# Modern Bagasse Handling and Storage Practices

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ABSTRACT

Bagasse is the fibrous residue left, after sugarcane is crushed in rhe sugar factories for extracting its juice. The chemical composition and physical characteristics of bagasse very much depend upon many factors. But the sugar, moisture and pith content of bagasse play a dominant role on the keeping qualities of bagasse during its long storage

All the constituents of bagasse excepting its moisture content, are combustibles and as such, bagasse is used as captive fuel in the sugar factory boilers for raising steam required to generate motive, electric and heating power in the sugar factories. As the bagasse is consumed in the sugar factories simultaneously with its production, normally no storage is necessary. Bagasse is carried from the million plant directly to the boilers on a slat type of conveyer. The excess bagasse is either heaped up outside the factory or pressed into bales for use in the next season or sold to the pulp and paper units.

When bagasse is supplied from the sugar factories to the pulp and paper factories it is usually depithed at the sugar factory site to some extent compressed into bales and transported to the paper factories in trucks trailers and railway wagons The pith so separated, is also used as fuel in the sugar factory boilers. Transport of loose bagasse over short distances, is also common. After reaching the paper factories sites, usually a second depithing adopting wet depithing technique, is conducted to remove as much pith as possible, due to the reason that pith interferes in the manufacture of good quality paper and hence, it has to be eliminated.

After depithing, storage of bagasse at the paper factory's site is done either in the form of bales or loose bagasse and to a major extent, by adopting wet bulk storage methods. Of all these methods, a special mention has to be made about the "Ritter Biological Process" and different modifications of this process, which are quite commonly adopted in big bagasse based paper plants working in different countries.

Modern practies for handling and storage of bagasse, are explained in this article.

Due to fast depletion of the traditional fibrous raw materials like wood, bamboo etc., used in the pulp and paper industry throughout the world and also the restrictions being imposed by the different national Governments to keep up ecological balance by arresting indiscriminate felling of wood in the forests, more and more dependence has to be laid on agricultural residues, as raw materials for the manufacture of pulp and paper. Of all these agricultural residues, bagasse holds a big promise, due to various reasons. Bagasse is a renewable source of fibrous raw material, as sugarcane is normally a 12-month crop and can be grown year after year for centuries together.

Sugarcane is grown in many countries, but sugar is produced from sugarcane in 80 countries of the world. Thus, in as many as 80 countries of the world, bagasse is available, in case ways & means can be introduced for diverting bagasse for the manufacture of pulp and paper. India is one of the major producers of sugarcane in the world. Sugarcane was born in India hundreds of years ago and till recently, India was the worl's largest producer of sugarcane of the order of 190 million tonnes per annum. Very recently, Brazil has emerged as a larger producer of sugercane, surpassing the production of sugarcane in India, as it is used in Brazil for the production of not only sugar, but also for the productiou of alcohol to be used as automotive fuel. Sugarcane is grown in almost all the States & Union Territories of India, but at present 367 sugar factories are working in 16 States and 2 Union Territories of India. 29 more new sugar factories are under various stages of establishment.

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The approximate production of bagasse is one third (33.3%) on the total sugarcane crushed in the sugar factories, though it varies to some extent from State to State, depending on the variety of sugarcane crushed and other factors. The total quantity of sugarcane crushed in the sugar factories of different States/ Union Territories of India and the approximate calculated quantity of bagasse produced (on the basis of the average production of bagasse % cane in the different States of India) during the last 4 years, are shown in Table No. 1.

A peculiar feature of the Indian sugar industry is that out of the total sugarcane grown in the country, only about one third (33.3%) is crushed in the sugar factories to produce sugar and as much as 55% of the cane is used for the manufacture of gur & khandsari and the balance 12% is used for seed and chewing purposes. Hence the bagasse production figures indicated in Table No. 1, are only in respect of the 1/3rd of the total sugarcane grown in India. No other country in the world, has such a large gur & khandsari industry as that existing in India and thus a large quantity of bagasse produced in the gur & khandsari industries also, is used as captive fuel at present.

