                            EXPLOSIVES
                                                             CHEMICALS
```

BLOCK DIAGRAM



The principal fiber resources for cellulose pulp are wood; fibrous annual crops and their by-products such as bagasse, straw, cotton linters, etc.; and waste or recycled paper products. There are some non-cellulose synthetics being used, but this is very slight, and only for very expensive specialties.

WOOD: This is by far the predominant and preferred fiber source. Those locations of the world where it exists in sufficient quantity, and is managed, tend to be the pulp and paper producing centers. The resource has many uses and values other than wood pulp. In fact most other uses are of higher value, with the exception of fuel. Therefore wood for pulp and fuel is often a residual from other wood processes. See Figure A4.

The pulp and paper maker tends to view wood in two categories: conifers or "**softwoods**" and broadleaf or "**hardwoods**".

Softwoods have long fibers and produce high strength chemical pulps as well as good mechanical pulps. More extensive "stock preparation" and energy may be required to render desired papermaking characteristics from softwood pulp than with hardwood pulp. Softwood pulps predominated industry for many years, and continue to do so; however, hardwood pulps are making important and substantial inroads to world production and commerce.

Hardwoods have much shorter fibers than softwoods and produce pulps of lower tensile and tear strength. However, this very characteristic contributes to filling the voids between the coarser softwood fibers in a paper sheet, and facilitate paper smoothness, a vital printing parameter. Also, their greater surface area increases light scattering properties, improving opacity. The bulky ray cells facilitate paper sheet bulk, another desirable property. Thus, the use and markets for hardwood chemical pulps has been expanding and it is now a well recognized, accepted and important component for paper making.

Hardwoods, traditionally, were difficult for mechanical pulp production; they consumed high energy and tended to produce unsatisfactory pulp. However, the advent of TMP, CMP and their variants as well as PGW have enabled satisfactory mechanical-type pulps from many hardwoods.

Eucalyptus is deserving of special mention. This wood, indigenous to Australia and Tasmania, has been planted many places in the world and grows very well. It has been the subject of extensive pulp and papermaking research and development and has been very successfully used for many years. Although it is of marginal desirability for most solid wood products, it is a superior hardwood for pulp manufacture. It yields chemical pulps superior to most hardwoods yet with the desirable hardwood properties, especially for fine, light weight and tissue products. It also yields very satisfactory CTMP pulps.

market pulp based on cultivated Eucalyptus plantations in Australia, New Zealand, Brazil, Argentina, Spain, Portugal and many other world locations. TMP, BCTMP and PGW are also highly satisfactory Eucalyptus pulp products. Of the many species, Eucalyptus camaldulensis is one of the more suitable, especially young wood.

Annual crop fiber was the earliest of papermaking substances. The word paper comes from papyrus, the ancient Egyptian writing media. The highest quality papers are made from cotton, linen (hemp) and the like. Jute, sisal etc. were the basis for strong packaging and bag papers; some of this is still called "jute board." Straw, Kahi, bagasse, bamboo, Kenaf and other "grasses", are still important papermaking fibers in many parts of the world. However, today they account for a very small proportion of world production, largely by the developing regions. This does not imply unimportance. As the worlds fiber needs increase, and available wood supply does not, these fiber sources will probably grow in utilization. The primary issue will become economic.

Until the mid-19th century many of the above, especially straw, was a primary fiber source and accounted for much of the world production. Several factors came to weigh against them though. These include:

-Mechanical harvesting of grain, and leaving most of the straw. in the soil and its use as green manure.

-High labor cost to collect, bundle and deliver.

-Advent of cheap anhydrous ammonia, enabling plowing straw and fortifying with ammonia, improving soil condition and fertility.

-Requirements for better paper strength and graphics arts quality.

-Economic impact of environmental requirements, particularly relative to effluents and emissions abatement.

-The economies of integrated wood harvest and conversion, and wood residuals as the pulp fiber source

-Economic disadvantage of the smaller production facility to the larger, more efficient wood pulp and paper mill.

Generally, where annual fiber crops are still used for fiber, the above circumstances cannot or do not prevail, or the annual crop is able to fit within the above. This may be due to being the only fiber available, low cost labor, manual harvesting and collection economics, etc. All of the above apply in Pakistan.

The use of annual crop fiber is not to be discounted nor avoided. There is a great deal of work being done to further develop both fiber, harvesting and process methods which are internationally competitive. Progressive wood scarcity will, in time compel use.

major : . tance for papermaking. There are several categories and aspects to be considered. Many paper mills exist wholly upon recycled fiber. These tend to be located near the fiber source, often metropolitan areas, for shipping advantage.

Every paper mill has trim, broke (from paper machine sheet breaks) and other waste. The paper converting industry also has trim and other waste. This is directly recycled if convenient to the papermaking, or baled for sale and use. It is good paper fiber, often comparable in worth to raw paper stuff. There are limitations to re-use, however depending upon specifics.

Waste paper is collected, sorted, baled and sold for papermaking fiber. Sorting, usage and value follows pulp categories--mechanical or chemical pulp; brightness or color. The matter of filler or loading material also must be considered; magazine and similar papers contain up to 60% clay and usually cannot be used. If the paper is not printed, or if color is not important, the fiber can be used for its other properties; white replaces bleached pulp; boxes, kraft bags and mixed waste replace unbleached kraft pulp; news paper and mixed waste are used for multi-layer boxboard.

Printed paper may be deinked and bleached. This again follows pulp type. Chemical pulp based papers are printed with paint-like inks that dry. Processes have long existed for separating the ink, the pulp can be bleached to 75%-85% brightness.

Newspaper, catalog, etc. papers from mechanical pulps are printed with a non-drying petroleum based ink. Processes have been developed for deinking and bleaching these papers for re-manufacture to newsprint.

The major problems with utilizing recycled paper is obtaining it economically and disposing of the ink, debris and chemicals containing effluent; both a technical and economic matter. Where this can be dealt with satisfactory, it is an excellent papermaking fiber source.

There are firms in the business of supplying recycle or secondary fiber pulp as a market commodity; the market is growing with Japan, Korea, most of Europe and other fiber-deficient being substantial consumers. It needs be emphasized that there must be some raw fiber produced, for a recycle fiber source. But with efficient collection and sorting, recycle can supply a very large proportion of needs.

Recycle fiber is a major portion of Pakistan's paper making fiber, including considerable import.

