PANDIA DIGESTER
The horizontal continuous digester with screw feeder and orifice discharge for agricultural residues

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Introduction

Forest based raw materials which have been the primary raw material for the Indian Pulp and Paper industry for many decades are fast dwindling. The techno-economical relationships which had led to this per dominance of woods are swinging in favour of non-wood raw materials and there is increased use of agricultural residues, particularly bagasse, to supplement the raw material requirement The potential uses of some agricultural residues are given in Table-I. Some Important properties of agricultural residues are given in Table II. The pulping processes commonly used for these agricultural residues are given in Table-III. A striking characteristic of these fibres is the much wider range between the length of fibers of different species. Many of the fibres are similar in length to the short fiber hardwoods. On the other hand, others are so long that they must be shortened to optimize their paper making value. By properly selecting the appropriate mixture of non-wood fibres and pulping process, any grade of paper and paperboard can be produced.

The Pandia Digester

A significant discovery in the non-wood plant fiber pulping field has been discovery that traditional pulping times with long batch cycles were completely unnecessary and in fact detrimental to pulp quality. The most revolutionary development in the past fifty years has been the optimization of the fast cook in the Horizontal Tube Continuous Digester with Screw Feeder and Orifice Discharger. The PANDIA DIGESTER is an unit of this type.

The PANDIA DIGESTER is a well proven equipment originally developed and commercialized by the Black Clawson Company (USA) and since acquired by VOEST ALPINE INDUSTRIEANLAGENBAU(AUSTRIA) with exclusive manufacturing rights, pilot plant as well as knowhow. Hindustan Dorr-Oliver Limited have a tie up with VAI for the supply of the PANDIA DIGESTER on part import-part indegenous basis in India.

The PANDIA DIGESTER is designed specially for rapid cooking agricultural fibre such as bagasse, jute, kenaf, straw and other agro residues in the production of high quality pulp. More than 200 PANDIA DIGESTERS have been installed worldwide with over 70 DIGESTERS based on non-wood plant fibers of wich about 25 are based on bagasse. (Refer Table-IV). In India PANDIA DIGESTERS are in operation at Seshasayee Paper, Mandya Paper, Mysore Paper and Sri Laxmi Saraswati.

The advantages offered by PANDIA DIGESTERS are listed in Table V. The primary advantages of this equipment will be enhanced yield and uniform pulp quality, reduced steam and chemical consumption, amenability to process automation and reduction in manpower and space.

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TABLE-I

Uses of CP/SCP from some Agricultural Residues for Paper Making Fiber Percent

USE		BAGASSE	STRAW	KENAF	JUTE	SABAI GRASS	FLAX	BALANCE FURNISH
Wood Free W/P	:	20-100	20-100 (CP)	20-80	20-80	50-100	20-60	Wood Pulp/Straw Pulp/ Cotton Pulp
Mech W/P	:	20-50	20-50 (CMP)	20-50	—	—	—	Wood Pulp+GW
Dup & Triplex	:	20-70	20-70	—	—	—	—	Wood Pulp
Corrugating Medium	:	50-90	50-90	50-100	—	50-100	—	Waste Paper/Straw Pulp
Board	:	50-80	80-100	40-50	—	—	—	Kraft Pulp
Wrapping	:	50-85	50-60	—	40-60	50-100	—	Kraft Pulp/Straw Pulp
Multiwall Sack	:	30-70	—	20-40	40-60	—	—	Kraft Pulp
N/P Substitute	:	80-90 (CMP)	—	80-90 (CMP)	—	—	—	Kraft/Wood Pulp
N/P Substitute	:	70-80 (TMP)	—	—	—	—	—	Kraft Pulp
Grease Proof	:	30-90	30-90	—	—	—	—	Sulfite Pulp
Tissue	:	60 90	—	50-60	—	—	—	Wood Pulp
Bleached Paper Board	:	—	—	40-50	—	—	—	Wood Pulp
Currency	:	—	—	—	—	—	60-80	Wood Pulp/Cotton Pulp
Ciggarette	:	—	—	—	—	—	70-100	Wood Pulp

TABLE-II

Properties of Agricultural Residue Fibers

PROPERTY	DEPITHED BAGASSE		RICE STRAW	WHEAT STRAW	BAST	KENAF CORE	JUTE SABAI
Aug. Length (MM)	1-1.5	0.5-1.0	1.5	2.6	0 6	2.5	4.1
Aug. DIA (Micron)	20	8-10	15	20	30	20	9-16
Cross & Bevan Cellulose (%)	49-62	43-49	49-54		47-57	57-58	54.5
Alpha Cellulose (%)	32-49	28-29	29-35		31-39	—	—
Lignin (%)	19-24	12-16	16-21		14.5-18	21-26	22
Pentosans (%)	27-32	23-28	26-32		22-22.7	18-21	23.9
Ash (%)	1.5-5	15-20	4.5-9		1.7-5.0	0.5 1.8	6
Silica (%)	0.7-3 5	9-14	3-7		—	—	—