Bagasse is a captive fuel in the sugar factories boilers for raising steam required to generate motive power for driving the various prime movers, electric power and for concentrating the sugarcane juice. This practice of using bagasse as captive fuel, is not only adopted in Indian sugar factories, but in all the cane sugar factories of the world. There are many reasons for adopting this practice from the very inception of the cane

TABLE—1

| S. No. | STATE/UT | No. of Working Facts in | CANE CRUSHED (Lakh tonnes) | | | | BAGASSE PRODUCED (Lakh tonnes) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 84-85 | 81-82 | 82-83 | 83-84 | 84-85 | 81-82 | 82-83 | 83-84 | 84-85 |
| 1. | A.P. | 30 | 63.20 | 56.62 | 30.54 | 37.74 | 20.83 | 17.91 | 9.69 | 12.19 |
| 2. | Assam | 2 | 1.45 | 1.21 | 0.60 | 0.37 | 0.49 | 0.42 | 0.19 | 0.12 |
| 3. | Goa | 1 | 1.20 | 1.06 | 0.79 | 0 80 | 0 38 | 0 37 | 0.25 | 0.27 |
| 4. | Gujarat | 12 | 54.61 | 49.45 | 37.24 | 37.17 | 16.38 | 14.99 | 11.10 | 11.39 |
| 5. | Haryana | 8 | 20.08 | 19.25 | 18.93 | 14.67 | 36.13 | 5.80 | 5.88 | 4.55 |
| 6. | Karnataka | 24 | 64.23 | 61.61 | 37.61 | 42.38 | 21.79 | 21 01 | 12 67 | 14 24 |
| 7. | Kerala | 2 | 2.07 | 2.20 | 1.31 | 0.90 | 0.66 | 0.69 | 0.41 | 0 27 |
| 8. | M.P. | 8 | 6.51 | 7.81 | 7.80 | 5.48 | 2.01 | 2.40 | 2.38 | 1.69 |
| 9. | Maharashtra | 87 | 282 92 | 276.25 | 179.04 | 209.54 | 88.19 | 87 68 | 56.18 | 65.27 |
| 10. | Nagaland | 1 | 0.73 | 0.81 | 0.43 | 0.25 | 0.26 | 0.28 | 0.14 | 0.08 |
| 11. | Orissa | 3 | 2.60 | 3.02 | 1.84 | 1.51 | 0.77 | 1.03 | 0.56 | 0.47 |
| 12. | Punjab | 2 | 15.34 | 14.17 | 13.96 | 13.39 | 4.81 | 4.27 | 4.11 | 4.19 |
| 13. | Pondicherry | 2 | 2.89 | 2.85 | 2.10 | 3.09 | 0.96 | 0.89 | 0.60 | 0.97 |
| 14. | Rajasthan | 3 | 2.50 | 2.60 | 2.43 | 1.97 | 0.82 | 0.89 | 0.70 | 0.63 |
| 15. | T.N. | 23 | 85.88 | 72.02 | 45.64 | 62.88 | 28.61 | 25.58 | 13.16 | 19.03 |
| 16. | U.P. | 98 | 227.89 | 210.43 | 185.15 | 150.99 | 81.03 | 71.98 | 61.69 | 47.97 |
| 17. | West Beng. | 3 | 1.14 | 1.08 | 0.24 | 0.08 | 0.40 | 0.37 | 0.08 | 0.02 |
| 18. | Bihar | 24 | 38.18 | 44.53 | 24.59 | 15.21 | 13.50 | 15.23 | 8.19 | 4.83 |
| | Total | 333 | 873.42 | 826.97 | 590.24 | 597.41 | 287.42 | 271.79 | 87.98 | 188.18 |

sugar industry in the world, but the main reason is that in an agro-based seasonal industry like sugar industry dealing with highly perishable raw material and intermediate products, it is not advisable to depend on extraneous fuels, which are expensive and whose supply position is not sure in some countries, and part with the readily available fuel i.e. bagasse.

