Programme for resource and energy management in the pulp & paper industry in the 21st century

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With the passage of time through nine decades of 20th century, rapid advances in science and technology have led the mankind on the path to progress and prosperity and provided unlimited means of production of goods of Human Consumption. The only objective of all human endeavour was to produce more and more goods so that our material needs could be satisfied to the fullest extent. This has led to the depletion of material resources beyond repairs and suddenly as if waking up from deep slumber we realized the extent of damage done to the Mother Nature, The necessity to maintain balance in ECO system has been realized in the last 2-3 decades and this awareness has reached to all strata of the society. Realizing the gravity of situation, Governmental authorities all over the world have enacted strict codes for environmental protection.

The growth of industries and production of goods of human consumption, today, can no longer be considered as absolute virtues in insolation without giving due consideration to other factors As a matter of fact, a new parameter has been added to the gamut of optimization in Industrial Production and this new parameter is the "Environmental Protection".

The ill effects of industrial pollution manifest in the form of:

1. Development of arid zones resulting from the depletion of forests.
2. Emission of carbon dioxide to atmosphere, causing global heating and generating greenhouse effect.
3. Emission of Chlorinated/Fluorinated organic compounds to atmosphere, causing tremendous damage to the upper layer of atmosphere by rupturing ozone layer.

It is indeed a matter of great concern for all of us that the Pulp and Paper Industry is directly or indirectly responsible for causing Environmental damage in almost all the areas ennumerated above.

To minimize and alleviate the ill effects of pollution an elaborate action plan could be developed on the following lines.

1. Selection of raw materials which are not based on forests.
2. Selection of Process and technology which consume less energy and help in minimizing the generation of Carbon dioxide.
3. Development of processes and technology which generate less pollution and are self sufficient to a great extent on their energy requirement.

Optimization through cost Effective Resource Management

In the age of free market economy, viability considerations deserve full attention at the conceptual stage. There exists a serious danger of economic setback and of drifting in an uncontrollable stream of market forces, if adequate precautions are not taken at the blueprint stage. Looking at the various facilities required for the proper functioning of Pulp & Paper Industry, it becomes apparent that the major capital investment is required for the establishment of infrastructure at the plant side to cater to the operational needs of the Mill-e.g. Water, Power/Energy & Pollution control. Today, there exists a possibility that such basic needs of the industry could be minimized by :

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i) Proper selection of raw material mix.

ii) Resorting to Environment friendly processes,

iii) Recycling of various streams and closing the loop within the plant,

iv) Adopting energy efficient processes and equipment.

On reviewing the "Capital Investment" structure of an Integrated Mill, it appears that nearly 35-45% of the total expenditure is attributed to the creation of Infra structural facilities. The profitability of the industry could be enhanced to a great extent, if this portion of capital Investment could be reduced.

Following comparison between Chemi-mechanical/ Semichemical and chemical pulping processes would be of considerable assistance in the selection of an appropriate process and/or raw material mix at the blueprint stage.

CATEGORY A Chemi-Mechanical/ Semi-Chemical Processes	CATEGORY B "Full Chemical Pulping Process"
1. High Yield	Low Yield
2. Generally more power Consumption	Comparatively less power Consumption
3. Chemical recovery may/may not be very crucial.	Absolutely necessary to establish Chemical recovery plant.
4. Pollution load per tonne of product is usually less (depending on end product)	Pollution load is usually higher
5. Bleaching is done by brightening, using Peroxide, Hydrosulphite etc.	Bleaching is done by lignin removal using chlorination, extraction hypochlorite and chlorine dioxide bleaching.
6. Energy Intensive	Chemical Intensive

Recycled Fibre as a source of Raw Materials

In the 21st century, the major source of raw material for the paper industry will be the recycled fibre. The contribution of this fibre could be easily upto 40% or even more. Among the basic advantages, following are noteworthy.

1. Capital investment required for the establishment of a mill based on this fibre is comparatively much less-about 60% of that required for a mill based on wood/Bamboo or Bagasse.

