Experience in Running Kamyr Continuous Digester for Kraft Pulping with Tropical Raw Material in Bengal Paper Mills

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The Kamyr Continuous Digester was commissioned on Second day of July 1967. This Plant is first of its type in India. A brief description of the digester system is given. This novel plant had given some teething problems during start up but settled down in six months time. During the last four years of its running, different problems were faced which were found to have special relationship with tropical raw material. The problems we faced, and the solutions to it have been dealt with here.
The advantage, Bengal Paper Mills experienced in walk of its day-to-day affairs, have been closely watched and touched in this article with facts and figures.

Introduction

On our tours to different pulp and paper industries and conferences in India, we found technical persons taking enormous interest in the working of this continuous pulping unit. During discussions, we felt that probably due to lack of proper informations, some of the technical persons are not fully aware of the advantages of this unit. This initiated us for writing this article.

Bengal Paper Mills uses bamboo and mixed hardwood as its raw material. Salai constitute the major portion as mixed hardwood in the furnish. The ratio of bamboo to mixed hardwood is approx. 60 : 40. The proximate chemical analysis of the bamboo and hardwood, we are using mainly, is given below:

%	Bambusa arundinaceae	Boswellia serrata
Ash	3.3	1.8
Cold Water Sol.	4.59	6.3
Hot Water ,,	5.95	8.9
Silica	3.30	
Alcohol Sol.	1.22	
Ether ,,	0.82	
1%NaOH	19.35	15.5
Pentosans	19.62	13.0
Lignin	30.09	28.6
Cellulose	57.5	50.7

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We have mixed cooking system Chip analysis of chips going to Kamyr Continuous Digester is:

Retention at Screen (Oversize)	$1\frac{1}{2}'' \times 1\frac{1}{2}''$ Sq. in.	5.0%
Between	$1\frac{1}{2}'' \times 1\frac{1}{2}''$	22.0%
	$1'' \times 1''$	
Between	$1'' \times 1''$	
	$3/4'' \times 3/4''$	29.0%
Between	$3/4'' \times 3/4''$	22.0%
	$1/2'' \times 1/2''$	
Between	$1/2'' \times 1/2''$	8.5%
	$3/8'' \times 3/8''$	
Between	$3/8'' \times 3/8''$	6.5%
	$1/4'' \times 1/4''$	
Passing through Dust & Fines	$1/4'' \times 1/4''$	7%

DESCRIPTION OF DIGESTER SYSTEM

A brief description of the digester system from chip feed to discharge of the pulp stock is given below:

Chips from a chip bin are metered by volume into the system through a chip meter, driven by a variable speed motor to control production rate, and pass in a low pressure feeder. The feeder has a specially designed rotatory plug, with pockets, allowing the chips to pass from atmospheric pressure into the steaming vessel which is operating at approx. 15 psig. pressure.

The steaming vessel is a horizontally mounted cylindrical vessel with a screw conveyor for transporting the chips and falling it through the chip chute into the High Pressure Feeder. The pressure in the steaming vessel is being produced by flash steam from the hot extracted liquor from the digester. If this is not adequate for maintaining pressure, fresh steam (50 Pisa) is automatically added. The chips are heated, air and inert gases are relieved from the chips in the steaming vessel and this makes them more accessible to impregnation by the cooking liquor.

The high pressure feeder rotor is totally submerged in liquor level controlled in the chip chute. The chips are packed into the H.P. feeder pockets by the chip chute circulation pump. The rotor of the H.P. feeder is so designed with four helical

oriented through type pockets at 45° to each other, that chip transfer for all practical purposes is continuous. The pocket full of chips on revolving 90° comes in contact with the liquor being circulated from the top circulation pump. This liquor then flushes the chips out of the pocket and carries them to the top separator at the top of the digester, consisting of a slotted strainer and a slow moving screw inside it to keep it clean. The liquor filters out through the screen into a chamber, is then recirculated through the H.P. feeder by top circulation pump to pick up more chips. The chips move downward into the digester shell.