In cane sugar producing countries like Mexico, Argentina, Peru, Cuba etc., where the supply position of alternate fuels like natural gas, furnace oil is abundant and at very low prices, clusters of sugar factories have substituted bagasse by the alternate fuels and established big bagasse-based paper plants. Similarly, in other countries like South Africa, Taiwan, Indonesia, India, Pakistan, Egypt etc., bassage has been substituted by other fuels, including coal. A noteworthy feature of the Indian Sugar Industry is its high thermal efficiency by virtue of which, some sugar factories are able to save large quantities of bagasse in spite of using it as captive fuel. Based on the saved or surplus bagasse, some of the sugar factories have already established small paper plants with a daily production capacity of 25 tonnes attached to sugar factories. Such plants have many advantages. Some more plants of this type are being established. Some sugar factories, which save bagasse, but do not have any paper plant attached to them, are selling their baggasse to the nearby paper factories.

## COMPOSITION OF BAGASSE :

Bagasse is the fibrous residue left over after sugarcane is crushed in the sugar factories milling plants for extracting its juice. As it comes out of the milling plant, bagasse contains about 50% moisture and is known as "mill-wet bagasse", and in a few countries as "green bagasse."

The composition of bagasse has some relevance to its keeping qualities during its long storage and its subsequent use as fibrous raw material in the manufacture of pulp and paper. Therefore, the composition of the mill-wet bagasse and bone-dry baggasse is indicated here. Though, the chemical composition of bagasse depends on many factors like the variety of sugarcane, agricultural inputs used for growing cane etc., the approximate composition of mill-wet bagasse, is as follows :—

| | |
|---|---|
| 1. Moisture | 50.0% |
| 2. Fibre/pith | 47.0% |
| 3. Sugar | 2.5% |
| 4. Insolubles (ash) | 0.5% |

All the above constituents of mill-wet bagasse with the exception of moisture, are combustible and, as such, bagasse is used as fuel in the sugar factories. Its calorific value is about 3900 b.t.u. per lb (1920 K. Cal per Kg.). When mill-wet bagasse is dried to reduce its moisture content from 50% to about 35%, its clorific value increases to a bout 4500 b.t.u. per lb by which less bagasse is sufficient as fuel and more bagasse can be saved for pulp and paper industry.

The approximate composition of bone-dry bagasse is as follows :

| | |
|---|---|
| 1. Cellulose | 45.0% |
| 2. Pentosans | 24.0% |
| 3. Lignin | 20.0% |
| 4. Sugar | 5.0% |
| 5. Ash | 1.0 % |

The physical characteristics of bagasse depend on many factors, out of which the important factor is the practice adopted in the sugar factories for preparation of cane (cutting into pieces) and milling of cane to extract the juice. In the present day milling plants which are using fibrizers, shrodders and similar equipment for preparation of cane (unlike the action of earlier equipment like cane knives for cutting the sugarcane into pieces), the sugarcane is torn iuto long fibres of about 2 to 4", which improves the mill performance in the sugar factories for extracting as much sugar as contained in cane. Incidentally, such long fibres in the bagasse with the sugar completely deprived, is ideal for paper industry.

## HANDLING OF BAGASSE :

As indicated earlier, all the cane sugar factories in the world use bagasse as captive fuel in the sugar factory boilers. Therefore, the mill-wet bagasse is conveyed on a slat type of conveyer directly from the milling plant to the boilers and fed into the furnace through rotary feeders, which arrest the entry of too

much air into the furnace. In order to burn the mill-wet bagasse containing about 50% moisture, the sugar factory boilers are provided with special types of furnaces known as "Step-Grate" Furnance, "Ward" Furnance, "Horse Shoe" Furnance, "Eisner" Furnance, "Spreader-Stoker" Furnace etc., wherein before the bagasse catches fire, the moisture content is driven out as far as possible.

In the recent years, many sugar factories in India, have improved their thermal efficiency by adopting various energy conservation measures and have reduced the consumption of bagasse, as fuel. By this, these fa tories are able to save a portion of the bagasse even after using it as captive fuel. In such factories, the surplus bagasse is conveyed on a specially designed "Return Carrier" from the Boiler House to outside area of the factory and heaped up. Whenever the bagasse production in the sugar factory is reduced due to low crushing or any break down in the plant, the surplus bagasse heaped up in the open yard, is carried back into the factory by means of the Return Carrier and fed to the boilers. By exposing the mill-wet bagasse to the ambient air in the open yard, particularly on the sunny days, the bagasse is partially dried and thereby the calorific value of bagasse is increased to some extent. In countries like Australia, Cuba etc., the sugar factories have a separate covered shed, known as "Bagasse House" to store the surplus bagasse and feed back the bagasse either to the sugar factory or sell it to outside users. In such cases, there is an elaborate system of bagasse carriers, front end loaders, transport vehicles etc., which would mean very heavy investment.