2. Virtually no investment, or very little investment required for facilities like pulping, recovery, pollution control etc.

3. Operating costs/conversion costs are much lower and as such higher profitability is ensured.

As far as forest resources are concerned, the conditions prevailing in the Indian subcontinent and Continental Europe are very similar and as such we in India also have to emulate the European practice of using waste paper as a major source of raw material.

Waste paper can be used upto 100% in packaging paper and board manufacture. It is only for cultural paper its usage has to be restricted to 10-20% (without drinking.)

With the use of additives, the strength properties of secondary fibre can be improved to a great extent and its content in the furnish can be increased.

Energy Management in Pulp and Paper Industry

Pulp and Paper Industry ranks third in U. S. A. as far as energy consumption is concerned. In India, the Industry has not developed to that extent and as such the total energy consumption is much less. This is, however, expected to rise rapidly with the development of the Industry-particularly the Newsprint Sector. On analyzing the efficiency of energy consumption in the industry it appears that the average energy consumption per metric ton of pulp or paper is considerably higher than that prevaling in U. S. A. and European countries. Following Tables illustrate this clearly.

TABLE—A

COMPARISON OF ENERGY CONSUMPTION IN INDIAN MILLS AND SWEDISH MILLS

	(PER TONNE OF PAPER)	
	Indian Mills	Swedish Mills
1. Steam Consumption	11.47 MkCal	7.38 MkCal
2. Back Pressure Power	2.48 MkCal	0.80 MkCal
3. Purchased Power	918 KWH	902 KWH
4. Back Pressure Power	658 KWH	787 KWH
5. Generating efficiency of Back Pressure Power	22.80%	85%

TABLE—B

COMPARISON OF UTILITY CONSUMPTION IN INDIAN MILLS W. R. T. OVERSEAS MILLS

	PER TONNE OF PAPER	
	Indian Mills	Overseas Mills
1. Steam Consumption	11–14 MT	6.5 – 8.5 MT
2. Eelectrical Energy	1500–1700 KWH	1150–1250 KWH
3. Water Consumption	270–350 m^3	130 – 140 m^3

The basic dissimilarity in the pattern of utility consumption can be attributed to the following:

1. Application of obsolete process/Technologies.
2. Use of Equipment which are not efficient.
3. Use of inferior variety of raw materials, fuel and other inputs.
4. Lower production capacity of the Mills denying thereby "Economy of Scale."

Among various inputs, raw material plays a very important role e. g. Waste Paper consumes much less Energy and generate much less effluent in relation to Bamboo/Hardwood. Following will serve as interesting Comparison between two mills using these raw materials.

TABLE—C

		CASE—A *Mill—1 (100% Wood/Bamboo Pulp)	CASE—B *Mill—2 (60% Wood/Bamboo pulp & 40% Waste Paper Pulp)
1.	Raw Material Consumption	2.70—2.80 MT	1.62—1.64 MT
2.	Water Consumption	272—276 m^3	—
2.	Power Consumption	1500—1700 KWH	1300—1350 KWH
4.	Steam Consumption	11—14 MT	8—8.5 MT
5.	Coal Consumption	1.3—1.40 MT	1.2—1.5 MT
6.	Solid Waste disposal	2.1—2.6 MT	1.2—1.5 MT

*All parameters are on the basis of 1 tonne of paper produced. It can be easily concluded from the above data that the consumption of all inputs-Energy/ Utility/Raw material are on the lower side for Case-B, employing waste Paper as a part of raw material. The overall reduction is of the order of 25-28% approximately.

With a view to substantiate this fact, more data are provided in Annexure I where generalized consumption pattern of various inputs to pulp & paper industry in Indian Mills is indicated. It becomes apparent that the consumption of various parameters decrease substantially with the change in product. e. g. by changing to Newsprint or Board from cultural papers. In the overall optimization programme at the planning stage, it would be therefore necessary to give a serious thought to the following alternatives.

