Role of Equipment Design in Ensuring Product Quality in a Paper Mill with Particular Reference to Bagasse as Raw Material

By

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Introduction

The Country is facing shortage of Paper. While the forest raw material for making paper is dwindling Bagasse promises to be an ideal alternative source. In order to successfully exploit this material, certain parameters peculiar to this material have to be kept in view for designing and selecting equipment. The Mandya National Paper Mills Limited, (A subsidiary of M/S Hindustan Paper Corporation Ltd., a Government of India Undertaking) is the only Mill in India which uses Bagasse as a primary raw material for making cultural varieties of paper successfully. An effort is made in clucidating the role of equipment design in ensuring product quality.

Paper is a felted piece of cellulose obtained from cellulossic raw materials like Wood, Bamboo, agricultural residues, grass reeds, cotton fibre, etc. In wood different species are available mainly divided as soft wood and hard woods. Since the availability of soft woods is limited in our Country, we limit our usage only to hard woods, and bamboo as major raw materials.

Since Bamboo is used in our Country from a long time the Chemistry of Pulp-making from Bamboo is quite familiar to our people. Usage of hard wood is developing and these are being used in many Mills to the extent of 30 to 40% of the total raw material requirement. As the forest raw-materials are depleting fast, we have to divert our attention to other available raw materials in our Country, out of which, agricultural residues, like wheat straw, rice straw and Bagasse are considered. Since, straw is used as a cattle fodder, they are out of question. Therefore the only other abundantly available raw material is bagasse (app. 13.26 Million Tons). (Times of India Directory and Year Book—1976.) [1]. There are plenty of sugar mills in North India, particularly in U.P. and Bihar, where plenty of pulp and paper mills can come up using bagasse as a raw material. For the present all the sugar mills are using this bagasse as a fuel in their Boiler for producing steam and power for their own use. These Boilers are presently designed only to burn the bagasse. Until and unless, these sugar mill Boilers are converted to Multi-fuel Boilers either to burn coal, fuel oil or bagasse, sugar mill people are not willing to give this bagasse to Paper Mills. If the Boilers of the sugar mills run efficiently then we can expect about 5% as surplus bagasse, which can be released to Paper Mills, which will not be sufficient for an integrated Pulp and Paper Mill. Until and unless the Government gives a serious thought over this raw material, the industry continues to suffer shortage of raw material and we will not be self-sufficient. For this purpose, the future licences to be given for new sugar mills, must be only based on multi-fuel boilers and all existing sugar mills have to convert in a phased manner their existing bagasse based boilers to multi-fuel boilers. The question arises as to who will pay for the conversion of Boilers? That is a complicated issue and Government is the only competent authority to streamline this problem, either by negotiation or by passing Ordinances, to release this valuable raw material for Paper Industry. Unless a marriage between Sugar Mills and Paper Mills is taken up by the Government, it will not be possible to obtain this valuable raw material to Paper Industry which is otherwise burnt and a sheer waste of National Wealth. Hoping that this problem is solved, an effort is made by the author to elucidate certain problems faced in the role of equipment design in Pulp &

Paper making, with this raw material. As mentioned earlier, since Bamboo is a well known raw material in this Country, most of the problems faced in using this material for pulp and paper making has been overcome by taking care of the design of the equipment. Most of the Pulping equipment and some of the small Paper Machines are being manufactured in our Country to use Bamboo as raw material for paper making. Since bagasse as raw material is not well exploited in our Country, the equipments for making Pulp and Paper with this material has not been well developed and has to be imported. But with the available Engineering skill and material in our Country, it is possible to design and develop the machinery required for the same. Unless and until more and more Pulp and Paper factories with bagasse as raw material come forward, it will be difficult to design, develop and manufacture the desired machinery only for one or two factories. Therefore it is necessary that Government has to assure the industrialist about the availability of this raw material.