White liquor and excess liquor from the chip chute goes to a level tank. A high pressure pump, called make up liquor pump, pumps out liquor from the level tank to the digester. A control valve in the discharge side of the pump controls the level in the level tank. The impregnation temperature at the top of the digester is 120-125°C and impregnation time is 90 mts. The cooking liquor is now heated to a temperature of around 165°C. This is accomplished by withdrawing liquor through the girth strainers inside the digester shell, circulating them through the heat exchangers and discharging through the central pipes in the centre of the digester slightly above the strainer plates. By introducing the liquor at the centre and withdrawing it radially in all the directions the chips receive a uniform treatment and consequently the product is more uniform. After the cooking process is complete the cooking reaction is stopped by extraction of the hot spent liquor by upper extraction strainer and cooling effect of the upflow of wash liquor from the washing zone. A portion of the liquor extracted from the lower extraction strainer is discharged by central pipe just above the 1st extraction strainer. It cools down the chip mass and permits washing to be carried out without further delignification. The high temperature liquor with high percentage solids goes to a primary flash tank where flash steam is recovered and piped to the steaming vessel. From primary tank, liquor is flushed into a secondary flash tank, steam recovered is used for heating water and the heavy liquor is taken to the evaporator department.

Washing is accomplished by extracting a greater volume of liquor than the volume coming down from the top of the digester with chips. To increase the washing efficiency the wash liquor moving counter currently is being heated by a wash liquor heater. The wash liquor is being introduced by a cold blow pump, a portion of which travels upwards and a portion travels downwards into the blow line with the pulp. This liquor cools the pulp to about 80°C and prevents the pulp fibres from damage.

A rotating scrapper in the digester bottom facilitates the pulp discharge. To ensure proper defibration before washing plant the pulp passes through a blow unit having an agitator. After the blow valve the pressure is released and chips separate into individual fibers.

The instrumentation in the system is extensive. All instruments are assembled in a control panel. All important pressures, flows and temperatures are recorded or indicated. Lamps indicate when the motor runs. Push buttons for all motors and ampere meters for the important ones are also located in the control panel room.

ADVANTAGES

(1) Low Labour Cost

Batch system usually require several more men than that required in operating continuous digester and washing plant.

(2) Saving in Capital

Only one stage washing is required from the pulp produced by Kamyr Digester with the high heat diffusional washing system.

(3) Reduced Steam Consumptions

Because continuous cooking is more efficient, steam requirement is considerably lower. Also load on boilers does not fluctuate as steam demand is fairly constant.

(4) Lower Corosion Problem

Kamyr Continuous Digester shells are pressurised all the times during operation, and temperatures in various zones stay constant, which effectively inhibit corrosion. With batch system, on the other hand, corrosion is a major cost item.

(5) High Yield

Uniformity of cooking in Kamyr Digester means virtual elimination of uncooked fibre bundle. In fact, screens of lower capacity is required.

(6) **Better Pulp**

Pulp fibre degradtion is prevented in Kamyr Continuous Digester by cooking the stock well below the point where mechanical handling could cause damage before discharge begins. This feature, plus optimum cooking conditions give pulps of superior breaking length and tear factor as compared with batch system pulps.

(7) **Less Cost for Bleaching**

Due to uniformity in the pulp from Kamyr Digester, bleaching chemical consumption is less.

PROBLEMS ENCOUNTERED

Chips Hanging

Due to poor bamboo quality or chipping conditions, the % of pin chips & slivers with the accepted chip increase and hanging problem is faced at the Bamboo Silo. This problem should not pose any difficulty if the chips are free from slivers. We have

a separate silo for wood chips of exactly similar construction which is free from such problems. Wear & tear of the parascrew blades have been observed and all the blades we built up after a service of only three to four years. Naturally suitable material of construction for the flights should be looked into.

Magnetic Separator

Magnetic Separator, suspension type, used for removing tramp iron, nuts, bolts etc. upto about 700 gms. from the chips being conveyed from parascrew to blower by belt conveyor should have sufficient lifting power. Magnetic separator should be tested as per manufactures advice time to time in order to establish its lifting capacity. This is essential for checking the iron materials which may pass on to the digester, causing stoppages and damaging other important units.

Chip Blowing

We have observed trouble in blowing chips from chipper house to the Kamyr Digester at an height of about 100 ft. in the rainy season, when free water was going with the chips. Seeing the errosion of the chips line, specially at bends, belt conveyors for the conveying system should be considered. If chips washing plant is already there, then belt conveyor will suit better.

Chip Cyclone

Chips blown enter the cyclone for releasing the air before these are stored in a chips bin. Due to constant errosion, cyclone plates develops holes and require welding time to time. We had to replace it with a new one only after four years of service.