1. **Use of Conventional raw Materials vs. Waste Paper, Rags Flax, Hemp Cotton, Linter etc.**
2. Selection of a good product mix for maximizing *profits and minimizing cost (as well as effluent load)*, by developing an appropriate Minimax Model.
3. Selection of efficient equipment for *pulping, recovery and power*
4. Selection of most appropriate Process/ Technology from the viewpoint of cost effectiveness as well as pollution control.

As far as raw material is concerned, conversion costs for Waste paper, Flax/Hemp etc. - materials rich in cellulose content - are much lower and hence they can be selected for a good raw material mix.

A good product mix should be able to withstand the shocks in the market place by maintaining an equilibrium between the market demand and mill output. A low value added product can contribute a great deal towards the overall profitability of the mill.

Measures to Improve Energy Management in An Integrated Mill

1. The concept of 'Co-generation" and "total energy" has now been well accepted in the industry and almost all medium and large size mills practise this concept.
2. By generating steam at the highest energy level than required by the process; and converting this excess energy into electrical power, it should be possible to achieve the best possible utilization of energy. Following illustration would elucidate the basic principle.

A) 70-72% of steam generated at 40 kg /cm^2 may be expanded to 3 kg/cm^2 and balance 28-30% steam may be expanded to 7 kg/cm^2 to meet the process steam requirement as well as power requirement of a medium sized pulp and paper mill. (steam requirement ; MT/T of paper & 1400 kwh/T of paper approximately).

ANNEXURE I

GENERALIZED CONSUMPTION PATTERN OF INPUTS IN INDIAN MILLS

Type of Mill	Raw material Consumtion Tonne/Tonne of Pulp	Steam Tonne/ Tonne of Pulp & Paper	Electrical Energy KWH/MT of Paper	Water m^3 Tonne of Paper	Chemical consumption Per Tonne of pulp
1. Newsprint Mill (80,000 MT/year)	i) 2.52 for chemical pulp ii) 1.50 for Chemi-Mechanical pulp (Reed & Bamboo)	11.50	1850	235	$NaOH$:44 kg Na_2S:35 kg Hypo:48 kg a) for Chemical pulp b) 137.60 kg for Chemi-Mechanical Pulp. Lime-351 kg for Chemicrl pulp
2. Writing/Printing Paper (57,600 MT/year	i) 2.2 for Wood & Bamboo ii) 6.0 Tonnes for Bagasse with 50% moisture	9.0	1500	250	$NaOH$:60 kg Na_2SO_4:31 kg Lime : 320 kg Cl_2 : 14% H_2SO_4:60 kg Alum : 22 kg Hypo : 6% Rosin ; 1%
3. Writing & Printing Paper (60,000 MT/year)	2.3 Hard Wood	12.80	1650	320	$NaOH$:100 kg Na_2SO_4:31 kg Cl_2 : 90 kg Alum : 80 kg Lime : 400 kg
4. Board & Kraft Paper (40,200 Board & Kraft or 30,900 paper)	2.25 using Bambo, Hardwood & Secondary Fibre	10.90	1505	255	$NaOH$:110 kg Na_2SO_4:40 kg Cl_2 : 120 kg Alum ; 110 kg Lime : 400 kg
5. Tissue Paper (18150 MT/Yr)	2.10 using Bamboo Rags & some imported pulp	10.90	1610	270	$NaOH$:90 kg Na_2SO_4:35 kg Cl_2 : 160 kg Alum : 110 kg Lime : 410 kg

3. The inherent capacity for power generation in low pressure steam is much less. e g. 1 kg. of steam at 20 and 30 kg/cm² can generate only 0 100 and 0.1333 kwh, of power.

4. In the case of a mill employing high yield pulping (mechanical pulping), it is not possible to balance "Power" and "Process Steam" requirement.

The alternate route in such a case would be to,

a) Install a gas turbine plant and use the exhaust in the boiler house for recovering waste heat, (combined cycle thermal efficiency is the highest)

b) Obtain extra electric power from grid, if available or,

c) Install a turboset with a condensing stage to generate maximum amount of power from steam, (It is, however, true that the overall thermal efficiency of condensing turboset is lower than that of non-condensing turboset).