The availability and management of its fiber resource requirements is fundamental to successful pulp mill operation. Lack of or changes in this account for one of the most common causes of mill operational and financial problems; the huge investment in plant can become valueless. Yet it is not uncommon for this to be improperly or under considered, particularly in developing regions. Pulp mills operate continuously around the clock and weekends; they will only shut down once or twice a year for major maintenance, often in conjunction with statuatory holidays. The fiber supply on-hand must satisfy requirements.

A 33,000 TPA, 100 TPD mill requires about 70,000 m3/yr., 200 m3/day of solid wood for mechanical pulp; 130,000 m3/yr., 400 m3/day for chemical pulp. This amounts to 3,500 to 6,500 hectares at 20 m3/yr./Hect yield. It also amounts to 20-40 10 m3 truckloads/day. If the wood is received as chips, there will be 60-120 such truckloads/day. The actual number of loads wil depend on cubic hauling capacity, legal load and work week.

Figure A2 shows wood flow in an integrated forest products industry; the whole point is to maximize wood utilization and total harvest value. Figure A3 shows the steps in wood preparation for pulp manufacture and fuel. Actual flows depend upon the quality of harvested timber and industry/processes existing. All or part of these operations may be carried out by the grower/land owner, wood products business operator, pulp mill or independent businesses. But the pulp mill should always screen chips, process to remove metal and rocks and store sufficient quantity to ensure availability.

It is common for there to be several wood suppliers: the using mill or forest products business, other operators, private growers and government entities. There is a place for other private businesses to carry out sectors of these operations, e.g., harvesting, timber trading, hauling, chipping. There is a great deal of timber, intermediate solid wood and chip trade; even overseas. Freight costs commonly make up 40%-70% of mill FIS chip costs. Stumppage value (standing, growing trees) is computed by subtracting all point of delivery costs from the composite sales value.

It is important for a pulp mill operator to manage and secure its fiber supply. This may be through direct ownership of woodlands, through contract with other suppliers and in all cases by maintaining good and fair relations. This is affected by extents of competition, but wood supply has generally proven to be a valuable, fragile commodity. Thus, it has been to the mill operator's interest to involve in reforestation, aforestation, tree-farming, nursery operation, forestry and harvest practices and transportation, whether or not directly engaged in these businesses. It is good business to do so.

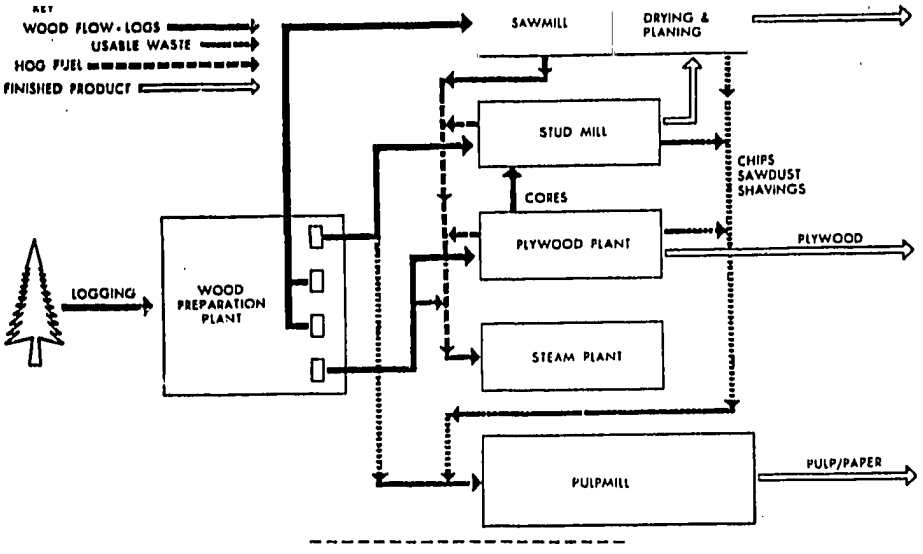
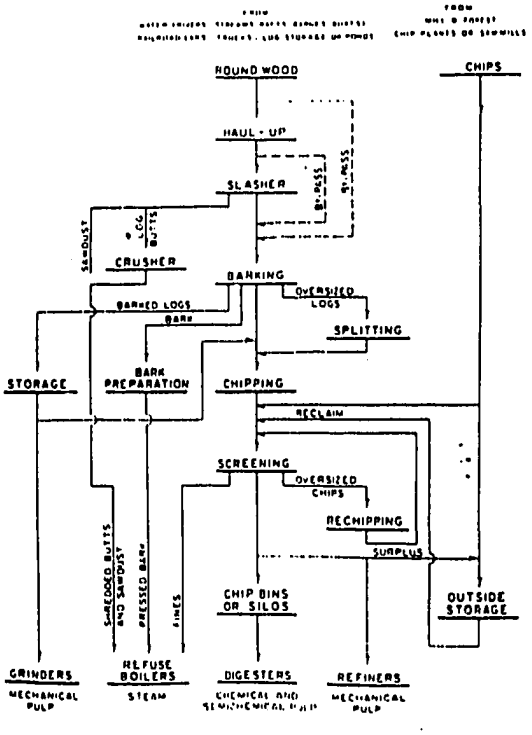


FIGURE A3: PULPWOOD PREPARATION FOR PROCESSING



Cellulose pulps have specific characteristics according to fiber source and process type. The fiber types are generally categorized as softwoods (conifers; gymnosperms), hardwoods (broad-leaf; angiosperms) and annual fibers. Certain fibers are limited as to suitable processing, either technically or economically.

Before examining process types, we should consider the composition of fiber sources. Wood and other fiber sources are agricultural products and for our purposes can be considered to consist of cellulose fibers (40%-50%), lignin binder (22%-28%)and various extractives (4%-7%). A common generic term for this is lignocellulose. The objective of pulp making is to render the lignocellulose solid mass into a fibrous state.

There are two general methods for doing this: mechanical and chemical. Intermediate or combination processes also exist, i.e. chemi-mechanical and semi-chemical. Chemical pulping endeavors to liberate cellulose fiber from the wood by dissolving away the lignin. Mechanical pulping renders pulp from wood by grinding action; it represents nearly the whole wood. Chemi-mechanical and semi-chemical processes employ combination of these.

Chemical pulp yields 50-65% unbleached pulp and 40-50% bleached pulp from dry wood. It has good strength and is bleachable to high, stable brightness, 80-90%. Mechanical pulp yields 80%-90% from dry wood. It has low strength and is bleachable to only 60% to 70% brightness, stable for only a short time. It is less costly than chemical pulp. Semi-chemical and chemi-mechanical pulps tend to have intermediary characteristics.

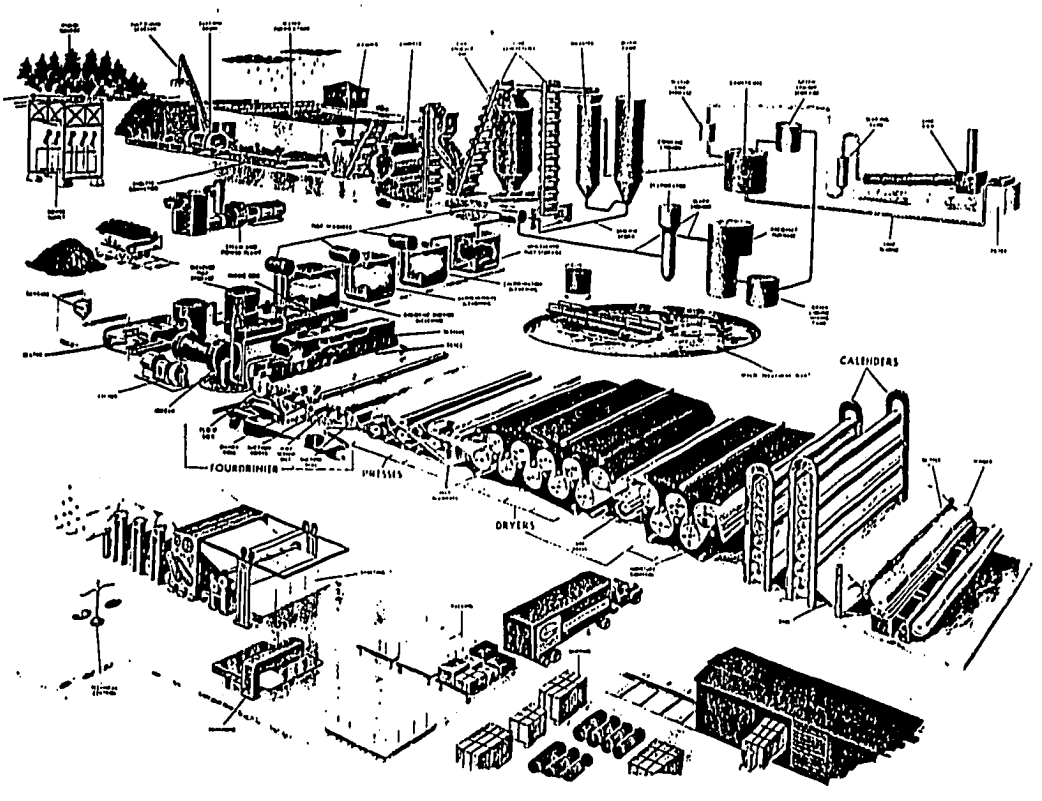
Table A3, page A3 shows these relationships and characteristics.

Each fiber and process product has a place in papermaking, depending on paper use. The available fiber supply and market needs tend to dictate the pulp and paper making processes used. Nearly all mechanical pulp and most chemical pulp is converted to paper at the pulp mill site.

About 20% of wood pulp production is sold on the market, however. It is a commodity of international commerce. This is primarily bleached chemical pulp although there also is some unbleached chemical pulp and rapidly expanding commerce in certain mechanical type pulps (TMP & BCTMP). For pulp to be delivered on the market, it must be dried, baled, labeled and assembled in lots for shipping. This is a substantial operation, akin papermaking and major capital expense.

Figure A4 shows a pulp and paper process flow.

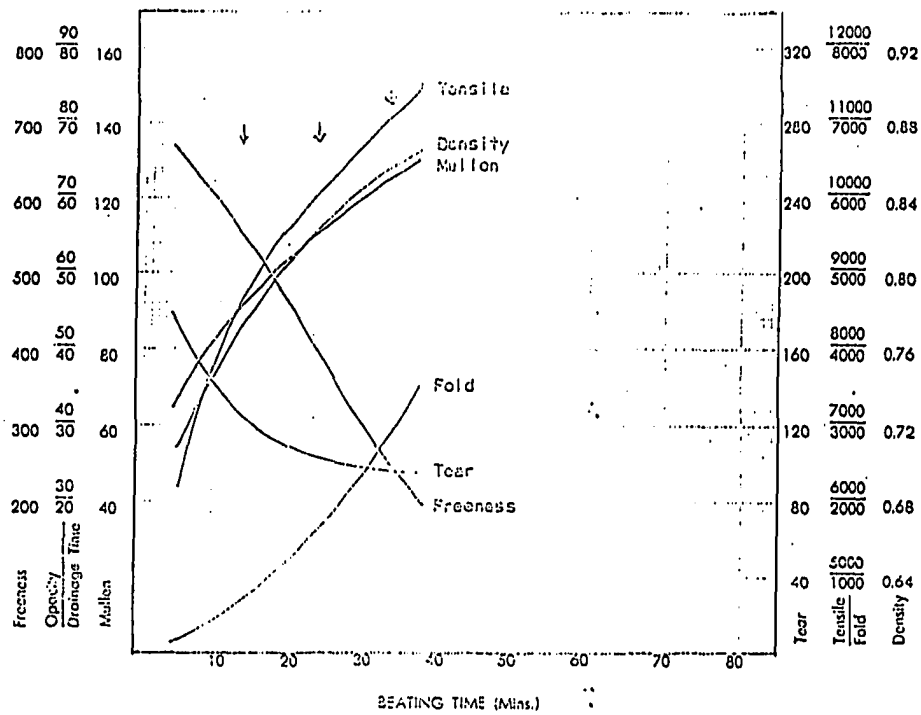
The details as to fiber source, pulping process and resulting pulp characteristics are of paramount importance to all aspects of usability, commercial viability and investment security.


CALENDERS
FOURDRINIER
PRESSES
DRYERS

Grade and Kind of Pulp: Puget Bleached "S" - 80-S
Manufactured by: Georgia Pacific Corp.
Reference:

Permanganate No.		cc
A. D. of Pulp	82	%
G. E. Brightness	91.2	%
Dirt Count	-	PPM
Speck Count	-	SPS
Viscosity	115	cp

Can. Std. Freeness	550	400	250
Beating Time	14	24	33
Mullen	94	111	126
Tear	125	105	98
Fold	700	1600	2900
Density	0.772	0.812	0.855
Opacity	-	-	-
Tensile	8600	10,000	11,000
Tear at 5 Mins.	-		



There are a number of pulp quality parameters in common usage. These relate to papermaking usage, process conditions and such. Many of the properties of pulp and paper are highly humidity and temperature dependent, and most physical tests should be carried out at standard conditions, particularly pulp (T 402). Standard conditions for pulp and paper testing are established, particularly by certain organizations. Notable are:

TAPPI - Technical Association of the Pulp & Paper Industry
CPPA - The Canadian Pulp & Paper Association
SCAN - The Scandinavian Pulp & Paper Association
ISO - The International Standards Organization.

These organizations collaborate and their standards are usually interchangeable or correlatable. Where referred, T-- represents the TAPPI method.

Some Important Pulp Physical Tests Relating to Papermaking:

Freeness, T 227: the rate and extent water drains from pulp; common methods are Canadian Standard (CSF), Schopper-Reigler (SR) and Williams. In CSF terms, lower freeness pulp drains slower and retains more water. This means the paper machine must run more slowly, the sheet will tend to be more delicate and harder to dry; conversely for higher freeness.

Mechanical pulps are produced to a freeness specification, i.e. 90-100 CSF for newsprint; 50-70 for book and specialty papers. **Chemical pulps** are refined to develop tensile and burst strength, at the expense of tear strength, bulk and opacity. The greater the degree of refining, the lower the CSF. Freeness also relates to the extent of mechanical effort expended in "refiners"; the lower the CSF, the more energy is required for production. It is a standard stock preparation parameter for all papermaking.

Brightness; T 525: Reflectance of 457 Nm light compared with MgO.

Beater Test; T 220: a standard refining or **"beater test"** to evaluate the basic and developable strength characteristics of chemical pulps Figure A3 shows some representative pulp "beater" test data. The procedure also defines handsheet preparation.

Tear Strength; T 220: relates to the fiber length and is an intrinsic pulp property. It is important to papermaking, converting, printing press runability, and to many usage factors.