Chip Feeding

Chip hoppers S. S. plate lining (1/16th mm thick) developed cracks only after two years of service. There are two vibrators at the hopper for helping in smooth chips feeding. After four years of service this plate had to be replaced with a mild steel plate. This plate must be kept in good condition for uniform chips supply to the system. With the existing chips quality at BPM, chip pocking at hopper become necessary at times and therefore, the exhaust pipe from L.P. feeder was made to discharge at the chip bin instead of chip hopper. The plant has two important feeding units Low Pressure Feeder and High Pressure Feeder.

Low Pressure Feeder

Its a rotory plug. Rotor is made of cast steel with conical wearing surface covered with special alloy. The housing is of stainless steel. The rotor length is 700 mm and has taper ratio 1:15. An overhauled low pressure feeder gives good performance for the first three to four months. Therefore the plug does not go in smoothly and the leakage of steam through the unit increases causing nonuniform chip feeding. This affects the working of the plant. The life of this unit also depends on the quantity of slivers, strings etc. coming along with the chips. These come in between the rotor and the housing, causing high load and mechanical stresses in different parts. The impact is so severe at times that the weaker parts e.g., thrust bearing, journal bolts, give way. The rotor edges and housing to an extent of the width of the inlet opening also wears out quickly in spite of providing necessary deflectors. The rotor edges were given a deposit of suitable special alloy. The thrust bearing was put for heavier duties. No mechanical problem has been faced in the last two years with this unit. Still this unit needs modifications to suit Indian conditions.

High Pressure Feeder

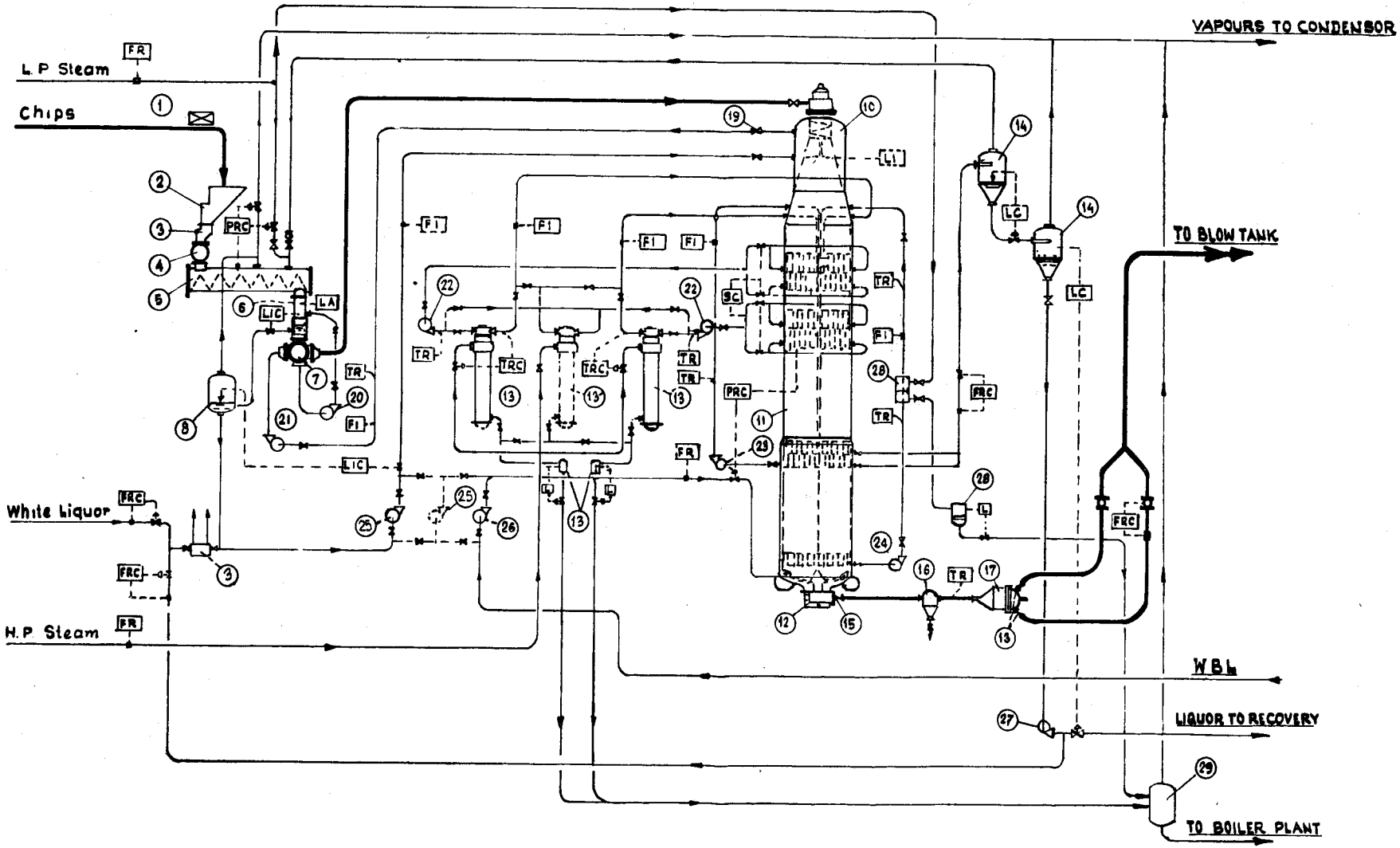
The heart of the plant is High Pressure Feeder. The rotor is of stainless steel. Housing is of cast steel with a sleeve of special allow. The H.P. feeder is designed to permit compensation for wear in the rotor and housing. This is accomplished by making the rotor and sleeve slightly conical. Length of the rotor is 1000 mm. Big end diameter and small end diameters are 780 and 710 mm respectively. The taper ratio is 1:20. Occasionally it is necessary to overhaul the feeder. There are different methods of carrying out this overhauling. Generally this is being done in Sweden but Bengal Paper Mills have been able to carry out the necessary repairs indigenously. Initially the wear and tear of the unit was too high due to fines and sand in the chips. The expected life from the feeder is more than ten months which has not been achieved. We put a high pressure weak black liquor purge line at the feeder and suitably altered the material of construction with good results. The life can be increased to 8 months if chips are washed for removing sand and extraneous matters.