5. "Equipment Models" for various sections of an integrated Pulp & Paper mill are available for maximizing energy efficiency—There are;

— Efficiency model for multiple fuel power boilers

— Models for power generation by steam turbines

— Models for pressure reducing stations

— Models for condensate removal systems.

Kraft Process—Versatile Process for Pulping in 21st Century

As stated above, the selection of a good process, versatile from various angles, is of utmost importance, particularly when we are getting more and more inclined towards environmentally friendly processes and systems.

As forecast by Mr. Raimo Malinen, KRAFT PROCESS will be the dominant process of the industry in the 21st century, as it is the most versatile process. It can be applied to a wide range of raw materials. It gives high quality pulp and contributes to energy efficiency in the system. Among all other processes, it is also cost effective and requires minimal investment.

Kraft process is also ideally suited for process development and variations to suit the conditions and limitations likely to be imposed due to several constraints in raw material availability, environment protection, resource limitations and many other consideration.

Industry experts forsee rapid changes in the further development of "Kraft Process" in the 21st century and the modifications will be targeted at,

1. Reduction in chlorinated organics from bleaching process.

2. Reduction of chlorinated organics (Dioxin etc) in air emission.

3. Improvement in viability and cost-effectiveness of small mills (by minimizing capital investment)

4. Reduction in Kappa No. prior to bleaching with acceptable yield and product quality.

   a) Modifide Kraft process allows cooking of soft woods to Kappa no. of 15 and below; and it appears that the final minimum no. has not yet been reached.

   b) There is a distinct possibility that Kraft cooking to a Kappa no of 10 will be a reality in 21st century.

Oxygen Delignification :

All modern mills will invariably be equipped with an Oxygen Delignification stage This processing stage will become a conventional step in an endeavour to extend the delignification process beyond digester, a realistic target is 50% with multistage application of chemicals. The final kappa no. after oxygen delignification will be around 5, corresponding to about 1% of lignin remaining to be removed in the bleaching stages.

Chlorine free bleaching will become an inherent part of the modern mills in 21st century. The environment problems of bleach plant effluents and odour will be resolved by selecting "OZONE" bleaching. Controlled ozone stage with acceptable selectivity and multistage ozonation will replace "chlorine" based bleaching processes. The use of oxygen, ozone, and peroxide in bleaching processes will increase. This would enable closing up unit operation in the bleach plant and eliminate uncontrolled emissions.

Ozone Bleaching :

Effect of various parameters on ozone bleaching has been studied in great detail and following conclusions have been reached.

1. Acidification of pulp to a pH of about 2 before the ozone stage, produces the lowest Kappa no. and highest viscosity.

2. The optimum pulp consistency range for ozone bleaching is 30-40%. Nearly 98% of the ozone charged (1-2% on pulp) can be consumed by pulp in a one minute reaction.

3. At higher dosage of ozone, Kappa no. decreases with higher brightness at the expense of viscosity.

4. Experimental data indicate that hardwoods are somewhat more amenable than softwood for ozone bleaching. There exists a direct relationship between "Kappa No." and "brightness".

Case study of a Modern Canadian Mill at Hinton—Alberta" (Simplified Flow Diagram is given at Annexure—II)