Some sugar factories in Philippines, Hawaii etc., have installed Bagasse driers for increasing the calorific value by partial drying thereby saving bagasse.

When there is a nominal saving of bagasse, the sugar factories usually store it in the form of loose bagasse. But, lot of bagasse is likely to be lost by wind etc. When the quantity of bagasse saved by the sugar factories is considerably high, the sugar factories instal bagasse baling equipment to bale the surplus bagasse. Normally, the sugar factories use MS wire for binding the bales, but at times of shortage of such wire, they even use coir rope also. Incidentally, the use of coir rope, is preferred when the bagasse bales are sold to the paper factories, as the presence of coir rope does not pose any problem in pulping of bagasse, as posed in the case of MS wire. The sugar factories, which save small quantities of bagasse, normally store it either in the loose form or in the shape of bales for use during the off-season to raise the steam required for the ancilliary industries like distillery or use it at the beginning of the next crushing season. It is only in the case of sugar factories which save large quantities of bagasse that the question of densification or compaction or baling arises to ensure economical transport of bagasse to the paper factories, which are usually far away. In case the paper factory and sugar factory are located adjacent to each, it is very advantageous, as baling and transport of bagasse can be avoided and bagasse can simply be conveyed from the sugar factory compund to the paper factory compund on belt conveyers or by pneumatic conveyers. This would be an ideal method, as experience of the experts in many bagasse based paper plants has shown that the incidence of transport expenses on bagasse and the complicated procedure involved therein, are mainly responsible for the high production cost of bagasse based paper.

## DEPITHING OF BAGASSE :

Sugarcane has a hard rind, which has a very good fibre value. Inside the rind is the pith, which is the white non-fibrous parenchyma cells portion of the cane in which the juice is stored. When sugarcane is crushed in the milling plant for extracting the juice, the rind as well as the pith of sugarcane are pressed and this residue is known as bagasse. In fact, bagasse consists of the real fibre portion of the sugarcane rind with the adhering pith, which has no fibre value. According to the experts, the Gross Calorific Value of the pith is about 93% of the whole bagasse. While pith has a fuel value, it has no fibre value and as such, pith is advantageous to sugar factories for using as fuel, whereas it is not required by the paper factories for using as fibrous raw material. Pith forms as much as 30% on the weight of dry bagasse. When bagasse is used as fibrous raw material for the paper industry, pith has to be removed as completely as possible due to the following reasons :

(1) Transport of full bagasse with as much as 30% pith from sugar factories to paper factories, would mean increasing the incidence of transport cost unnecessarily on material, which has no fibre value and thereby, increasing the cost of production of paper.

(2) While pith is not useful to the paper factories, it is useful to sugar factories as fuel and hence, it is advantageous to depith bagasse at the sugar factory site, rather than at paper factory site.

(3) The presence of pith in the bagasse increase the requirement of chemicals during cooking, thereby increasing the cost of production of paper.

(4) Pith includes large quantities of dirt and as a result, requires more bleaching chemicals. In spite of this, pith particles appear on white paper as dark spots.

(5) The presence of pith reduce the drainage of water on the pulp washers and on the paper machine, thereby resulting in reduced speed of paper machine and low production.

(6) The presence of pith in the pulp causes press stickiness on the paper machine.

(7) Pith reduces the strength of paper.

Due to the above reasons, the experience of experts in many bagase-based paper plants throughout the world, has shown that for producing good quality paper and reducing the cost of production of bagasse based paper, it is very essential to remove as much pith as possible from the bagasse. But, any attempt to remove the pith completely, is also dangerous, as there is a possibility of removing the adhering fibre also, thereby reducing the yield of pulp from bagasse.