Bagasse (Sacharim Officinarium) is the residue left from the sugar mills after extracting the juice from the sugar cane. About 5.6 tonnes bagasse with 50% moisture is required for one tonne of Pulp. Bagasse as it comes out of sugar mills, will be with 50% moisture, about 5% solubles of different forms of sugar not recovered and 30% of pith. It with be at a pH around 3.0. In addition, this pith if not removed, having high surface area and being porous in nature consumes lot of chemicals at the time of processing, yet producing inferior quality pulps with more of silica, dust and extraneous material. Further it slows down the rate of production by clogging the machine wire, and slowing down the rate of drainage and causing sticky press. Therefore it is essential that this undesirable pith has to be eliminated. The pith so removed, can be burnt in the boiler.

In order to reduce the cost of raw material, transportation and handling, partial depithing and baling must be done at the Sugar Mills. It is the usual practice to store and stack the bagasse in the open at the Paper Mills, wherein fermentation of sugar takes place with liberation of enormous amount of heat. After about 8 weeks storage the moisture stabilises, the pH value will increase to about 5.5, the pith gets partially loosened, which can be removed better and the sugar converts to alcohol and oxidises to acetic acid which is soluble in water.

Depithing can be done by hammer mills either by dry system or wet process. (Maurice Paturau J.) [2]. If the depithing is done in dry stage by hammer mills no doubt depithing takes place but lot of damage is done to the fibre by the cutting action and hence more of fines are created which will not be conducive for production. Dust hazards are indicated. Therefore it is better to adopt moist/wet depithing process wherein less damage is done to the fiber, more of extraneous materials are removed yet with good depithing. In wet depithing, bagasse is made into slurry of 2.5% consistency in a hydropulper with a rotor normally clad with stainless steel which rotates at about 200 RPM. A retention time of 20 to 30 mts. is preferable. Afterwards it is passed through hammer mills, vertical and horizontal type having screen plates at the outer periphery. When the hammers are rotating at high speeds, say about 2000 to 3000 RPM, the pith is hammered out, gets separated and thrown out of the screen plates, whereas the depithed bagasse falls down. Care should be taken that the total losses including pith and fibre should not exceed more than 25%, (20% pith + 5% broken fibre) on the B.D. basis of the raw material. The pith so separated can be thickened, dried and used in boiler or can be used for making Boards. In a sixty tonne/day based Pulp Mill, about 30 tonnes/day pith will be obtained.

It is desirable that, for a good quality of pulp, the pith entering the digestion system should be minimum. But however, after depithing if about 5 to 8% pith is still left behind with the depithed fiber from a hammer mill, it can be considered as ideal. An integrated Pulp and Paper mill consists mainly of Pulp Mill, Soda Recovery, the Paper Machine section and Boiler House along with maintenance, laboratory, etc. Major chemicals used in the Pulp and Paper Industry in India are sodium hydroxide, sodium sulphate, chlorine, lime, alum, rosin size, etc. Pulp Mill consists of raw material preparations, digestion, unbleached washing, screening and multistage bleaching. At each stage, the role of equipment is critical for bagasse pulping. After the raw material is prepared the next