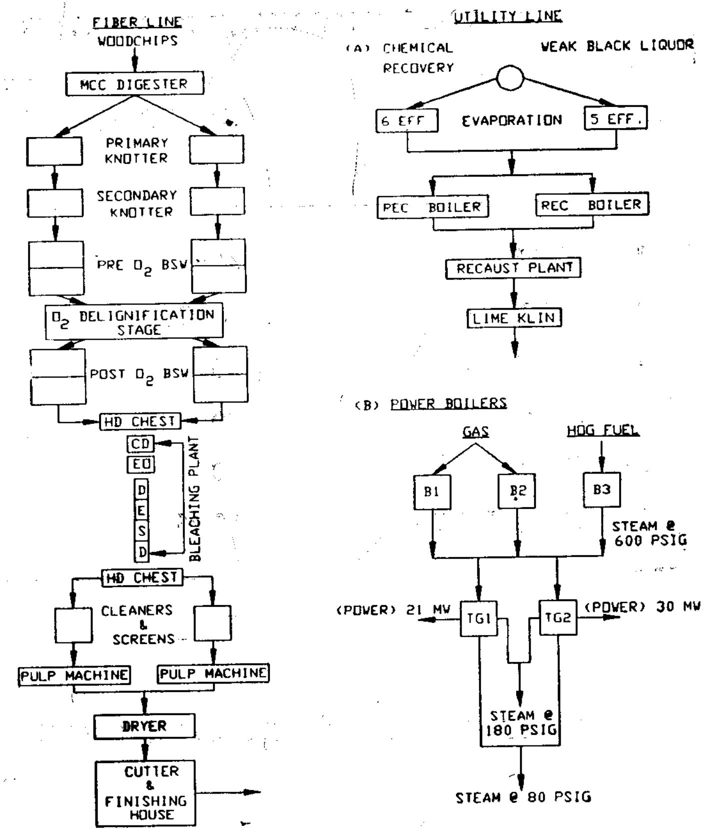
Weldwood's Mill at Hinton. Alberta is an excellent example of "Modernization of an existing unit" by integrating latest technologies in the manufacturing process; to upgrade and to equip the existing mill to face the latest challanges in the field of Environmental Protection. Some of the salient data are given below :

1 A 550 TPD pulp mill in 1985 was expanded to produce 1100 MTD pulp in 1989 involving an expenditure of nearly $ 400 million.

2 Raw material consists of spruce, balsam, & Pine from forests. Reforestation has been taken up from the beginning.

ANNEXURE - II

SIMPLIFIED FLOW DIAGRAM OF WELDWOOD MILL AT HINTON - ALBERTA - CANADA



3 Expansion included;

a) R—8 ClO_2 plant
b) Oxygen Delignification stage
c) Twin wire sludge disposal system.
d) New Lime Kiln
e) New Recovery Boiler (capacity 2.6 million pounds dry solids)
f) Two vessel Hydraulic MCC Continuous digester.
g) Effluent Clarifier
h) Mixed media bed filters, in water treatment plant.
k) 30 Megawatt turbo - generator for power generation.
i) BC pulp machine and dryer.
m) Modernization by reinstrumentation with DCS system.

ANNEXURE III

A. SOME IMPORTANT PROPERTIES OF PULP FROM DIFFERENT PROCESSES

		KRAFT	CSSC	COLD SODA	GROUND WOOD
1	Yield	45%	65—85	85—90	90
2	Brightness	85°GE	75°GE	75°GE	70°GE
3	Opacity	75	80	88	94
4	Tear	90	75	65	10
5	Burst	60	25	20	5
6	Power HP/Ton	15.25	30.60	50—60	70

B. AVERAGE STEAM CONSUMPTION IN AN INTEGRATED PULP & PAPER MILL USING BAMBOO/HARDWOOD (Capacity 120 BD MTD)

	SECTION	HP STEAM TONS/HR	LP STEAM TONS/HR	TOTAL TONS/HR
1	Digester	11.78	1.47	13 25
2	Bleaching	—	2.05	2.05
3	Evaporator	0.49	12.76	13.25
4	Recausticizing	—	1.96	1.96
5	Chemical Preparation	—	0.91	0 91
5A	Misc.	—	2.44	2.44
6	Paper Making	—	18.04	18.04
7	Recovery Boiler	2.45	3.43	5.88
8	Deaerator	—	7.37	7.37
		14.72	50.43	65.15

ANNEXURE (Contd)

C. POWER CONSUMPTION IN VARIOUS SECTIONS

(MILL—BDMTD CAPACITY : 120)