TABLE-III

Pulping Processes For Agricultural Residues

AGRI. RESIDUE	PULPING	TYPE	% YIELD UN-BL	% YIELD BL
Depithed Bagasse	Soda/Sulfate	Corrugating	70	—
		Liner Board	63	—
		Multiwall Sack Paper	60	—
		BL. Paper	50-52	45-48
Rice Straw	Soda	Paper	42	39
Mixed Cereal Straw	Lime	Paper	55-65	—
	Lime	Straw Board	70-80	—
	Soda/Kraft	Paper	55	50
	Soda/Kraft	Corrugating	67	—
Kenaf	Soda/Sulfate	Paper	45-51	40-46
Jute	Soda	Paper	62	58
Sabai	Soda	Paper		
Flax-Seed	Soda	Cigarette Paper	42-45	40
Flax-Textile	Soda	Paper	—	65
Cotton Linter	Soda/Kraft	Paper	—	70
Cotton Rags	Lime Soda/Soda	Paper	—	70

TABLE-IV

Pandia Digester Reference List (1940–1990)

1.0	INSTALLATION SUMMARY	NUMBER OF DIGESTERS	DESIGN/PRODUCTION TONS/YEAR
1.1	Wood Structural Grades	52	550,000
	Filter Grades	12	380,000
	High Yield	49	1,291,000
	Liner Board	4	314,000
1.2	Paper pulp-Hot Dispersion (Asphalt, Wet Strength, Stickies, Etc.)	25	1,489,000
1.3	Non-Wood Plant Fibres		
	Structural Grades	7	105,000
	Filler Grades	2	49,000
	Corrugating	16	380,000
	Liner Board	7	141,000
	Bleachable	31	894,000
	Furfural	2	382,000
	(Sub Total)	(65)	1,910,000
1.4	Grand Total	207	5,934,000

TABLE-V

ADVANTAGES :

1. Greater processing flexibility, including the ability to employ any normal cooking liquor without change in the digester equipment.
2. Maximum uniformity of pulp quality due to thorough and continuous mixing of chemicals and steam with fibrous raw materials.
3. Uniform raw material consumption, limiting the size of the "in process" material storage facilities.
4. Uniform steam and power requirements which reduce peak load demand in the steam and power plant and allow operation at high load factors.
5. Low steam requirements because of low liquor ratio and continuous heat recovery from blow tank cyclone.
6. Uniform liquor demand, avoiding large storage facilities.
7. Potentially higher yields or equivalent pulp quality.
8. Small space requirements.
9. High capacity per unit due to compacting the bulky raw material and operating at high pressure and temperature.
10. Low labour cost because of greater productivity per man hour of labour.
11. The possibility of increasing production, in steps, by relatively simple and economical additions to the unit itself without disturbing other equipment; without requiring any additional building space and without increasing the number of operators required.

Features :

The PANDIA DIGESTER (Figure-1) comprises four basic elements

PANDIA Screw Feeder
PANDIA Inlet Chamber
CHEMIPULPER Reaction tube
PANDIA Discharger

Pandia Screw Feeder (Figure-II)

The function of the PANDIA Screw Feeder, which is the initial element of the system, is to deliver the agricultural fiber from atmospheric to the pressure zone at a constant predetermined rate. The Feeder is designed for full control of the input of cellulosic raw material in to the CHEMI-PULPER tubes of the PANDIA continuous digester and this determines the capacity of the digester. Many types of agricultural fibers including wood can be fed through the screw-type feeder in precise quantities.

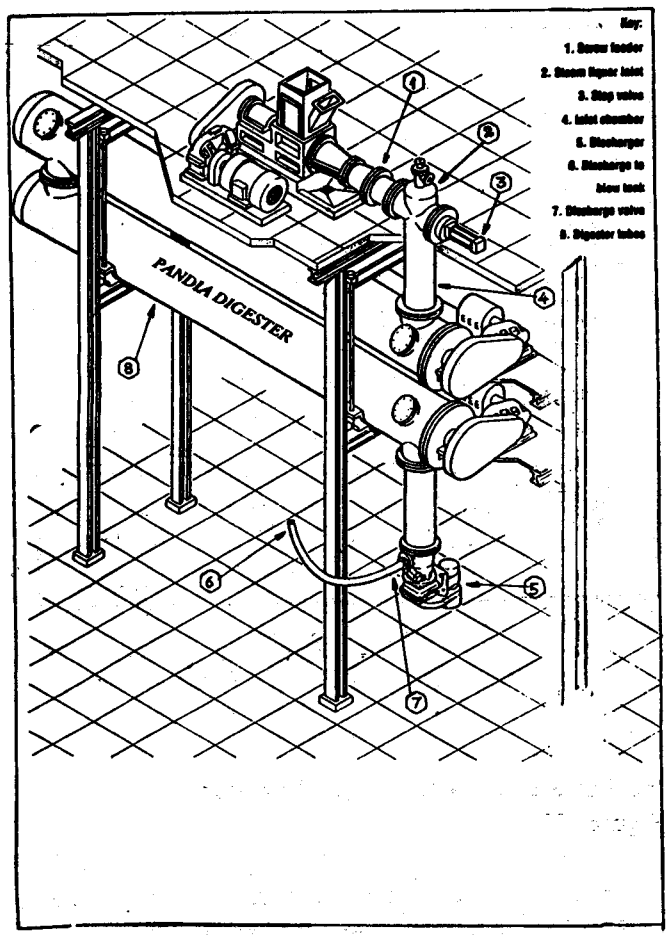

FIGURE I

The feeder is available in six basic diameter sizes of 152,229,267,406,508 and 660 mm, as well as in a variety of compression ratios. This makes it adaptable to a wide range of materials and production rates.