Tensile strength; T 220: relates to inherent fiber strength **and** inter-fiber bonding, e.g. chemical pulp "refining".

Burst or Mullin Test; T 220: the force to burst a sample and relates to a combination of the above strength parameters.

Fold; T 220: the number of folds a sample can withstand before breaking.

General Tests:

Dirt count; shieve count: this is a measure of the extent of dirt or shieves (course fiber particles) in the pulp. Cleanliness and avoidance of such matter is a paramount pulp quality parameter.

Brightness: Reflectance of light at 457 Nm compared with MgO.

Freeness: per above

Moisture, grammage (basis weight) and mass; T 208, 220, and 228: mass and moisture determination are pervasive to pulp and paper manufacture from wood receipt to final paper. Pulp slurries are handled between 0.5% and 95%; pumping occurs up to about 5%. These slurries are difficult to sample. Dry pulp is hygroscopic so that achieving reliable OD measurement is difficult. Procedures and apparatus are rigorous to minimize error.

OD Pulp: Oven Dry Pulp; often as % on weight; e.g. %OD; ODT/day.

AD pulp: Air dry pulp; 100%AD = 90%OD by definition; this is the convention for pulp sales and mill capacity rating: e.g. ADT/day.

Consistency, T 240: mass of OD pulp/total mass, %

Chemical Pulping Tests:

The following apply only to chemical pulp manufacture:

Ka. No. (Kappa No.); T 236: an empirical test reacting pulp with $KMnO_4$; this value directly correlates with lignin content and is a principal pulping and bleaching control test.

K No., P No., Permanganate No.; T 214: similar to Kappa No. but easier to perform; relates to lignin content but not linearly.

Note: the lower the K. or Ka. Nos. the lower will be the lignin content, but also the greater the pulp degradation. .

CED Viscosity:T 230 & T 254: this is the viscosity of a bleached pulp slurry dispersed in a solution of cupri-ethylene diamine tetracetic acid. Viscosity relates to the average degree of polymerization of the cellulose and hence to the intrinsic pulp strength. This is not a direct measurement as is the beater test. However, the procedure is relatively fast and so, useful for production monitoring. The procedure is delicate, and if not carried out properly will, in itself, severely degrade the pulp.

Ka. No. or K. No. and CED Viscosity should be carried out routinely on digester (washer) samples, E stage washer pulp in bleaching; viscosity should be likewise carried out on final bleached pulp samples, i.e., every hour.

MECHANICAL PULP MANUFACTURE

General

Mechanical pulping processes render solid wood into pulp by, in affect grinding, i.e. mechanical action. This does not separate fiber from fiber or from lignin. Mechanical processes yield 85%-90% of dry wood with attendant economies. It is a papermaking substance of relatively high bulk, low strength, low brightness and rapid degradability.

Products made from mechanical pulp tend to be viewed as lower in quality than chemical, but this is really relative to usage and cost. It accounts for about 25% of world pulp production. It is used where its characteristics are desirable such as for newsprint, textbook, catalog, sanitary and lower quality printing and forms. One of the fastest growing paper grades is light weight coated or LWC, for which mechanical pulp is a primary component.

Until recently, it was always necessary to use some long-fiber chemical pulp with mechanical pulp in order to make paper or to use it. Advances in the TMP, CTMP and variant processes is reducing or eliminating this need.

Mechanical pulp has been a very limited commodity of pulp commerce. A primary reason is that when dried it forms very hard particles which resist re-slurrying. However, development of fluff drying coupled with the vastly improved characteristics of TMP and CTMP are bringing about a growing market and supply.

Mechanical pulping requires very substantial power, primarily electrical. Typically 1,800 to 2,500 Kw-hr./ton. The refiners use 500 to 25,000 kW motors. Process unit size ranges from about 25 TPD to several hundred tons daily, i.e. 5 MW to 35 MW of power.

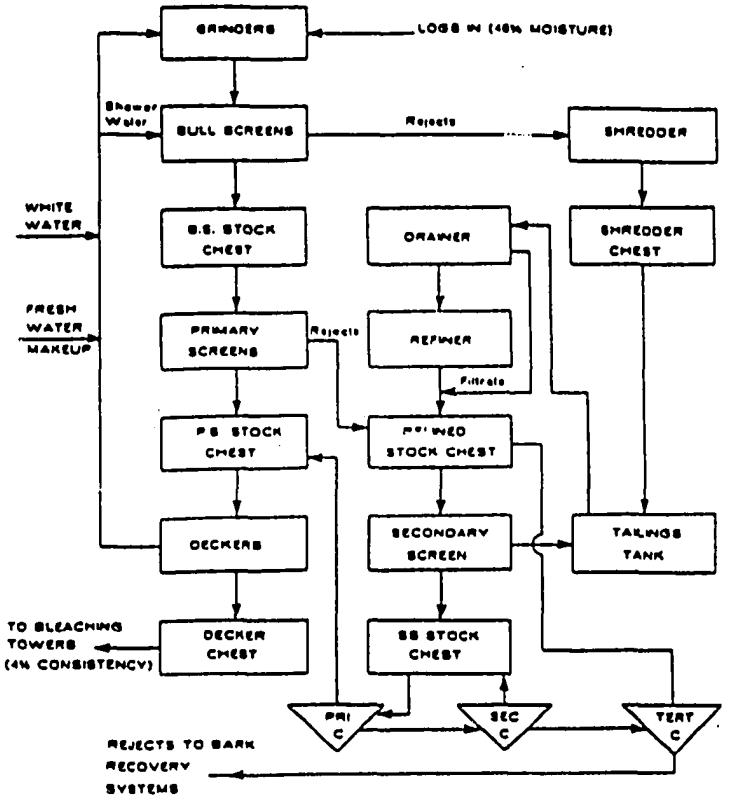
Mechanical pulps are bleached by surface whitening, typically with hydrosulfite or peroxide. Typical brightness is 60% (newsprint) but may reach up to 75% (book and LWC).

Following are the important mechanical pulping processes. They are shown in Figures A6-A8.

STONE GROUNDWOOD (SGW), Figure 6: This is an ancient and traditional process wherein pulp is made by grinding solid "bolts" of wood about 1 meter wide with a large, circular electric or water driven stone; this required man-handling of the wood to a great extent. Traditional groundwood is only suitable for softwoods i.e. most conifers and some "soft" deciduous woods, i.e., poplar, cottonwood, etc. Harder woods grind to a powder and consume too much power. SGW is rarely a market commodity.

PRESSURE GROUNDWOOD (PGW): A recent variant of the groundwood process which has the wood and grinder under pressure. This results in more uniform quality pulp, lower power consumption and possible use of Hardwood. Some market for PGW is occurring.

FIGURE A6: STONE GROUNDWOOD PROCESS FLOW



REFINER MECHANICAL PULPS

The wood handling and refiner flow schemes for the following processes are similar, with additional front-end apparatus for thermal or chemical aspects. Most often the pulping is integral with papermaking, but there is a growing commodity market for these pulps. If market pulp is to be made, then the additional drying and baling apparatus is required.

REFINER GROUNDWOOD (RGW, RMP), Figure A7: In the mid-50's the process for making mechanical pulp from wood chips using disk refiners was developed. There are several advantages: use of chips and wood residuals rather than round wood; greater process automation and less labor; better product strength and uniformity. Modern versions of this process employ pressurized refiners and schemes to recover much of the electrical power expended as process heat. This process has developed to where it or its variants account for most new installations. Hardwoods are usually unsuitable for RMP processing.

The following are important variants of the RMP process:

THERMO-MECHANICAL PULP (TMP), Figure A8: TMP evolved from the idea that wood is thermo-plastic, and if heated prior to the refiner, the fibers could be separated with less cutting, bruising and consequent strength loss; also, hopefully with less power required. Except for power reduction, this has happened. However power consumption seems to increase with softwoods. Some hardwoods are satisfactorily pulpable by TMP, including Eucalyptus.

CHEMI-MECHANICAL PULP (CMP),
CHEMI-THERMO-MECHANICAL PULP (CTMP),
BLEACHED CHEMI-THERMO-MECHANICAL PULP (BCTMP),
NEUTRAL SULFITE CHEMI-MECHANICAL PULP (NSCM): The chemi-mechanical processes were developed and are operated with two primary purposes: 1. to chemically soften the wood in advance of the refiner, with the same objective as TMP,; 2. to facilitate brightness. The actual process conditions for a given mill then, will depend upon its fiber source and process results relative to its needs. The chemicals employed are usually sulfites and brightness enhancing additives; the point of addition varies, but usually will be a small digester in advance of the primary refiner. These processes are more suitable for hardwoods. They also may produce pulps with strength properties approaching chemical pulps.

TMP, CMP, CTMP,BCTMP and NSCM pulp fiber characteristics are between those of mechanical and chemical pulps and less chemical pulp is required for papermaking with them, sometimes none. This has brought the process into considerable favor, especially for newsprint, catalog, and LWC; also satisfactory new grades of printing, writing and other papers are being developed.

In many respects TMP, CTMP, etc. are similar to chemical pulps from annual crops, i.e., straw, grasses, bagasse, etc.

FIGURE A7: REFINER MECHANICAL PULPING PROCESS FLOW