I.	SECTION	HP
1	Chippers	1930
2	Bamboo/Wood Handling	140
3	Digester	455
4	Blow Heat Recovery	300
5	Brownstock Washing	800
6	Unbleached Screening	813
7	Bleach Washer	1534
8	Stock Preparation	4310
9	Paper Machine	3241
10	Finishing	470
11	Recausticizing	398
12	Hypo Plant	67
13	Evaporator	580
14	Soda Recovery	644
15	Deaerator	—
	TOTAL	15682

II.	OTHER AREAS SECTION	HP
16	Workshop	102
17	ETP	580
18	Coal Fired Boiler	520
19	Coal Handling	130
20	DM Plant	72
21	Water Intake	536
22	WTP	600
23	Compressed Air	375
		2915

Total For (I)+(II)=18597 H.P.

ANNEXURE IV

A. CLASSIFICATION OF PAPER MILLS ACCORDING TO CAPACITY

CATEGORY	AS ON 1/1/84	AS ON 1/1/88	AS ON 1/1/90
UPTO 5,000 MTY	126	150	270
UPTO 10,000	60	57	270
UPTO 20,000	13	55	270
ABOVE 20,000	23	29	35
TOTAL	222	297	305
TOTAL INSTALLED CAPACITY	2.165 MILLION TONNES/YR	2.865	—

B. PRODUCTION OF PAPER AND PAPER BOARDS-VARIETYWISE.

('000 TONNES)

VARIETY OF PAPER	1983/89 PRODUCTION		1989/90 PRODUCTION	
Writing & Printing	630	52%	1000	54 54%
Packaging & Writing	386	32%	588	31.78%
Paperboard	166	14%	187	10.11%
Other Specialized Papers	24	2%	68%	3.57%

C. DEMAND PROJECTIONS.

Based on Historical Data, Econometric study was made for consumption figures (projected) in 1995-96 and 2000-2001. Following are the estimated values :

Year	Cultural Paper	Indust. Paper	Population	Index of Ind. Prodn.	GDP	Disposable Income
	('000 Tonnes)		(Growth rate from 1989/90— % per annum)			
1995/96	1226	1242	1.837	8.4%	5.5%	5.24%
2000/2001	1503	1583	1.736	8.50%	5.1%	5.15%

Total Demand in 2000/2001 A. D. =2.729 Million Tonnes

Assuming 65% & 70% capacity utilization

65% — a) Installed capacity should be 4.198 Million/year
70% — b) Installed capacity should be 3.898 Million/year

The most interesting section in this rebuilt mill is "Bleach Plant". This is a short sequence C/D/E/o/(DESD)/ plant with three washing stages—arranged in this way to maximize the use of existing equipment.

As far as power generation is concerned, out of the three boilers, two are run on natural gas and third on hog fuel Steam is generated at 600 psig. at 750°F and distributed to the process at 180 and 80 psig. The mill is self sufficient in power.

The most interesting aspect of the mill is the care taken in water management. The increase in water consumption was very marginal (about 10%) although pulp production capacity was doubled.

Water, effluent treatment, and the environment are closely linked. ETP consists of inplant controls, 200 ft dia clarifier, and 6 5 day ASB. Total horsepower in ASB is 3000 H.P.

Final effluent is tested daily for BOD, TSS, colour etc. AOX is tested thrice a week, and it must meet the limit of 1.5 kg/t of pulp as per guidelines.

The permitted levels for BOD is 7 kg/t, whereas the mill is running at 2.8 kg/t.

Alberta Pacific Mill Alberta — Canada — Mill Based on 21st Century Philosophy

A green field mill, with a capacity of 1500 TPD kraft Pulp is taking shape in northern Alberta, Canada, at a project cost of $ 1.3 billion. When completed in Sept' 93 it will be among the most efficient and cost effective mill in the world. Its chlorine free bleaching process will virtually eliminate the creation of dioxins and furans, making it the cleanest bleached kraft pulp mill in Canada. With the emergence of this mill, a new philosophy based on the latest proven technologies is taking shape, reflecting positive attitude and environmental responsiveness.