Other feeder features include :

— Variable speed drive which permits precise control of input and allows the choice of the best speed for minimum wear of the feeder.

— The availability of each basic size in proven modifications adapted to different raw material for ensuring a tight plug against the digester pressure.

— The adapted compressive action of the screw feeder which enables the removal of excess moisture and air from the feed material while it is conveyed into the CHEMI - PULPER pressure zone. The result is improved liquor penetration and the ability to adjust to the optimum bath ratio.

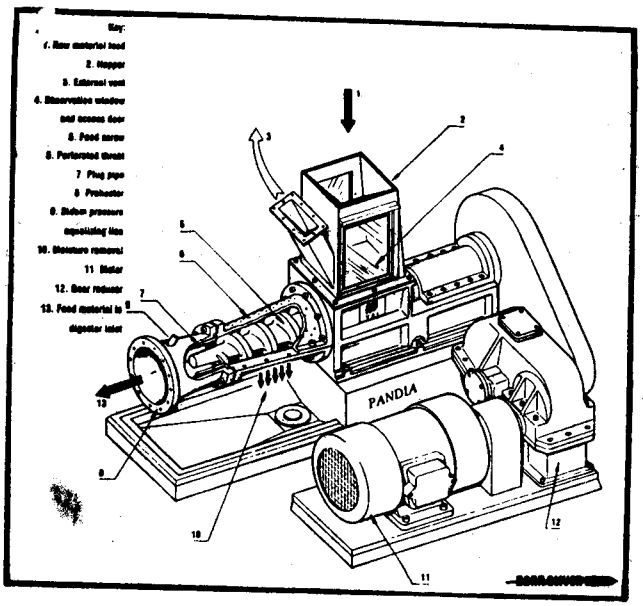

FIGURE II
PANDIA SCREW FEEDER

The Pandia Digester inlet Chamber (Figure-III)

In an initial step towards homogenous digestion, the PANDIA inlet chamber mixes the incoming decompressing raw material with steam and the cooking liquor.

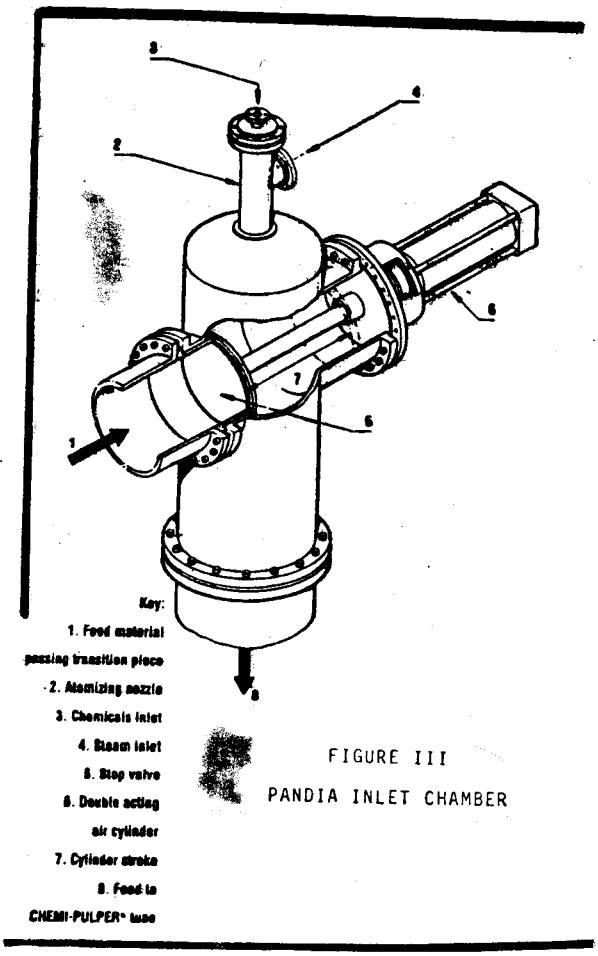

FIGURE III
PANDIA INLET CHAMBER

The inlet chamber prossesses

— A special cooking liquor atomizing nozzle that facilitates the complete mixing of the fiber feed with steam and cooking liquor for optimum heat transfer.

— Provision of stop valve for protection against blow-backs and losses of steam. Both heads of the double acting air cylinder are cushioned and it is equipped with a solenoid valve and supported by a steam equalizing valve.