Impregnation Temperature

The impregnation temperature in the digester was kept 110°C. With this temperature, we used to get uncooked chips pockets and shives with the pulp. The impregnation temperature was increased and the system was suitably modified to get temperature as high as 124°C. Things began to improve and we claim that this has helped us in uniform cooking.

Gland Packings

Bengal Paper Mills was plagued with constant troubles about the short life of its important pump packings. These pumps use to handle hot alkalmic liquors. All types of packing materials were tried but failed. We were thinking of sand, silica and other suspended matters in black liquor



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being the cause of short life of packing material. Meanwhile we launched a strong drive regarding accurate machining and fitting in our workshop but conditions did not improve. Later on, it was thought that the gland packings which are in contact with and are lubricated by high temperature cooking liquor with good amount of alkali, should be lubricated with water by providing high pressure water sealing arrangements. Therefore, glands were equipped with lantern rings and high pressure water supply lines were connected. Packing material now became free from contact with cooking liquor. This along with other minor modifications solved the problem with the pumps in total. These pumps in question should have extra heavy duty shaft with oversize sleeve of hard material at their gland portions. The design of the gland should be heavy duty, water cooled and should have modern features of high pressure sealing.

Scaling

There is high percentage of silica with our raw material. The inherent silica along with the extraneous one, help in forming hard silica scale on cooking zone, strainers and heat exchanger tubes. The silica, along with binding material existing in the raw material and fibres, give rise to heavy deposits behind the cooking zone strainers and in cooking liquor circulation pipe lines. The plugging of the strainers starts interfering with the process after six months time from the annual shut when these are cleaned. The S. S. tubes of heat exchanger need cleaning after every three months. All the pipe lines in the cooking zone circulation need cleaning for scale deposits after one/ three years of time. Necessary flange joints should be made during erection days itself for this purpose which we had to do afterwards. Due to high % of silica in our scales, hydrochloric acid and other available chemicals are not effective. Presently we are giving an acid circulation with suitable inhibitor and then are cleaning the tubes mechanically by means of flexible shafts provided with suitable cutters. The results are not to our satisfaction. We invite suggestions for removing the scale. Regarding the choking of the strainers we feel that even after we introduce chip washing system, owing to presence of inherent silica in the bamboo chips, cooking zone strainers plugging may still continue but its intensity will undoubtedly be reduced. Looking to our problems, Kamyr's latest development for direct steaming for getting rid of costly S. S. tube heat exchangers and accessories, for heating cooking liquor may probably be suitable under Indian conditions. But the disadvantages of direct steaming should be looked into before taking any final decision.

Bottom Scraper

Probably due to quality of raw materials used in India the load on the bottom scraper is high. Therefore new installations should put in stronger units. Relief was achieved by modification with the dilution system at the discharge end. We were supplied with a under capacity PIV gear box for bottom scraper which gave way and we are presently running it at fixed RPM. Variable speed system is important for good control.