```
                /-------\
                |PRIMARY|
            /---|REFINER|--\
            |   \-------/  |  /-----------\    /---------\  /---------\       /---------\  /---------\
WOOD        |              |  |SECONDARY|    |TERTIARY |  | SCREEN  |ACCEPTS |CENTRI-  |  |BLEACHING| BLEACHED
CHIPS---    |              |--| REFINER |-----| REFINER |--|         |--------|CLEANERS |--|         |-----------
            |              |  \---------/ |   \---------/  \---------/       \---------/  \---------/   PULP
            |   /-------\  |              |   /---------\  /---------\                     /-------\
            \---|PRIMARY|--/              |   | REJECTS |  | REJECT  |                     | CHEM. |
                |REFINER|                 \---| REFINER |--|THICKENER|                     | PREP. |
                \-------/                     \---------/  \---------/                     \-------/
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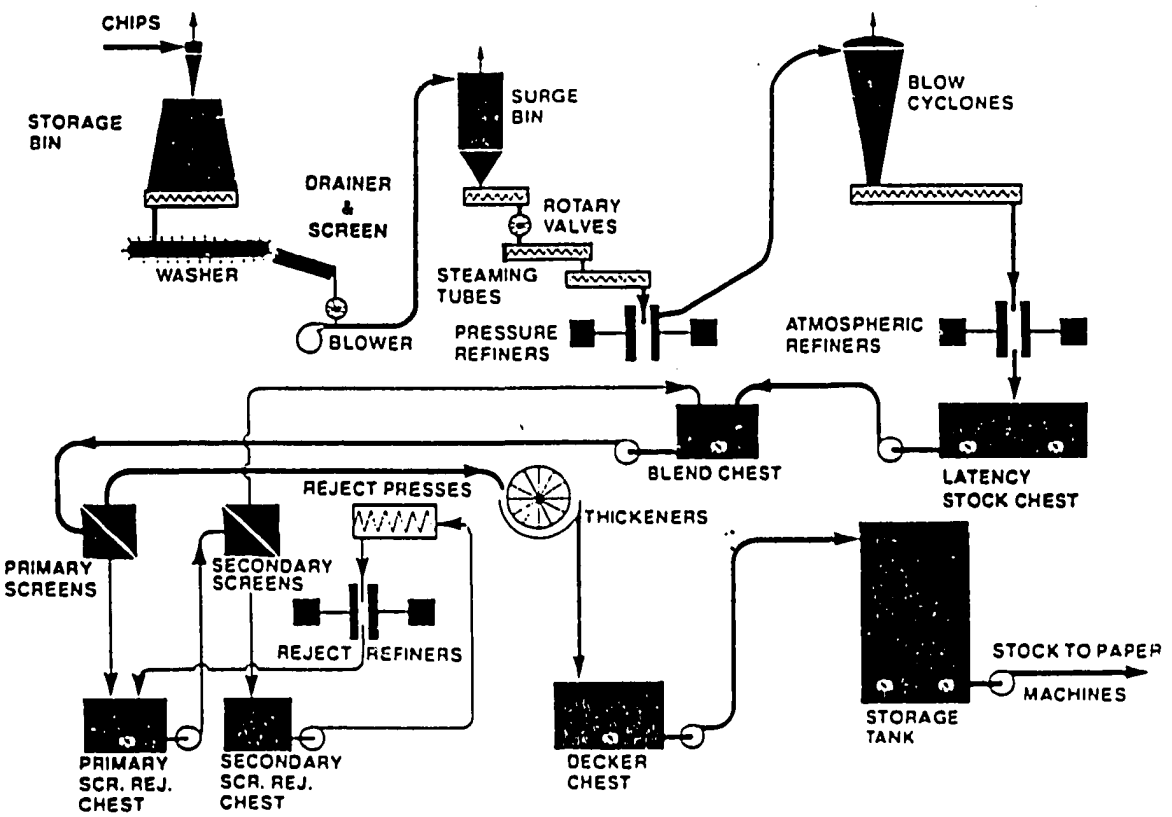
FIGURE A8: THERMAL-MECHANICAL PULPING PROCESS FLOW