— Automatic control, linked to the load sensor of the screw feeder motor. If the plug in the screw feeder should weaken due to non-availability of feed, the stop valve then serves as an automatic tightening device. Additional interlock can be provided with steam and liquor flows.

The Chemi-Pulper Reaction Tube (Figure-IV)

The PANDIA CHEMI-PULPER reaction tube is a continuous autoclave designed for processing agricultural fibers, wood chips, and other raw materials. It can be used both for vapour phase cooking with low liquor to wood ratios and for totally submerged cooking at high liquor ratios.

The CHEMI-PULPER is available in more than 12 diameters, ranging from457-2,134 mm, and in processing lengths of between 4,572-14,630 mm.

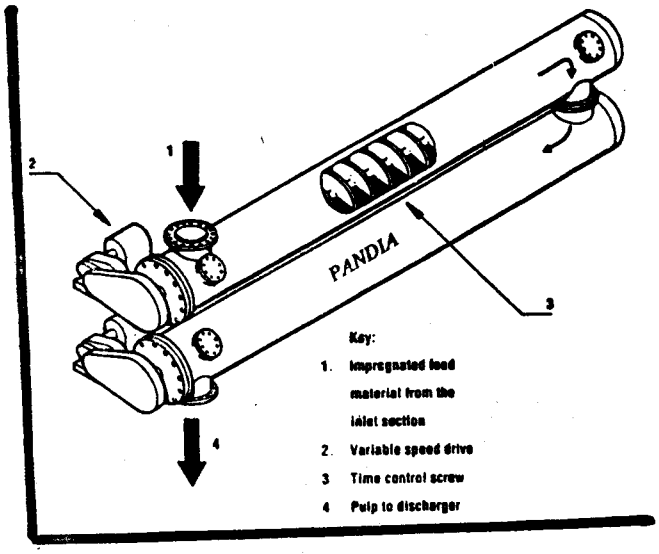

FIGURE IV
CHEMI-PULPER REACTION TUBE

The tube includes :

Time control screws that move the materials to be cooked through at controlled and uniform speeds. This ensures adherence to the predetermined digestion time for each CHEMI-PULPER tube. For lower requirements, mixing screws are available.

Automatic and accurate control of temperature, pressure and chemical concentration.

Modular design that meets any process requirement by individual use or multiple arrangements. Supplementary tubes can be added for subsequent increases in capacity.

Suitability for steaming impregnation, cooking, extraction and other reaction stages.

The Pandia Discharger (Figure-V)

The PANDIA orifice-type discharger is designed for the continuous and uniform transfer of the digested material (including high consistency pulp such as softened wood chips) from the high-pressure CHEMI-PULPER tubes of the continuous digester to the blow tank (both hot and cold blow).

The discharge orifice is adjustable by means of pneumatic control mechanism. Within the housing of the discharger an impeller continuously wipes the face of the orifice to prevent any blocking.

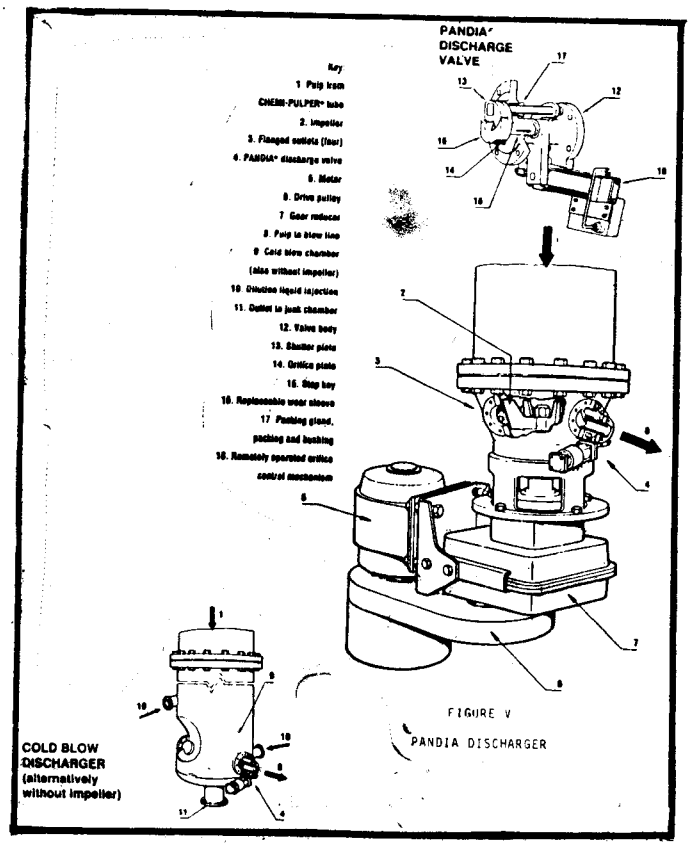

FIGURE V
PANDIA DISCHARGER

Instrumentation (Figure-VI)