The usual depithing methods adopted are as follows :

(1) Moist depithing

(2) Dry depithing

(3) Wet depithing

There are many types of dipthers like "Horkel", "Peadco", "Gunkel", "Rietz", "SPM", "Revinco", "Belloits", "Kimberly-Clark" etc. But, the principle of working of the different types of depithers developed so far is, more or less the same. All these depithers are some sort of hammer mills, which beat the bagasse by which the adhering pith is loosened and removed either by screening or by washing with large quantities of water. Pith particles are much smaller than fibre particles and hence, the pith particles pass out through screen. The 3 methods of depithing are explained below, briefly :—

(1) MOIST DEPITHING :

As the mill-wet bagasse coming out of the milling plant in the sugar factories contains about 50% moisture, this method of moist depithing is usually adopted at the sugar factory site alone. This method has an advantage due to the fact that the pith so separated, can be used advantageously as fuel in the sugar factory boilers. Briqueting of pith using some kind of binding material, has been tried in some sugar factories, but provided to be uneconomical. Hence, usually loose pith is burnt in the sugar factory boilers. By adopting such a method of depithing, the residual sugar in the depithed bagasse remains as such, which is not desirable.

In the Kedawung Sugar Factory located near Surabaya in Indonesia, the bagasse is transported on belt conveyer to the adjoining compound where, by means of a set of 3 depithers, moist depithing is carried out to remove a portion of the pith. The pith so separated is conveyed by another set of belt conveyers to a 50 tonnes oil fired boiler, wherein pith is also used as fuel. The depithed bagasse is loaded by front-end loaders into special type of covered railway wagons and transported to the paper factory–Perusahan Negara Letjes, located 60 KMs away from this sugar factory. This paper factory produces 116,200 tonnes of writing, printing, and tissue papers and 90,000 tonnes of newsprint per annum based on bagasse and rice straw.

Similarly, the paper factory known as "Sociedad Paramonga Ltd.", located at Lima in Peru, producing about 450 tonnes of different kinds of paper per day is situated in the adjoining campus of a sugar factory. The major supplies of bagasse required in this paper factory, are obtained from the adjoining sugar factory on a set of belt conveyers. A set of 3 depithers remove the pith by moist depithing method and the pith is carried back to the sugar factory boilers.

This practice is common in other bagasse based paper plants like Pars Papers in Iran, Pingtung Paper Factory in Taiwan etc., which are attached to sugar

factories. In other paper factories which are located far away from the sugar factories supplying bagasse, like the Kimberly-Clark de Mexico (KCM), the factory operates at its own expense depithing plants at different sugar factories and bring the depithed bagasse in trucks. When the sugar factory is nearby, the depithed bagasse is usually transported in loose form and when it is far away, the depithed bagasse is usually densified by using hydraulic presses and transported to the paper factory. Similar method is also being adopted by the Tamil Nadu Newsprints Ltd. located at Pugalur in Tamil Nadu, which gets bagasse supplies from 5 sugar factories located at distances varying from 6 KMs to 95KMs away from the paper factory.

(2) DRY DEPITHING :

When bagasse is stored at the paper factory site, part of its moisture is removed by solar drying. The pith can be removed from dried bagasse by simple screening making use of either rotating screens or vibrating screens. This type of depithing is normally done at the paper factory site, where bagasse is usually stored. But, by adopting this process, the removal of the pith is only partial and, as such, this method is not adopted in big paper factories. However, in the case of small bagasse based paper mills, this method is simple and economical. This method has also the dis-advantages of creating lot of dust, which is injurious to health and the sugar content of depithed bagasse remains as such, which is not desirable.

(3) WET DEPITHING :

This method is usually adopted at the big bagasse-based paper factory site. In this method, the bagasse is fed into a Hydra-Pulper, which has a powerful agitator. Lot of water is added to the bagasse in the Hydra-Pulper to make it into a slurry and churned. In this process, the residual sugar in bagasse, is completely removed as it is washed away with large quantities of water. By this, foaming during the cooking process, is avoided. The slurry of bagasse is then fed to special type of depithing machines in which the pith is beaten by the hammers and pass out through the screens along with large quantities of water. This water removes all kinds of other dirt, suspended impurities, as well as dissolved sugar. Therefore, the depithed fibre obtained in this method, is quite clean. This method also eliminates the problem of dust creation. However, this method requires large quantities of water and, as a result, the water has to be recirculated.