CHEMICAL PULPS:

Chemical pulping sets about to free the cellulose fibers from the ligno-cellulose solid by dissolving away the lignin. The ideal is to dissolve away all the lignin without harming the cellulose. This never happens, and so the process and conditions are selected to optimize depending upon usage of the pulp and costs.

In all cases the more extensively the degree of delignification (Ka. No.), the more extensive is the cellulose degradation (viscosity). This varies widely with fiber source, process and process conditions. The process conditions will then be selected and managed in accordance with intended use of the final pulp. For bleached chemical pulp, this is an attempt to optimize strength, brightness and cost.

It is convenient and appropriate to consider the chemical processes generically as alkaline, sulfite and other. Figures 4-6 show the process flows.

ALKALINE (SODA, KRAFT, SULFATE) PULPING, Figure 9: the alkaline processes by convention are soda and kraft; process wise they are very similar. The Alkaline processes have chemicals recovery and heat cogeneration in common. Although the neutral sulfite process is often at alkaline conditions, it will be considered with sulfite processes.

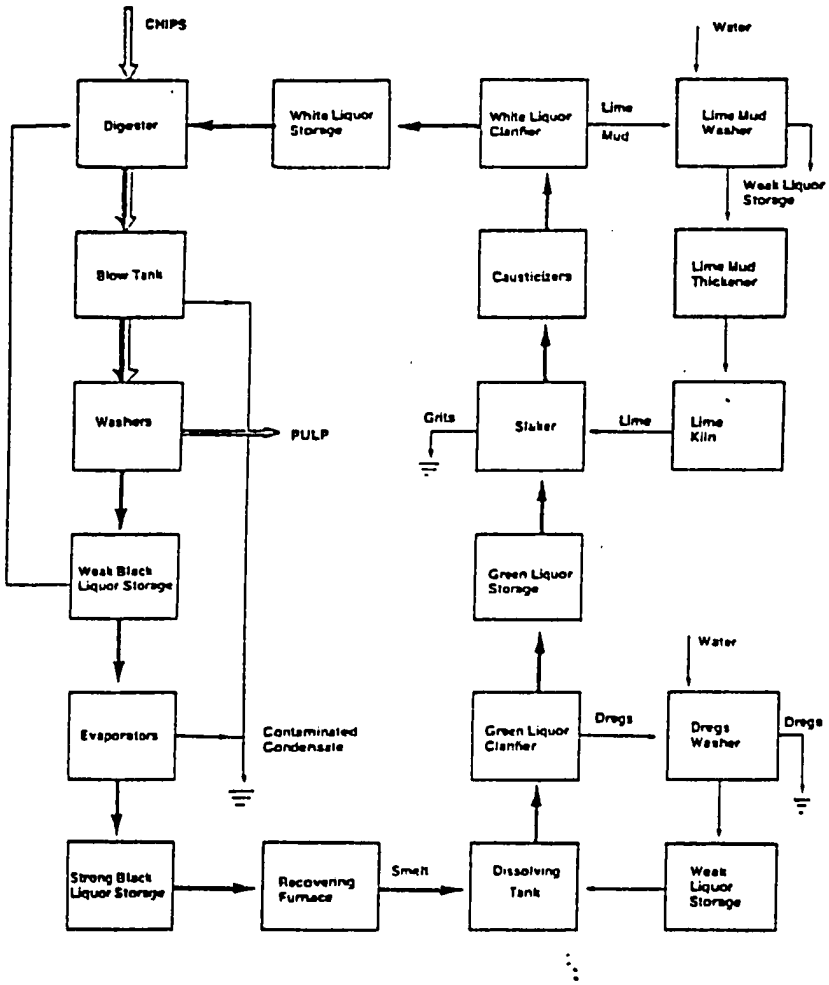
The alkaline processes involve the digestion of wood chips in a strong alkali solution for 2-4 hours at 150-170C. The pulp is discharged to a blow or dump tank, screened and washed to separate pulp from the pulping liquor and dissolved solids, about 50% of the dry wood charged.