The PANDIA DIGESTER operation offers flexibility as all controls can be achieved from the control room. The basic instrumentation includes an enclosed cabinet panel completely wired, piped and with relays to provide cascade type interlock in the AUTO mode. Indicators/Recordars for variable parameters are provi, ded with alarms to warn of any maloperation,

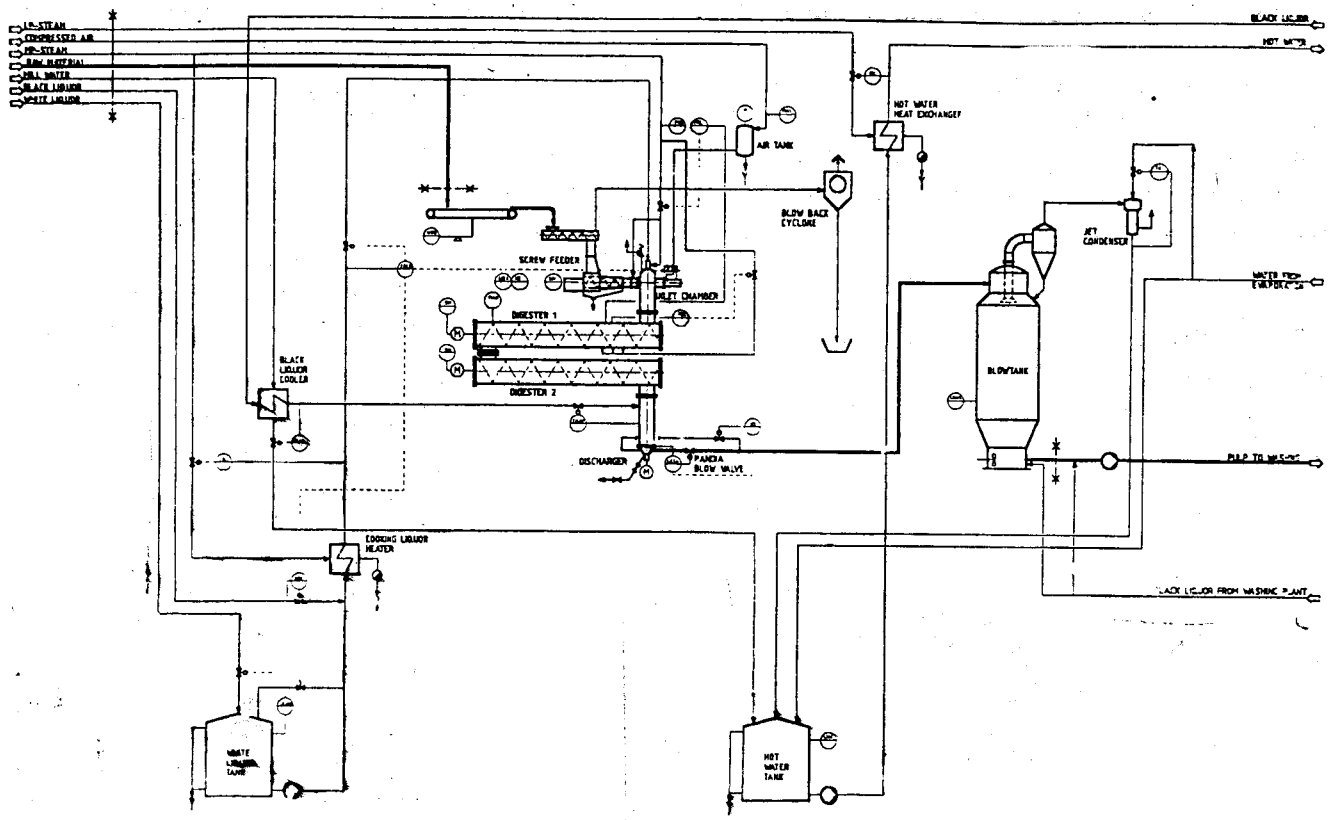

FIGURE VI
P & I DIAGRAM—PANDIA DIGESTER SYSTEM

Bagasse Pulping

The state of art for pulping bagasse (Table-VI) is almost fully equivalent to that for pulping wood. Practically all types of pulp, ranging from mechanical pulp similar to ground wood all the way to quality bleached pulp of high brightness can be produced from bagasse. Among the many agricultural fibres used for pulp manufacture, bagasse seems most promising on account of its localised presence in bulk quantities from sugar mills. However the economics of its availability will be dependent on its alternate application as fuel (Refer Table-VII). It is recommended that a 2-stage depithing involving moist as well as wet depithing be conducted to prepare the bagasse for better quality pulps, paper and board products (Figure-VII). Partial list of modern depithing equipment and systems are given in Table VIII of which several versions are available in India. The Atchison method of wet depithing is shown in Figure-VIII.