PITH REMOVAL BY CHEMICAL METHODS :

It would be interesting to know that some paper experts believe that it is dangerous to try to remove the pith completely to make excellent quality papers, as there is a possibility of losing a portion of the good fibre also along with pith. On the other hand, they are of opinion that after removing the pith, as far as possible by mechanical methods, it would be advisable to remove the balance portion of the pith by chemical methods during the cooking of pulp and recover the chemical.

For instance, the world renowned bagasse based paper plant i.e. Scott Paper Company, San Cristobal (Mexico) is noted for its excellent quality tissues and receives partially depith bagasse in the form of bales from the nearby sugar factories. The bales are broken on a carrier by manual labour during which the binding wire is removed. After passing through a set of powerful magnets to remove any binding wire, the bagasse is washed with large quantities of water in screw conveyers, which have perforated bottoms. A portion of the pith is also washed away in this way and the partially depithed bagasse is impregnated with the chemical liquor and cooked. It is learnt that a much higher percentage of caustic soda is used by which the remaining portion of the pith is dissolved. This factory makes different types of excellent quality tissues, which are world renowned as "Scott Tissues" with different brand names. The experts in this factory believe that this method would be very economical, as the extra chemicals used can be recovered in the chemical recovery system. A few other factories also adopt this technology.

STORAGE OF BAGASSE :

As sugar factories normally work for about 3 to 6 months in many countries with the exception of Hawaii and Peru where they work for 9 to 11 months, and the paper factories work round the year, it is essential to store bagasse at the paper factories site after transporting it from sugar factories during the crushing season. As indicated earlier, the sugar, moisture and pith con-

tent of whole bagasse, plays a dominant role on the keeping qualities of bagasse during its long storage at the paper factory site. Residual sugar content of bagasse in the presence of moisture, is responsible for fermentation due to the action of natural enzymes and bacteria. As a result of fermentation, the temperature of bagasse increases leading to partial deterioration and darkening of bagasse. Fungus growth also takes place on the surface of bagasse particles. Acid formed during this fermentation lowers the pH of bagasse. A combination of high temperature and acidity, results in hydrolysis of the cellulose contained in bagasse and ultimately lead to low yield of pulp. To get over these disadvantages, the following steps are necessary :—

(1) Reduce the sugar content of bagasse by all possible means, such as depithing as far as possible to eliminate the pith and its sugar content and wash the depithed bagasse with large quantities of water to eliminate the sugar content therein.

(2) Store bagasse in such a way as to aeriate the bagasse bales to reduce development of high temperature in the bales. Storage of loose bagasse in a heap without any treatment of bagasse with liquid is not advisable.

The above 2 objectives can be achieved by storing bagasse in the following manner :—

## STORAGE OF BAGASSE IN BALES :

Storage of bagasse in the form of bales, is the oldest method adopted by the sugar factories, as well as paper factories since the year 1920 when this method was introduced and developed by the Celotex Corporation in Lousiana. In countries, where there is shortage of manual labour, large bales of even 750 Kgs each are made and handled completely by mechanical equipment. But in actual practice, it has been observed that in such large bales, the deterioration of bagasse is more pronounced due to the compactness of bagasse and less aeriation. On the other hand, almost all the developing countries where there is no dearth of manual labour, adopt the system of making small bales of 15 to 30 Kg each, which can be easily carried by manual labour and heaped up in a pyramid fashion with openings in between the bales. By this method the deterioration of bagasse is less pronounced due to more aeriation.

The bagasse based paper plants like the Mandya National Paper Mills Ltd., in Karnataka, the Kimberley-Clark de-Mexico at Orizaba in Mexico and many other plants adopt this method of storing bagasse in the form of bales. Some factories have even introduced the techniques of making the bales with openings like the hollow bricks.