The cooking solution is caustic soda (NaOH), and in the case of Kraft, 20%-25% as sodium sulfide (Na2S). For reasons of costs and environment, THe chemicals and heat are recovered from the spent pulping liquor. The "weak black liquor" from the digester and "brown stock" washers at 12%-18% solids is evaporated to 55%-65% solids and used for fuel in a recovery furnace. Conditions of combustion recover the sulfur as Na2S and the balance of sodium as Na2CO3.

A common make-up chemical is sodium **sulfate**, (Na2SO4) from whence the term "sulfate" process derives. The heat from the organic dissolved wood solids combustion produces process steam and if a high pressure boiler, may co-generate power through back-pressure turbo-generators.

The soda process employs only caustic soda as described above, and no sulfide. It is used only with hardwoods and some annual fibers. The process excessively degrades softwoods. Introducing sulfur to the process produces a superior "kraft" pulp or "sulfate" pulp the latter term due to the practice of using sodium sulfate for make-up chemical.

FIGURE 9: KRAFT PULPING PROCESS FLOW



Unbleached kraft pulp for bags or liner has a Ka. No. of 50-120 and higher; for bleachable grades Ka. No. is 28-34. Bleachable hardwood soda pulp has a Ka. No. of 16-20.

The kraft recovery furnace is operated such that sodium sulfide (Na_2S) is formed to the extent of sulfur presence, and the balance of sodium goes to soda ash, Na_2CO_3. This flow flows out the bottom of the furnace as a molten "smelt". The carbonate is recausticized with lime, forming NaOH and $CaCO_3$; this is calcined in a kiln, reforming CaO. Figure 4 shows the Kraft alkaline process and the liquor cycle.

Kraft pulping is the dominant chemical pulping process in the world. The product is superior to all others, in most cases. It is suitable for both hardwoods and softwoods. It has additional advantages of recovering dissolved wood solids for biomass fuel. Recovery of 89%-99% of chemicals, cogeneration of substantial heat and power requirements, and reduced effluent discharge is standard. With other fuels such as waste wood and biomass, a modern kraft mill can produce surplus power.

Kraft process disadvantages are the complicated, multiple processing operations, mills have an unpleasant sulfide and mercaptan emission odors, and capital requirements are high. Modern mills are 800-1000 TPD and cost $700-1,200 million. Minimum unit sizes are about 100 tpd and with used equipment and developing nation circumstances may cost as low as $25-50 million depending upon extent of plant and infrastructure. It must be noted however, that best product and efficiency require large plants and full plant and investment. Such of this can be in lieu of otherwise required infrastructure.

The kraft process would probably be the chemical pulping process of choice for Pakistani woods. It is most versatile, and would produce very satisfactory pulp. It also can cogenerate substantial steam and power, even net surplus in some cases.

The major disadvantages are the sulfide (rotten egg-like) odor, the need of large unit capacity to economically enable all desirable amenities, and large capital investment required. They are also very complex operations and require astute management and good operating labor. The minimum unit size is about 100 TPD. This could be installed for $50.-$100 millions, depending on used or new equipment, and extent of facility. A modern, 600 TPD greenfield mill (about the minimum size) cost $600-$800 million.

The Pakistan Paper Corp. mill at Charsadda is capable of full kraft processing. It has been operated as a bagasse soda mill, i.e. no sulfide. It would require addition of wood receiving and handling facilities, increased digester capacity (new, batch digesters) and some revamp due to shut-down, and wood pulp. However, all of this might be minor cost compared with a new facility. It should be in good position to use tree-farm E. camaldulensis and poplar as well as some softwoods (per Manshera) and bagasse.

SULFITE PULPING

The sulfite process is divided into two categories commonly called acid sulfite (pH < 2), and variously, bisulfite, neutral sulfite, NSSC and possibly others (pH 3-12). The pulping liquor is usually prepared by burning sulfur, S+O2-->SO2; this is absorbed into a base compound of sodium, ammonium, magnesium or calcium. could be used. This makes the HSO3--SO3= solution at the desired concentration and pH.

NEUTRAL SULFITE, (Figure 10): The "neutral sulfite" variations neutral sulfite, bisulfite, NSSC, etc. processes employ Na2SO3 solutions at a pH from 5 to 9, depending upon process raw material and pulp use. The raw fiber is cooked 2-3 hours in a 120-150 gpl solution to render pulp. Sometimes spent or surplus sulfite is available from other local industry, at an attractive price and convenient delivery and this is used. Ammonium and magnesium bases could be used satisfactorily, but other than "Magnefite" they are not. That is due to chemicals recovery convenience; most NSSC mills are in conjunction with a large kraft mill.
In many cases, especially with hardwoods and corrugation medium, the cooking conditions will not render a defibrated mass. Mechanical action is required, akin to the above described RMP. This process is called neutral sulfite semi-chemical or NSSC. It still can produce a fully bleachable pulp from hardwoods. Typical NS and NSSC Ka. Nos. are 15-22 for fully bleachable pulp; this is particularly suitable for fine and light-weight papers. It is also a satisfactory process for corrugation medium from softwoods and this only satisfactory softwood neutral sulfite process product. Ka. No. for this is 30-80 and higher.

Common and suitable raw materials include all hardwoods and most annual crop fibers, bagasse, straw, Kahi, etc. Generally softwoods are unsuitable, except for corrugation medium.

Economics and effluent abatement usually mandate that chemicals recovery be employed. This is problematic; a scheme such as described for kraft would recover sulfide; this can be subsequently oxidized to produce sulfite, and is sometimes done. However, it is a difficult process and at best marginally satisfactory with a few exceptions reported. Large mills may integrate the liquor recovery with their Kraft process as make-up chemical.

Due to the recovery difficulty the process is avoided in developed nations, as there or better alternatives. It most often is employed by very small mills, which can discharge the effluent and suffer the high chemicals cost; this is particularly true in developing regions of the world.

Full chemical sulfite processing is the preponderant method in Pakistan. Chemical recovery is not practiced, but the effluent is sewered. There are claims it benefits agricultural soil.