Bagasse Chemical Pulping

A number of different processes have been used for the chemical pulping of bagasse in horizontal tube digesters. These include the kraft, Soda, neutral sulphite and alkaline sulphite process. The soda process is the most commonly used process, and there is an increasing number of mills using a small amount of anth raquinone, which increases the yield at reduced chemical consumption. The normal cooking time for bleachable grade bagasse chemical pulp is 12-15 minutes at a temperature of 170°C and a presssure of 7—8 bar. Chemical consumption is 13-14% NaOH on B.D. bagasse, and the bleached yield around 48%.

Bagasse chemical pulp is being used in a wide range of papers including writing and printing paper, tissue, sack kraft and liner board. A number of different processes have been developed to produce news-

TABLE-VI
Parameters For Bagasse Pulping and Refining

		CP	SCP	CTMP	CMP
Cooking Time	(Minutes)	12-15	10-15	5-10	(5-10)
Temperature	(°C)	165-170	160-170	110-135	40-50
Press	(Bar)	6-7	6-7	2	—
Chem. Charge On B.D. Bag.	(%)	13-14 (NaOH)	6-8 (NaOH)	2-3 NaOH) 1-2(Na_2SO_3)	4-5(NaOH)
Yield	(%)	50-55	60-70	75-85	80-90
Steam consumption	(T/BDMT Pulp)	1.8-2.0	1.5-1.6	1.0	
Power consumption	(KWH/BDMT Pulp)	45-50	35-40	900-1200	650-800

TALE-VII
Economics of Bagasse Availability*
Basis : Moist Depithed Bagasse With 50% H_2O

		BAGASSE	COAL	FUEL OIL	NATURAL GAS
C.V.	(Kcal/Kg)	4600	6000	10,000	—
	(Kcal/Cum)	—	—	—	9400
Boiler Eff	(%)	58	80	80	80
Heat Avail	(Kcal/Kg)	2670	4800	8000	—
	(Kcal/Cum)	—	—	—	7500
Bagasse Equivalent	(Kg/Kg Bag)	1	1.8	3.0	—
	(Cum/Kg.Bag)	—	—	—	2.8

* Thumb Rule For Steam Generation
1 Mt Bagasse : 374 Cum Natural Gas
: 0.5 MT Coal

TABLE-VIII
Modern Bagasse Depithing and Handling Equipment & Systems

A. Depithing Equipment

Depither	Horkel	Rivenco	Peadco	SPM
Type	Horiz.	Vert.	Vert.	Horiz.
Rotors	One	One	One	Two
Capacity (OD MTH)	1-6	5-10	10-20	10-14
Motor (HP)	30-200	200-400	200-400	2×150-2×200
Rotor Speed (RPM)	800-1400	1800-3600	1200-1800	—
Perforantions				
Moist (MM DIA)	8	8	8	(Air Regulated)
Wet (MM DIA)	5	5	5	(Air Regulated)