## WET BULK STORAGE OF BAGASSE :

Of all the wet processes of bulk storage of bagasse "Ritter Biological Process", is the most common one, as this process or modifications of this process, are adopted in many bagasse based big paper plants of the world. This process was originally developed by E.A. Ritter in South Africa. While adopting this process, bagasse is partially depithed at the sugar factory site and the partially depithed bagasse is transported to the paper factory site either in the loose way or compacted or baled. At the paper factory site, this bagasse is churned with large quantities of Biological Liquid to make it into a slurry. In the original Ritter Process, the biological fluid used was a thin solution of molasses with 2.5% concentration and containing lactic acid bacteria. The action of the lactic acid producing micro-organism is to preserve the fibre content of bagasse. The biological fluid softens the pith adhering to the fibre and allows easy removal of the pith during the subsequent final depithing operation.

The slurry of bagasse in the biological fluid is pumped to a distribution channel located at an elevated place and from there fed on to a cemented sloping storage yard, when the bagasse is heaped up, draining out the biological fluid. This flooring is provided with many drainage channels through which the excess biological fluid flows out, collected in a pond and re-circulated. During this re-circulation, more and more sugar is washed out from the depithed bagasse and the biological fluid gets enriched with sugar and lactic acid producing micro-organisms.

In the bagasse-based paper factories, which are adopting this process, many modifications have been brought about based on their own R & D work. For

instance, the concentration of molasses in the biological fluid varies from 2.0 to 8.0%. In some factories, even simple water is used with advantage, as they feel that the water washes out the sugar content of depithed bagasse and, as such, there is no need to add molasses. In some other factories, they do not reveal the composition of biological fluid and keep it as a secret. However, the principle adopted in all these methods, is more or less the same and many advantages are claimed by adopting this process. Some of the advantages are as follows :—

(1) As this process is a wet process, the problems of pollution by dust and fire hazard are completely eliminated.

(2) Large quantities of bagasse can be stored in a small area, as compared to the area required for storing equivalent quantity of bagasse, when stored in the shape of bales.

(3) The pith is softened by the biological fluid and easily removed by simple depithing methods or even washing with water jets.

(4) The quality of the cellulose in depithed bagasse is preserved over a long storage period by using biological fluids.

(5) The use of baling wire, which poses problem in pulping, is climinated and manual labour is also not necessary for adopting this method.

(6) Depithed bagasse treated in this manner, requires less chemicals for cooking and bleaching.

(7) Cooking liquor is easily and uniformly impregnated in the wet bagasse and thereby result in uniform cooked pulp, as compared to pulp produced from dry bagasse.

The Ritter Biological Process or Modifications of this process, are adopted in many bagasse-based paper plants of the world. Some of these are briefly explained in the following paragraphs :—

LEDESMA S.A. AGRICOLA INDUSTRIAL, ARGENTINA :

Ledesma plant is operating the largest and most sophisticated bulk storage system based on Ritter Biological Process. The storage construction was personally supervised by late Dr. E.A. Ritter. The entire system was supplied by P.W.A. Group of West Germany.

In Argentina the sugarcane crushing season is only for 4 months and hence, bagasse has to be stored at this plant for about 8 months in a year. The storage slab has an area of 340,000 sq. ft. made of concrete, covered with a polymar compound (Epoxy resin) to preserve the concrete from deterioration due to the corrosive action of the liquor. The experts at this plant are of the opinion that due to the mild action of the acid produced during storage of bagasse, pre-hydrolysis of fibre takes place, which dissolves some of the pentasons and also permit the removal of a large amount of pith from the fibre.

The Ritter Biological Liquor, which is the main secret of this operation, is received from Germany and further developed at the mill. This liquor is a type of lactic acid with a pH of 4.0 and does not admit tne natural fermentation of bagasse, thus preserving the fibre from degradation. At the Ledesma plant 70,000 tonnes of depithed bagasse (on bone-dry basis) is stored every year on a concrete slab of 25 cms thick, $100 \times 300$ Mtrs. surface.

CUBA-9 EXPERIMENTAL PAPER PLANT, QUIVICAN, CUBA :

The 35 tonnes Cuba-9 Experimental Paper Plant based on bagasse, is located by the side of a sugar factory known as "Central Pablo Noriega" at Quivican. This sugar factory makes use of furnace oil in the Boilers and conveys its entire bagasse (after depitting) on a belt conveyer to the adjoining paper plant. At the paper factory, the depithed bagasse is treated with Biological liquid in a masonary tank and pumped to the distribution channels located over the concrete storage slab. From the distribution channel, the slurry of bagasse is loaded on to the concrete slab wherever there is space. The Biological fluid is drained out and re-circulated. The factory staff, during the visit of the author mentioned that this Biological fluid is their own composition developed after constant R & D work.