FIGURE A10a: NEUTRAL SULFITE PULPING PROCESS FLOW

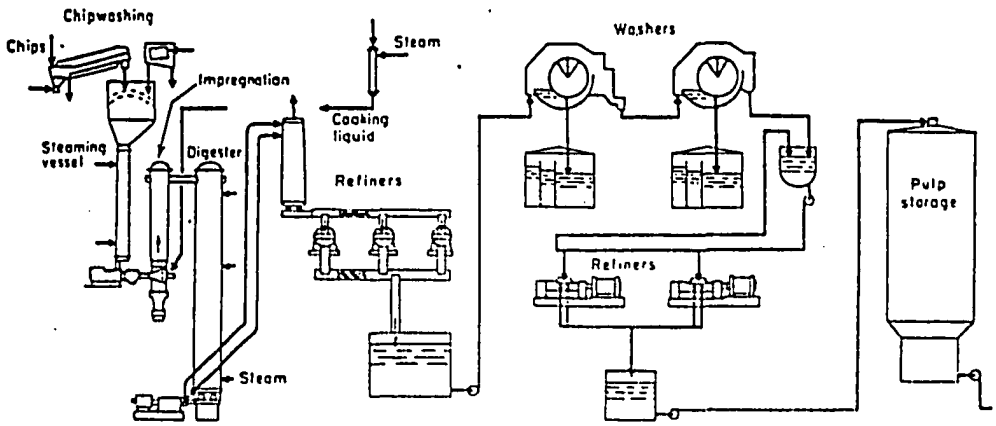
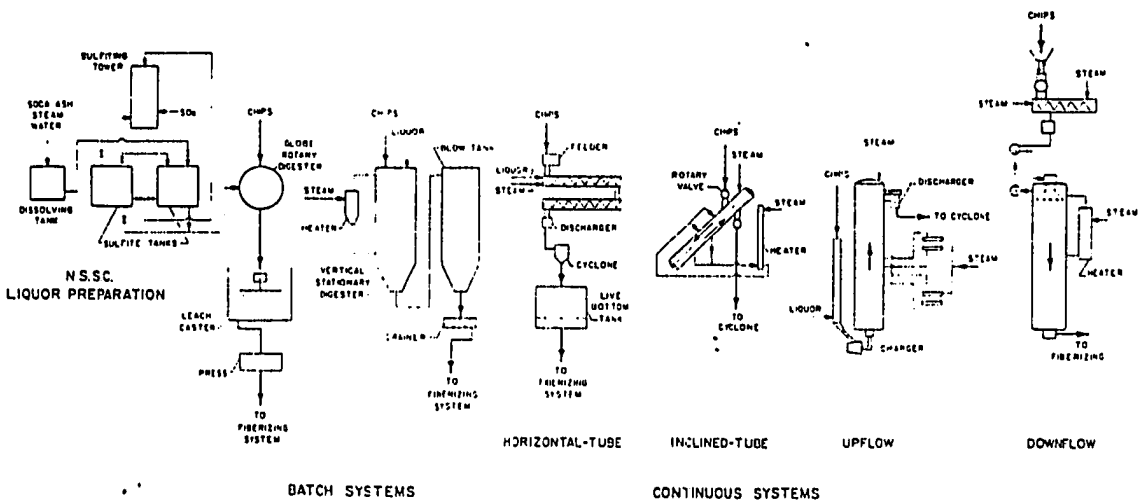


FIGURE A9b: NEUTRAL SULFITE PULPING DIGESTER SYSTEMS



ACID SULFITE, Figure 11): The acid sulfite process employs a solution of sulfurous acid, H_2SO_3 (Free SO_2) with a base (Combined SO_2) cation of calcium ($CaCO_3$), ammonium (NH_3), magnesium (MgO) or sodium (Na_2CO_3). The cooking solution is very acid and very corrosive; special materials of construction are necessary. The fiber source is cooked 4-8 hours; the resulting pulp is much lower Ka No. than kraft pulp, and of brighter color. However, it also tends to be substantially weaker, of higher density and more brittle. Both softwoods and hardwoods are successfully processed in this way, although highly resinous woods such as pines may be problematic.

Sulfite pulp is produced at Ka. No. of 14-18 for bleachable grades, higher for unbleached grades. Sulfite pulps have higher brightness but lower strength than kraft. Bleached sulfite is highly satisfactory for tissue, fine and light weight papers. It is not often used for board and products needing high strength. It is commonly used to provide long fiber for newsprint manufacture. It is much easier and less costly to bleach than Kraft. It is also processed for dissolving or chemical pulp. Much of Pakistan's imported pulp is bleached softwood sulfite pulp.

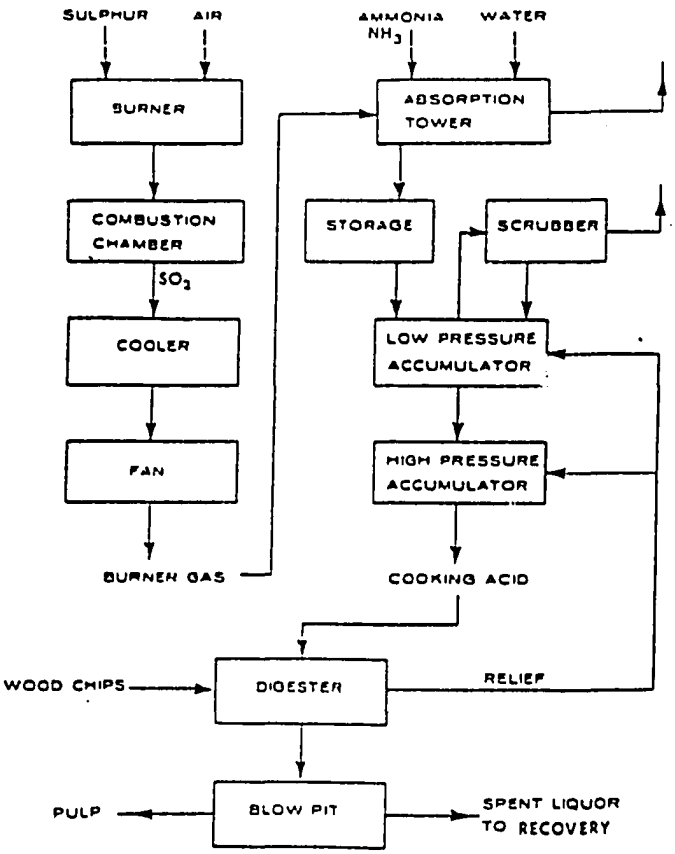
Sodium base acid sulfite has the same recovery problems as neutral sulfite; its natural tendency is to sulfide. Calcium base also has severe recovery problems, due to scaling. However, there are isolated incidences of both recovery processes in commercial use.

The Mgo base process has a well established and successful recovery scheme; the Mgo is recovered as Mgo; the sulfur as SO_2. "Magnefite" is a process variant where Free and Combined SO_2 are equal, pH~3-4; it has improved strength and yield

Ammonia is destroyed and lost upon combustion, but SO_2 is recovered akin to the MgO process. Both are commonly used, ammonia due to its low purchase cost and reduced recovery plant capital cost.

There have been few new acid sulfite mills constructed in recent years and total world tonnage is declining; several sulfite mills have been converted to kraft. This is mainly due to the superior pulp quality, better recovery and large-scale economics of the kraft process. Still, there are circumstances where acid sulfite still might be considered, e.g. it does not have the obnoxious kraft odor and is superior pulp for certain uses.

FIGURE 11: ACID SULFITE PULPING PROCESS



Sulfite pulping process with ammonia base

OTHER PULPING PROCESSES

Caustic Lime Process: this is primarily employed with annual fiber crops such as straw, kahi, and bagasse. The fiber is cooked in a CaO solution, sometimes fortified with soda ash or caustic soda. A course pulp of relatively high yield is produced, for conversion to corrugation medium, core and cone board and other industrial papers. Pulp from this process is not suitable for bleaching. This process is employed by Pakistani mills in the Gujranwalla region, to make textile cones.

Use of ammonia in place of sodium may be worth consideration, especially for alkaline sulfite processes where recovery is not feasible and the effluent is discharged adjacent to cropland. The dissolved wood contains potassium, phosphate and the organics for soil improvement; the ammonia will contribute nitrogen. THis scheme is dependent upon satisfactory ammonia availability and price, and satisfactory pulp quality.

In a similar vein, magnesium base processes such as Magnefite and bi-sulfite may be worth consideration. If the cost is low enough, it might be discarded as per current Pakistani practice, and be more beneficial to the soil than sodium.

There have been other pulping processes advanced from time to time. The writer knows of none that are in substantial commercial practice or otherwise commendable for possible employment in Pakistan. However, there are variations and combinations of the above which could be.