B. Wet Depithing Systems

1. Celotex System
2. Peadco System
3. Atchison Method

C. Bagasse Storage Systems

1. Celotex bale Method
2. Ritter Biological Pre-treatment Process.

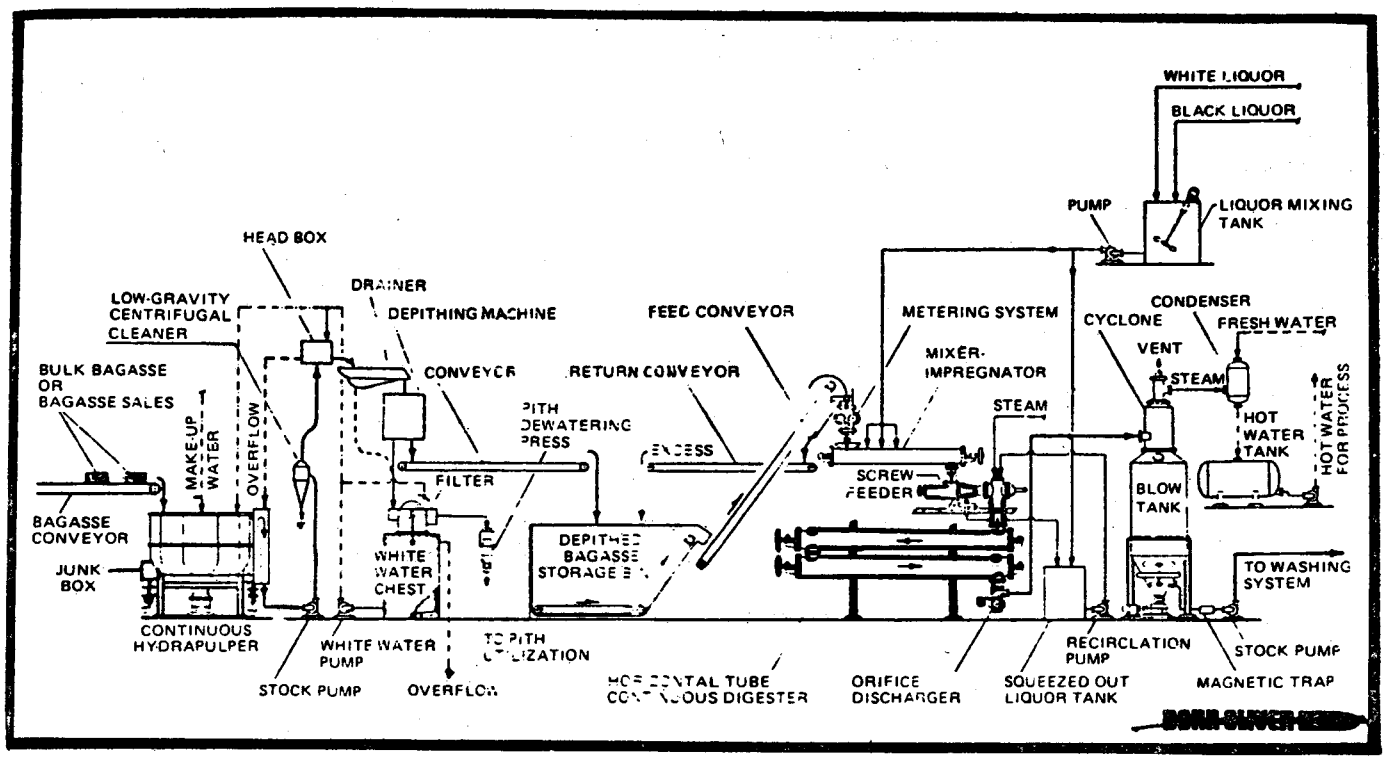

FIGURE VII
FLOWSHEET–WET DEPITHING AND CONTINUOUS DIGESTER

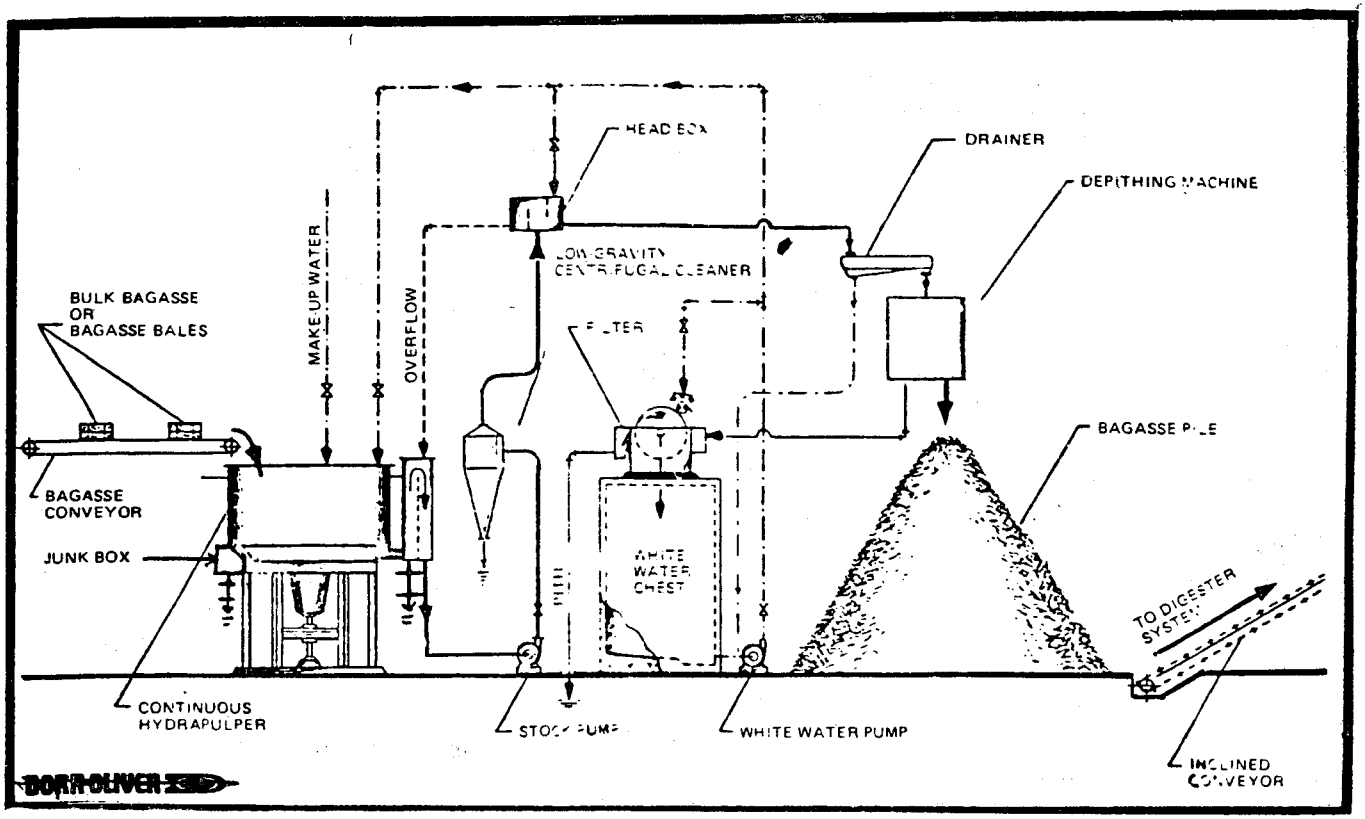

FIGURE VIII
ATCHISON METHOD–WET DEPITHING SYSTEM

print from bagasse, but all require a supporting chemical pulp component to provide the necessary strength and runnability on the paper machine.