KIMBERLY-CLARK De-MEXICO, ORIZABA (MEXICO) :

This factory obtains its bagasse supplies in specially built trailors from a nearby factory i e San Miguelito, which is just 13 miles away and another factory i.e. La Margarita, which is 50 miles away. The paper

factory has installed its own depithing plants at the sugar factories sites and the pith is burnt in the sugar factories boilers. The depithed bagasse is simply compacted hydraulically and transported to the paper factory.

At the paper factory site, the depithed bagasse bales are dumped on a slab in the bagasse receiving area and pushed by a tractor into a slat conveyor and moved to 2 receiving water slurry tanks, which are mechanically agitated. Biological liquor is pumped into these tanks providing a preserving effect along with enzyme action which starts to free the fibre from gums, waxes, pectin and sugar. By this, the fibre does not deteriorate very much during storage. Consistency is controlled, as the slurry is pumped to the outside bagasse storage piles by 2 open impeller pumps.

Bagasse piles are built up on a sloped, paved storage yard. The excess liquor drains off the piles into a canal returning it to a large plastic coated bricklined storage pit, ready for re-use. Both the pile area and transmission pipes are designed so as to be extended easily to handle double the capacity.

Bull-dozers operate on the top of the pile to push the bagasse down to the ground level. The front-end loaders scoop out the bagasse from the dump into large mixing tanks loacated in the centre of the storage yard. From the large mixing tanks, bagasse is pumped for further processing.

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In this plant, bagasse is received from 5 sugar factories located at a distance of 6 KMs to 95 KMs. In respect of 2 factories, which are located at a distance of 6 KMs and 25 KMs, bagasse is received in trucks in loose form. In respect of the remaining 3 sugar factories, which are located far away, bagasse is compacted and received in trucks.

After depithing of bagasse, as explained earlier, the depithed bagasse is carried on a belt conveyer to the storage yard. From there, it is fed to the Boom Stacker, which consists of a belt conveyer to take the bagasse to the end of the arm and below the arm mixed together in the funnel located at the end of the arm. The arm is raised or lowered and turned in any direction to dump the bagasse on the concrete floorings wherever space is avilable. There are 2 arms of this type for the Boom Stacker to store the bagasse mixed with water on the storage yard, which is of 540 Mtrs × 90 Mtrs on each side of the Boom Stacker. On this large storage yard, they can store 3 lakh tonnes of bagasse.

The moist bagasse stored in the yard is loaded on to a conveyer by means of a front-end loader and taken for further processing. The water collected in the channels of cement storage lab is re-circulated.

SUMMARY :

Bagasse is a promising raw material in India for the pulp and paper industry. The sugar factories and paper factories should enter into suitable agreements to make use of bagasse in more and more quantities for the production of pulp and paper. As the incidence of freight on the transport of bagasse is the main high cost component in the manufacture of bagasse based paper, all possible efforts should be made to locate the bagasse based paper plants in the proximity of a cluster of sugar factories.

Preferably preliminary depithing of bagasse should be made at the factory site and the pith should be used as fuel in the boilers. The depithed bagasse should be transported either in the form of bales or after simple compaction to the paper factories, but not in loose form.

Storage of bagasse at the paper factory site should preferably be done after depithing and by adopting wet storage methods like the Ritter Biological Process or modifications of this process.

The above methods of handling, transport and storage of bagasse are based on the experience gained by the experts already involved in the manufacture of paper from bagasse. Adoption of these techniques would go a long way to make the bagasse based paper factories financially viable, reduce the cost of production of paper and convert successfully the agricultural residue like bagasse into value added product like papers of different kind. This will improve the prosperity of the sugar industry as well as the paper industry and the country as a whole.

REFERENCE :

1. Albert W. Wilson — Bagasse Pulping in Remote Argentina (Pulp & Paper International—Feb. 1971)