There are also pulping-energy technology combinations worthy of consideration. For example, low quality coal is gasified and the gas cleaned for direct fired pulp and paper drying; the dirty gas is an excellent lime kiln fuel. We have also carried out studies wherein high sulfur coal is to be gasified with the sulfur used in kraft or sulfite pulping, and the clean gas used to fuel a gas turbine combined cycle power and steam generation.

CHEMICAL PULP BLEACHING, Figure A11

Bleaching of chemical pulps is, in affect a continuation of the delignification process. However, it employs more selective and generally more expensive chemicals in multiple stages. The convencional stages and chemistries employed are:

O - oxygen (O2) with NaOH; Mfg in Pakistan by air cryogenics

C - Chlorine gas (Cl2); Mfg in Pakistan by salt electrolysis

E - Extraction, with NaOH; Mfg in Pakistan by salt electrolysis

H - Hypochlorite, (NaOCL or Ca(OCL)2; Mfg on-site, Cl2+NaOH

D - Chlorine Dioxide (ClO2); Mfg on site, Na2ClO3 by salt electr.

P - Peroxide (H2O2); not mfg in Pakistan, avail. ?

Typically, pulp of Ka. No. of 18-22 for hardwoods (K.No. 10-12) and of 28-34 for softwoods (K.No. 22-26) is reacted with chlorine 10-20 min. such as to reduce the Ka. No. to 4-8. It must then be extracted with NaOH to complete chlorine-lignin product removal. This may be followed by hypochlorite and/or ClO2 stages. Both of these delignify, brighten and whiten. There often will be multiple stages, for example CEH, CEHD, CEDED, CEHED. The more extensive multiple stages are, in part, endeavors to refine the optimization of chemical-cellulose reaction delicacy and cost. It also enables overcoming sloppy reaction and control conditions.

Chlorine dioxide requires some special discussion. This is an unique, strong oxidizer, but which does not harm cellulose fiber. Besides the above described usage for brightening, it is often used in conjunction with Cl2 in the C-stage, and sometimes as a replacement for it. This is primarily for reasons of both cellulose fiber and environmental protection. It does not form toxic and mutagenic polychlorinated organics as does chlorine.

ClO2 is very reactive, may be explosive and cannot be transported. Therefore it must be manufactured at the place of use. This is by reduction of sodium chlorate (Na2ClO4) and absorption in cold water by a special plant. There are several variations of ClO2 processes, which must be carefully evaluated and selected relative to other plant and process circumstances.

Oxygen is also being used for delignification. It has virtues of cost and environmental benefits. There are several procedures in use. One is as a pre-bleach delignification. This requires a pressurized reactor and washers as well as attendant apparatus. This process is a major plant and capital component. Another procedure is to use oxygen with the first extraction stage, E+O. This uses much less O2 and relatively modest capital cost.

Oxygen may be produced on site or purchased, depending on volume and availability.
Peroxide is used as a brightening agent and akin to the E+O application (E+P). It has relatively high purchase cost, although this is declining in many regions. However, it is easy to use and involves relatively low capital investment.

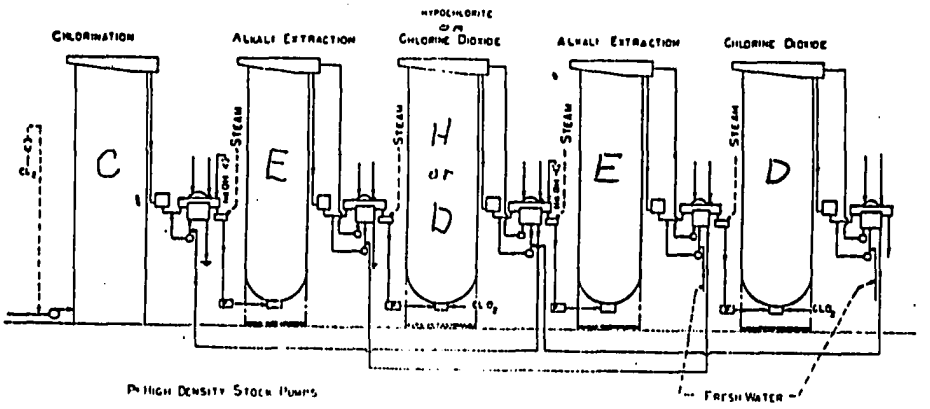
Typical bleached pulp brightnesses are as follows:

Newsprint and manilas	60-65%
Book and light weight coated	70-80%
Fine papers, solid bleached board	80-84%
Competitive market pulp	88-92%

A good bleach plant and operation is also necessary for pulp cleanliness; it is essential to produce competitive market pulp which can bring a good price. Off-grade and dirty pulp are very substantially discounted, often at below cost. This, of course depends upon market conditions.

All Pakistani bleach plants are of the CEH configuration.

FIGURE A12: PULP BLEACHING FLOW



3-Stage Bleach: CEH

5-Stage Bleach: CEHED or CEDED

MARKET PULP DRYING, Figure A13: In order to produce pulp for the market, i.e. for sale to other paper companies, it must be dried and baled for shipping. This requires a pulp dryer and baling apparatus. Usually it is dried on a machine similar to a paperboard machine, that is a sheet is formed, pressed and dried. It is then cut into sheets about 1m square. These are stacked, pressed into a bale, wrapped and tied. Since this pulp is usually to be reslurried by the purchasing mill, sheet characteristics are not of greatest importance, as with paper; but neither are they unimportant. There must be some care as not to cause fiber or mat hardening, "fish-eyes" or other anomalies which might cause papermaking adversities.

There is a good and growing market for fluff-pulp for sanitary and hygienic products. This market requires that the pulp be dried in a very uniform sheet and delivered in rolls; similar requirements exist for dissolving pulp and some other uses. The dryer for this has more rigorous specifications than a conventional pulp dryer and is more similar to a paperboard machine.

Pulp drying-baling apparatus is similar to but somewhat less in cost than a paperboard machine. Often paperboard mills will run excess pulp capacity as market pulp on their board machines. This still requires the bale press, wrapping and handling apparatus.

TMP, CTMP and sometimes chemical pulp may be dried in a fluff dryer. For this method the pulp is not formed into a sheet, but is pressed to 35-40% moisture, shredded, dried in a flash dryer, and baled. This is limited to small-scale production, i.e. under about 250 TPD. It is lower in capital cost but prone to fiber problems due to harsh mechanical actions. This apparatus is lower in capacity than conventional pulp dryers, less than about 250 TPD. Minimum baling press capacity is about 250 TPD.

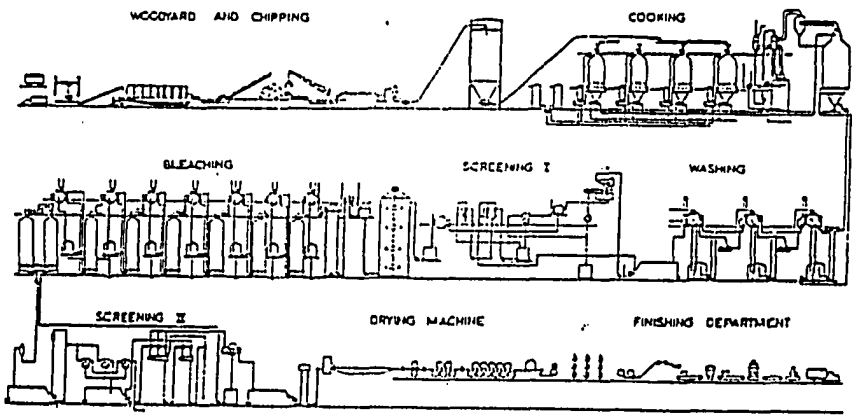



FIGURE 12: MARKET CHEMICAL PULP PROCESS FLOW