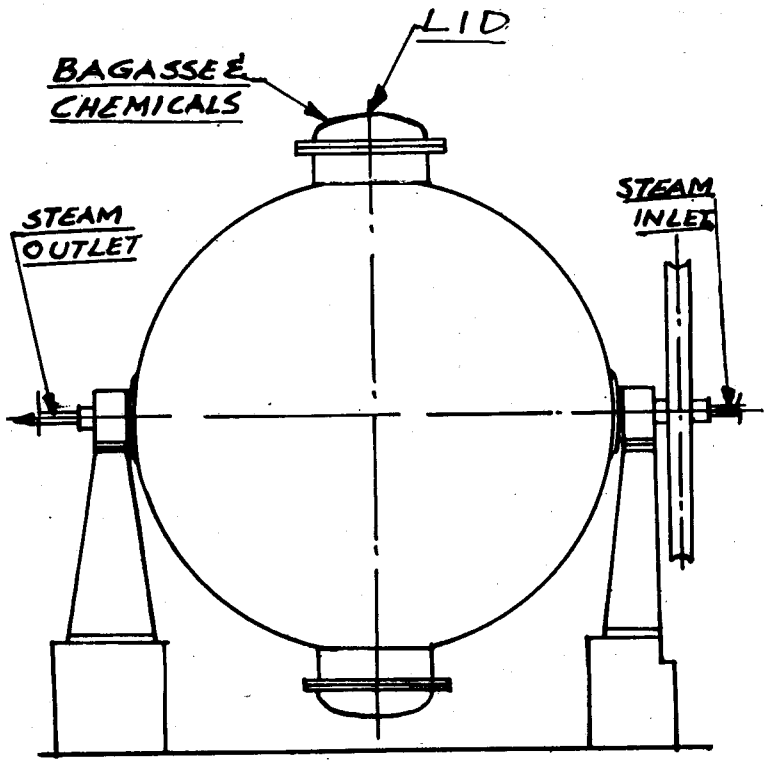
stage is to cook and separate out the cellulossic portion from its binding material. Here particularly for this raw material the role played by the cooking equipment is very much critical for Paper making and its quality with its end use.

In our Country, as mentioned earlier this raw material is used to a limited extent and hence the equipments for depithing and cooking are not taken care of. The Mandya National Paper Mills Ltd. in India is using this raw material as a major raw material with about 90% bagasse pulp furnish successfully and one of the reason is the equipment design.

Few mills are using only about 20 to 30% of bagasse pulp furnish. The only reason is they cannot make standard acceptable quality pulp which can run on the machine due to the limitation of the equipment in our Country. Cooking equipments are of two types, batch and continuous. In our Country bamboo and woods are mainly cooked in a stationery batch digester with sulphate process. Rags, cotton fibre are cooked in rotary digester (Fig. 2). Since right type of cooking equipments are not available, for bagasse also, rotary globe digesters are used which is also batch type.

As wood and bamboo are dense in nature the chips require longer time with more chemicals under pressure to separate the bonding material from the cellulose. As bagasse is an open type of material (as the sugar cane is crushed) less chemicals, less retention time are required for pulping. Bagasse pulp fibre is shorter and softer in nature compared to bamboo pulp. Bagasse pulp hydrates very quickly. Therefore, for bagasse longer cooking time is not conducive to the quality of pulp consequently for making acceptable quality paper (Table I). (Maurice Paturau J.) [3]

FIG-2



ROTARY DIGESTER

TABLE I

Effect of cooking time on the quality of Bagasse Pulp (3)

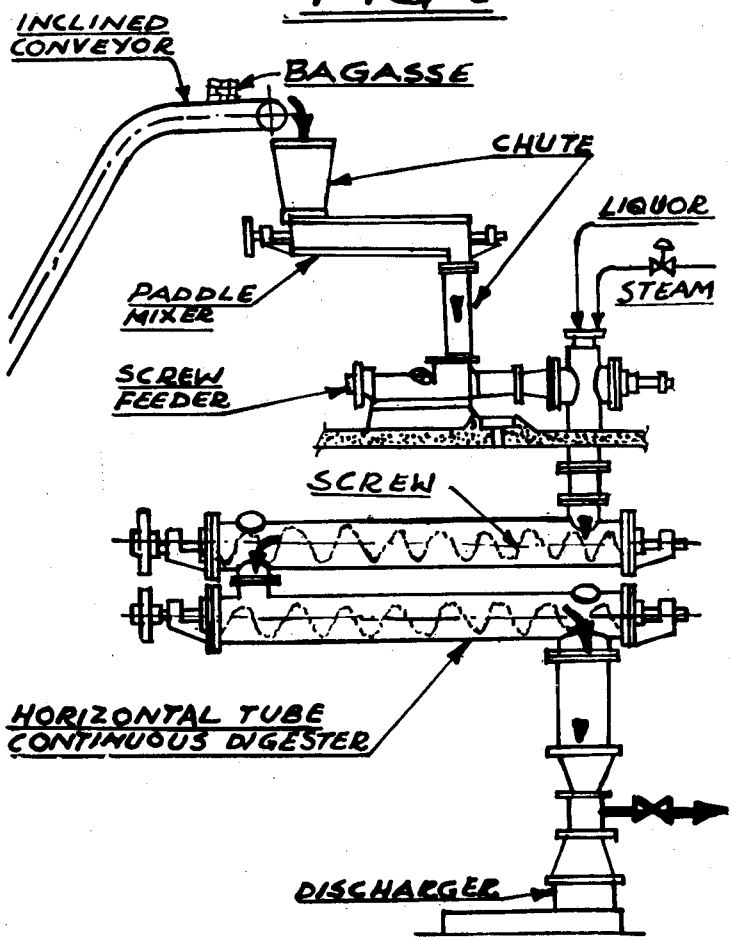
Cooking time min.	15	30	45	60	120	180
Screened yield %	58.7	58.0	57.6	57.0	56.3	58.7
Permanganate No.	16.2	16.2	16.6	17.0	18.6	21.0
Bleach demand (% cl)	4.5	3.5	4.0	4.5	6.6	9.0
Breaking length (m)	9900	9850	9750	9650	9000	8300
Burst factor	46.0	46.5	46.5	46.3	43.6	39.8
Fold (Schopper)	560	550	540	530	475	360