Metal Trap

After the pulp comes out of the discharge unit, there is a metal trap. This unit never worked successfully and is causing blow line jamming due to foreign materials coming with chips. Proper design may help.

Instruments

An attempt is made to present only the difficulties faced with the control instruments in Digester.

Chips are measured volumetrically. Therefore fluctuations in chip density, bamboo to wood ratio, vary the quantity of chips fed in the digester. Additional electrical interlocks have been provided to avoid damage to the units and to reduce the downtime.

Cleaning of the different orifices used for measuring liquor flows, specially the cooking liquor, are required every year due to diposition of silica base scales.

The manifold of the differential pressure transmitter gets jam owing to fines and dust in the liquor. It may be cleaned with high pressure water line connections.

Magnetic flow transmitters are not giving good service probably due to passing of metallic pieces, deposition of scale on the electrodes etc.

In our valves, seat rings wear out due to erosion and the valve stems at times have broken due to highly turbulent flow of liquor and high vibrations in the pipe line.

RESULTS & SUGGESTIONS

Now let us compare the properties of pulps from forced circulation indirectly heated batch digesters and Kamyr Continuous Digester. The following two tables I & II will give a comparable picture.

These results show that inspite of mixed cooking it's mainly the good control system and the advantages of cooking at higher pressure which results in strong and clean pulp. At times it has been observed that after cooking under identical conditions in the laboratory with 15 litres laboratory digester and at continuous digester, the pulp from the continuous digester is better in all respects due to reasons mentioned earlier.

Runability of paper machines, specially the high speed machines improve if the pulp character is

TABLE I

	Batch Digesters	Kamyr Continuous Digester (150 ton B.D. Pulp/day)
Raw material	100% Bamboo	35% mixed hardwood 65% Bamboo
% A.A. as NaOH	21	18
Cooking Temp. °C	165 °C	165°C-167°C
Impregnation time at about 125°C	—	70 mnts.
Time to Temp.	90 mnts.	20 mnts.
Time at Temp. Hrs.	60 mnts.	60 mnts.
Pressure Kg/Sq cm etc.	7-8 kg/sq. cm.	10 kg/sq. cm.
Permanganate No. of pulp	19-20	18
Pulp	Specky	Clean
Pulp shade.	Dark	Comparatively bright.
% reject in screening on chips.	4	2.5
Steam consumption ton/ton of pulp	1.8	1.1

TABLE II

	Pulp from batch Digester	Pulp from Continuous Digester
Permanganate No.	19—20	18
Freeness, °SR	40	40
Beating period, Mnts.	45	45
Breaking length	5800	6500
Burst factor	38	45
Tear factor	100	120

TABLE III

BLACK LIQUOR ANALYSIS (KAMYR DIGESTER)

Solid content	%	15.28
Organic matters	%	8.5
Inorganic matters	%	6.78
Sodium Compds. As Na O	%	3.22
Silica as SiO	%	0.31

consistent. In case of the batch digester the character of the pulp from different batches will vary whereas in case of a continuous digester, uniformity is maintained. It has been observed that °SR of unbeaten bleached pulp is steady in case of pulp from continuous digesters resulting in good performance of paper machines.

Inspite of using 40% mixed hardwood and 60% bamboo in our furnish we have gone upto 20% loading in our paper which is not possible in case of batch digester pulp. We have maintained high sulphidity of the cooking liquor which has further increased pulp strength.

Due to homogeneous cooking of pulp, the shade of the pulp is uniform along with the uniform quality. As a result, the paper shades are also steady. In case of batch digester pulp, it's very difficult to maintain uniform shade.

With limited cleaning system in BPM, we have been successfully making speciality papers like base papers for Decorative Laminators, Off-sets, Airmails and Bond Papers and also S.S.S. Maplitho, which is due to very satisfactory pulp manufactured in the Kamyr Digester.

CONCLUSION

There is no doubt in the fact that this novel plant had given some teething problem during the first six months of its commissioning. AB Kamyr, Sweden, too did not have enough experience with the Indian raw materials, specially with erosive bamboo chips. But in course of time the working of the plant had settled down with united efforts of all who were working in this plant and active co-operation of the AB Kamyr, Sweden. We feel, seeing the advantages of this modern continuous pulping unit, any new mill coming up will give due consideration for this plant and should not face problems which this first unit faced with the Bamboo chips.