Through the years, sevral companies have tried to develop alternative systems for chemical pulping of non-wood plant fibre materials using liquid phase or vapour phase vertical digesters, but these have not been successful for this material, due to difficulty of packing and bridging in the column, and of obtaining a uniform heat transfer. Similarly, a considerable amount of work has been done on low conistency alkali-oxygen cooking, but this has the disadvantages of high steam, chemical and power consumptions, and it does not seem to be a viable alternative to rapid vapour phase cooking.

Bagasse High Yield Pulping

The bagasse newsprint installations currently in operation include Mexicana del Papel Periodice in Mexico and Papel del Tucuman in Argentina, P.N. Kertas Letjes in Indonesia, which uses the Peadco process,Tamil Nadu Newsprint and Paper Ltd.in India, which uses the Beloit-Seshasayee Paper and Boards process, as well as Cuba-9 which has developed their own technology.

Early work on bagasse pulping on newsprint was based largely on chemical and semi-chemical pulping, which gave good runnability, but poor optical properties. This necessitated the addition of stone groundwood or refiner mechanical wood pulp, and fillers to obtain acceptable printing properties. The development of large high consistency refiners made it possible to produce mechanical pulps from bagasse, and the three most recent installations in Indonesia, India and Cuba utilise semi-chemical, C.T.M.P, T.M P and C.M P pulps in their furnish.

The Cuba-9 pilot plant was established in 1981 by the Cuban Sugar Cane By-Products Research Insitute (I.C.I.D.C.A.) and was partially funded by U.N.D.P. It was designed for a capacity of 25-20 T/D of mechanical type bagasse pulp, and upto 35T/D of Newsprint. The pulping plant included a PANDIA horizontal tube continuous digester, and was extremely flexible in that it was possible to produce the following types of bagasse pulp.

- Refiner mechanical pulp (RMP) with peroxide bleaching
- Thermo-mechanical pulp (TMP) with peroxide bleaching
- Chemi-mechanical pulp (CMP) with peroxide bleaching
- Semi-Chemical pulp (SCP) with hypo-chlorite blea ching or a 3-Stage bleaching process
- Full chemical pulp with 3-stage bleaching
- Pre-hydrolysis dissolving pulp with full bleaching

Bagasse high yield pulp processing conditions

High yield pulping of bagasse uses the same screw feeders and preheater as for chemical pulping, but a high speed pressurised refiner is installed instead of the discharge. Prior to refining, the bagasse is softened by pretreatment with chemicals and/or steam. For chemi-mechanical pulp, about 2% caustic soda and 2% sodium sulphite can be used for yields over 80%. Pretreatment time is 5-10 minutes at a temperature of 40-50degree C. For C.T.M.P, the retention time and chemical consumption is about the same, but the refining temperature is increased to about 120 degree Centigrade.

The size of refiners and power input depends on the process, and other components in the furnish, but is generally around 800-1200 kwh/ton to obtain the required optical properties. One particular area which requires consideration in new bagasse newsprint plants is the cleanliness of the bagasse. In the existing mills the screw feeder and refiner plate life is considerably shorter than that obtained for wood pulping.

For future installations special care will have to be taken in harvesting, transporting and storing the cane and bagasse in the Sugar mills, since it is difficult to remove in the bagasse washer all the sand which is embedded in the bagasse during the crushing process. Consideration should also be given to washing the cane prior to milling, since the sand is relatively easy to remove on the conveyors. While the efforts to improve the cleanliness of the bagasse are a long term aim,work is continuing on the immediate problem by developing harder materials for the feeding screw and refiner plates, as well as using plate patterns which are more resistant to wear.

Conclusions

It can be seen from the above comments that the PANDIA Continuous digester is an extremely flexible system which can be used to produce full chemical pulp through to various types of high yield/semi chemical and mechanical pulps for different applications. This digester can also be used to process many different non-wood fibre raw materials. Therefore, we are convinced to have an ideal key equipment for our projects in the field of non wood plant fibre pulping in particular for bagasse which is one of the future raw materials.

The PANDIA DIGESTER has the back up support of Continuous digesting technology that incorporates over 80 years of experience. It is superior to all other alternatives due to long term development work which has profited from the practical expertise deriving from the successful competition of over 200 pulp plants worldwide.

The PANDIA DIGESTER clearly offers attractive benefits over globe digester and also promises an excelent ROI by way of savings in steam, chemicals, manpower and space.

References :

i) Internal communication with VAI.

ii) Secondary Fibers and Non-wood pulping, Vol 3. Pulp & Paper Manf. Joint Text book committee of the Paper Industry, TAPPI (USA).