That means batch system of cooking is not suitable. But in India (except in MNPM) still it is cooked in batches in rotary digester. Since bagasse is bulky in nature, output of Pulp per digester in batch system will be less compared to bamboo pulp.

The bath ratio (for thorough mixing) and steam consumption will be high and the recovery of spent liquor will be poor or none. There will be variation in quality of pulp from batch to batch and the digesters occupy large areas and huge buildings. These problems can be avoided by using a continuous digester for bagasse. There are different types of continuous digesters, out of which we restrict here to the "PANDIA" continuous digester (Fig. 1), which is being used in MNPM for bagasse cooking. After the wet depithing is over the wet material at about 80% moisture is continuously fed to a cooking zone through a screw feeder. The screw feeder takes out come more pith and squeezes excess water from the material, brings it down to 50% constant moisture and feeds uniformly and continuously to the cooking zone. Here the bulk of the material is taken care of i.e. increases the density from 50 kgs/m^3 to about 350 kgs/m^3 on the B.D. Basis of bagasse. Thus by means of screw feeder the density of the material is increased and so output of pulp per unit volume of the digester increases. (Dr. Atchison J.E.) [4]

In the cooking zone chemicals are added along with steam & these things are controlled by means of automatic control system and hence no variation. This mixture of bagasse, chemicals and steam passes through two horizontal tubes with the help of timing screws. By varying the RPM of the timing screws in tubes, time factor can be controlled instantaneously, depending upon the condition of raw material used and the type of pulp required, whereas in batch system this can't be done. The continuously fed raw material gets cooked continuously with a retention of 10 to 15 minutes and discharges continuously (Dr. Atchison J.E.) [4]; (Boyhan G.E.) [5], whereas in case of batch digesters you have to wait for 4 to 6 hours per batch.

FIG-1



PANDIA CONTINUOUS DIGESTER

Because of the constant feed and discharge in a continuous digester with automatic control, the following are the main advantages for bagasse pulping.

1. Uniform quality of pulp.
2. Changes can be made to suit our condition with a short notice for different variety of pulp.
3. Easy to operate.
4. Constant load on Boiler.
5. Uniform steam consumption.
6. Less operators required because of the simplicity to handle the equipment and less area occupied.

Therefore bagasse pulp cooked in a continuous digester always has a better performance and better quality than the pulp cooked in batch rotary digester (Table II). Due to the hydration nature of this pulp, even in the Blow Tank it is not to be stored for a longer time. The mixture of the cooked material and the spent liquor has to be separated and washed thoroughly. Before washing, a prefiner and a vibratory screen are preferred to separate the bundle of partially cooked fibre which helps in uniform mat formation and better drainage on the Brown Stock washing system.