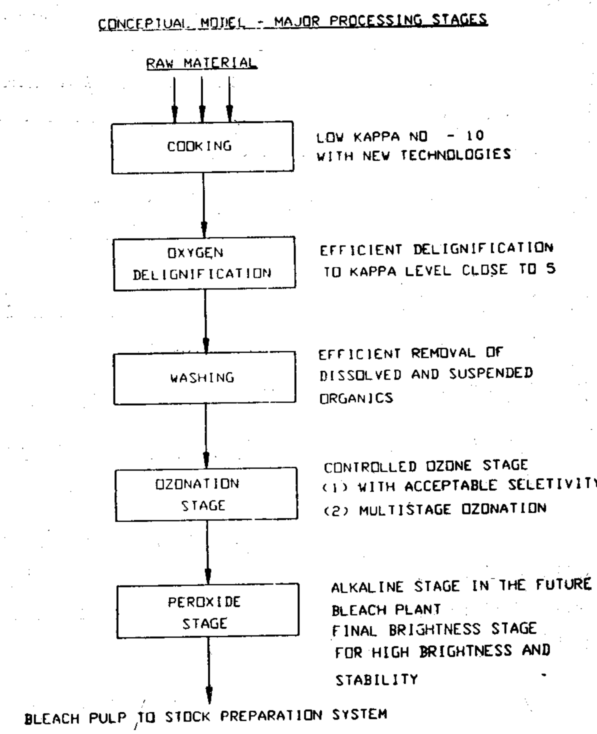
The salient features of pulping system at Al—Pac are as follows :

1 MCC digester with future provision for high sulfidity liquor impregnation.

2 An MC Oxygen delignification system.

ANNEXURE V

CHLORINE FREE KRAFT PULP MILL IN 21ST CENTURY



3 Modified 5 stage DO EOP DND bleaching sequence with four tower and four vacuum washers.

4 The extraction process is reinforced with oxygen as well as Hydrogen Peroxide.

5 Anticipated performance data are as follows :

(i)	Kappa No. from digester	10
(i i)	Kappa No. from Oxygen (Delignification stage)	6.5
(iii)	Final Brightness	90–91° ISO

Process Chemical Consumption :

	Kg/ADT
Cl_2	0.0
NaOH	12.5
O_2	18.5
H_2SO_4	15.3
$MgSO_4$	2.0
$NaClO_3$	16.9
Methanol	1.2
H_2O_2	3.0

Environmental Considerations and Bleach Plaut

The bleach plant has been designed to operate, without molecular chlorine bleaching. Infact the incoming pulp would need very little bleaching or purification on account of low kappa Lo. and low COD carryover. The major changes in the bleach plant design are as follows :

1. Increased fibre residence time in the first bleach stage for slower impregnation of cholrine dioxide.
2. Modification of oxygen extraction stage to operate at high temperature and pressure.
3. Reinforcement of the Eo stage using H_2O_2.
4. The installation of a full DN tower plus washer for better control.

As a result of the above precaution, the mill is confident of reducing Aox emission to 0.3 kg/ADT. This is the standard set by Germany and Sweden to be achieved in the year 2000/2005.

Al–Pac will install a non-condensable gas (NCG) system to collect gases from various sections. The concentrated NCGs will be put into a white liquor scrubber to absorb some of the sulphur. The remaining concentrated NCG will be fired in the kiln and the dilute steam will be burnt in the recovery boiler. This technology will reduce odour by containing odorous emissions from the recovery evaporator through incineration.

Conclusion :

1. Contrary to common belief, environmental friendly process could be included in a modern pulp mill without creating any additional burden on the mill's Investment Programme.
2. Cost effectiveness in the mill operation can be achieved by selecting a *proper 'Raw material" and 'Product Mix''.*
3. Kraft process will still be the most dominant process in the 21st century; as it is admirably suited for changes and modifications to suit the local conditions.
4. By taking adequate care and precautions in the design of a bleach plant, air emissions of toxic compounds like dioxin, furans, etc. could be totally eliminated.

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