Bamboo pulp has got a fibre length of about 2.5 to 3 mm and has a °SR of 13 to 14 in the unbleached stage, whereas bagasse pulp is very short fibred and it has a fibre length of 1.0 to 1.5 mm and has a °SR of about 18 to 20 for unbleached pulp. Therefore the drainage of water in case of bagasse pulp is very poor. The cooked pulp is washed on vacuum washer with counter current washing system to wash and separate the cellulose from spent liquor.

Normally for bamboo pulp washing under vacuum, by barometric leg is used for the washers whereas in case of bagasse pulp, since it is slow draining, vacuum pumps are required. The surface area required for washing bagasse pulp should be twice compared to bamboo pulp washers. High pressure back shower wire cleaning system should be provided to avoid choking of wire cloth, otherwise carry over alkali will be more and creates effluent problems. This not only adds to the loss of alkali but also to the degradation of the fibre at the bleaching stage, foaming, loss of pulp through foam, and the cleanliness of the pulp. Taking the above into consideration, the design of the Brown Stock system should be taken care of for bagasse pulping. The spent liquor recovered after counter current washing is spent to the recovery system for recovering the chemicals. As the spent liquor will be containing lot of alkali and organics, it can't be drained for economic reasons. Therefore they have to be recovered. In case of bamboo pulp the dilution factor in washing will be low say about 2.5 due to the free drainage nature of the pulp, whereas due to the slow drainage nature of the bagasse pulp it will be 3.0 to 3.5. Therefore the recovered spent liquor in case of bamboo will have about 15% total solids (including organics and inorganics) whereas in case of bagasse it will be around 10% only. Therefore the spent black liquor from bagasse pulping will be dilute in nature and hence requires more steam to raise it to same concentration of bamboo liquor at the evaporating station.

TABLE II

Comparative strength properties of the Bagasse Pulp cooked in Rotary digester and Pandia continuous digester

Particulars	*Rotary digester*	*Pandia continuous digester*
Breaking length meters	2111	6389
Burst factor	11.4	39.9
Double folds	2	20
Ash %	2.6	0.8

Due to the nature of bagasse pulp, as the fines are more, (By fibre classification passing through 100 mesh will be about 25%) some dead fibre and fines go along with the spent black liquor to the recovery station. In the recovery the black liquor of 10% solids will be concentrated to 50% total solids by multiple effect evaporators. Before feeding the liquor to the evaporators it must be screened by vibrating screens to eliminate the fines which will help for better heat transfer at the evaporators. Since the liquor is dilute it is desirable to have a high surface area of contact, therefore long tube evaporators are preferred. Forced circulation evaporators are required to pass the liquor in tubes with high velocity wherein less of scale formation takes place.

Cyclone evaporators by using the chimney gases are advocated to further raise the total solids and to have a smooth run in the furnace. Compared to Bamboo black liquor the bagasse black liquor is highly viscous. This may be due to the high pentosan content in the bagasse. This viscosity poses a problem to

pump the liquor to the forward process. As such, special care has to be taken in designing the centrifugal pumps. (Misra D. K.) [6]

This thick liquor is fired in furnaces, wherein the organics will burn producing lot of heat which will be used for steam generation and the inorganics form a smelt of mostly sodium carbonate. This smelt is dissolved in water, made into desired concentration and filtered. This is called green liquor mostly containing sodium carbonate. In causticizing section this solution of sodium carbonate will be double decomposed with calcium hydroxide, wherein calcium carbonate settles down as a precipitate and the supernatent liquid is sodium hydroxide, regenerated. This will be reused in the digestion system. Since this liquor will be recycled, it is essential to see that this is clear as possible. Otherwise due to the high hydration nature of bagasse pulp, the particles of calcium carbonate adhere to the fibre and create sizing problem and hence the quality of paper will be poor.

After the unbleached pulp is washed thoroughly it has to be screened for uncooked shives and foreign material if any. As sugar cane is collected from the fields, there will be lot of silica adhering to it, which will be carried forward from the cooking and washing stages. Therefore sand traps are to be provided before screening, otherwise centricleaners will be affected. Since bagasse pulp is highly soft in nature too much of agitation at different stages of storage has to be avoided. Otherwise it further gets hydrated and more fines will be created.

In order to avoid this high density storage is preferred over the horizontal chest. In the horizontal chests the pulp will be at about 4 per cent consistency and the entire mass is circulated and agitated in the chests. Whereas in high density storage towers pulp will be at 10 to 15% consistency in 3/4 the tower and only the bottom portion gets agitated which will be dilute. Since bagasse pulp is very tender, it requires a careful treatment while bleaching. Any drastic bleaching measures will deteriorate the quality of pulp badly. Normally for bagasse pulp, bleaching sequence of chlorination, caustic extraction and hypochlorite (C.E.H. process) is sufficient and can obtain 82 to 85° GE brightness. Due to the slow drainage of the pulp, the bleach plant washers have to be designed with larger surface areas. The loading factors may be same as that of brown washers. It is preferable to have bleaching in high density towers of downward flow rather than low consistency upward flow type of towers except in chlorination stage. At chlorination stage it is our experience, that injection of chlorine gas and water through a disperser gives a thorough mixing with the pulp. By this method it is possible to use 60 to 65% of the total chlorine demand in the gaseous stage.

A good instrumentation system like pH indicator recorder, oxidation reduction potentiometer (O R P), temperature controller recorder, flow meter recorder controller for pulp and chemicals, with level indicators are absolutely essential to have a quality end product. Since chlorine has got a high affinity for lignin in the pulp, if arrangements are made for thorough mixing, for bagasse pulp of about 10-11 K.No, about 30 to 40 minutes retention time, at the chlorination stage, about one hour in the caustic extraction stage and about 1½ hours to 2 hours at the hypo stage is more than sufficient to get about 82°GE pulp. (Misra D.K.) [7]

It is said that paper is made in the stock preparation section. Since bagasse pulp is highly hydrated fibre by nature and contains almost 25% fines passing through 1°0 mesh, it is desirable to have less cutting action and moderate refining. Higher horse power is not required. It is preferable to have either disc refiners or wide angle refiners with broader bar width rather than conventional conical refiners with bars of narrow width. Care should be taken, not to cut the fibre any more by excess jordaning.

Centricleaning system after preparing the stock is a must to have clean paper.

At the paper machine, the following parameters have to be taken into consideration to have smooth runnability. (Misra D.K.) [8]

Since the fibre is very light in nature, it has a tendency to floculate and accumulate at corners and has a quick tendency to form slime. As such distribution roll in the machine headbox, lump breaker rolls on the couch and suction pick up arran-

gements are suggested due to the low wet web strength properties of the pulp.

Due to the nature of bagasse pulp, as it contains more fines, it has a tendency to clog the wire. As such high pressure water showers upto 300 lbs/sq. inch are required at the return of the wire to keep it clean. Due to the slow drainage nature of the pulp longer wire lengths are preferred. It is better to avoid high vacuum at the wet stage which causes the double sidedness of the paper. It is better to use felts of more open in nature at the presses with good felt cleaning system. Even with three presses, it is difficult to reduce the moisture to less than 65% before entering the dryers due to the nature of the pulp. Therefore it is perferable to have more number of groups with smaller sections at the drier stage. The shrinkage in paper is about 8 to 10% from wet to dry stage which has to be well taken care of in the design of the paper machine.

In Mandya National Paper Mills, we are using 90 to 95% bagasse pulp in the paper furnish, to produce good quality, writing, printing and other cultural varieties of paper. However if some special quality paper has to be made, 10 to 15% long fibred pulp has to be used in admixture with the bagasse pulp to have smooth run and sustained production. If all the factors that have been mentioned above in the design of the equipments are taken care of, it is possible to exploit this potential raw material for making quality paper and to meet the growing demand of the Nation.

I am grateful to my Management for permitting me to publish this article.

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