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on the Production of Panels
from Agricultural Wastes

Vienna, Austria, 14 - 18 December 1970

TECHNICAL AND ECONOMIC ASPECTS OF BAGASSE UTILIZATION[1]

by

M. H. Tantawi
Director
Société des Sucreries
et Distilleries d'Egypte

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SUMMARY

TECHNICAL AND ECONOMIC ASPECTS OF BAGASSE UTILIZATION 1/

by

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The cane sugar industry, which is concentrated in countries short of wood resources, produces considerable quantities of a ligno-cellulosic material which has proved to be quite suitable for panel and paper manufacture.

Interest has been centred on sugar cane bagasse because it is an industrial by-product of relatively low value, especially in countries where the fibre content of the cane is higher than 15% and because it is generally produced in countries and regions of the world which are short of wood resources.

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The mill-run bagasse contains a large fraction (25 - 30%) of a non-fibrous material, the pith, which must be removed.

Moist depithing of the mill-run bagasse is the most appropriate system as it solves the problem of pith disposal by using it as fuel at the steam generating plant of the sugar factory. Excessive disintegration of the sugar cane prior to sugar extraction would give a high proportion of fine fibres which will be separated together with the pith. Such highly disintegrated bagasse would also give lower value panels.

A panel mill should be planned to run all the year round on stored bagasse in order to avoid excessive capital cost, social problems resulting from a seasonal industry, the problems of storing huge stocks of panels, and the difficulties of establishing an appropriate programme of production to face the actual needs of the markets

Natural drying of bagasse during storage is the only applicable system as artificial drying would give rise to many technical and economical problems.

Transport problems of bagasse from the sugar factory to the panel mill could be reduced to a minimum if the panel mill is built next to the sugar factory.

If bagasse is to be processed into particle board, it should be baled and stored in open stacks and left to dry until its moisture content drops to ± 15 %. The latest innovation in bulk storage in the dry state looks very appealing from both technical and economical points of view, provided that it results in appropriate drying of the bagasse. In case the bagasse is processed into hardboard or other types using moulding, the wet bulk storage system would be the most appropriate.

When adopting the storage system of baled bagasse, great care should be taken with regard to the way of building the stacks, with sufficient air gaps between the bales to preserve the bagasse against discoloration and decay due to destructive fermentation. Great attention should also be paid in providing a fire-fighting system.

Bagasse is not a cheap raw material; its fuel replacement value and baling cost are the main items of its cost. However, if the panel mill is a complementary plant to a sugar factory where surplus of bagasse is available, the economical picture would be completely different. Bulk storage would also contribute to some extent in cutting down the cost of the raw material.

Before processing the dried bagasse into particle board, the last pith fraction should be separated by pneumatic classification or sifting.

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TECHNICAL AND ECONOMIC ASPECTS OF BAGASSE UTILIZATION

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Corrigendum

Page 8, para. 4 (item 3, line 1)

Delete: "100,000".

Insert the following: "60,000".

Page 13, line 11

Delete: "reduced by 20%".

Substitute the following: "reduced by a further 2%".

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Corrigendum

Page 8, para. 4 (item 3, line 1)

Delete: "60,000", as quoted in Corrigendum 1.

Insert: the figure "100,000", which is correct, as in the original paper.

id.71-201

In the UAR, sugar is produced from cane sugar which is mainly grown along the Nile Valley in Upper Egypt.

During the coming season of 1970-71, the six Egyptian sugar factories will crush 6 million tons of cane. With the expansion of the actual mills and the putting into operation of a seventh factory, under construction, it is expected to crush 8 million tons by 1975-76. The ultimate production of one million tons of sugar from cane is expected to be attained around 1980, when an eighth factory will go into operation. This target being achieved, further expansion in sugar production should be obtained from sugar beet which is actually grown experimentally in the Nile Delta.

Being a country short of wood resources, the UAR has either to depend on imported raw material for its paper and board industries or to promote the use of ligno-cellulosic materials available from annual plants, mainly rice straw, flax shives and bagasse. For the production of panels, flax shives and bagasse proved to be suitable material and both are available in UAR; bagasse has the advantage of being available in large quantities as a by-product of cane sugar factories.

For many decades, bagasse has been used by the cane sugar factories as fuel for steam and power generation; and in almost all cases, the bagasse produced is largely sufficient for that purpose. Moreover, when the crushing capacity of the factory exceeds 4000 t/day, a surplus of bagasse could be obtained, the value of which is largely dependent on

a. the efficiency of the steam balance of the factory

& b. the fiber contents of the cane.

In the Egyptian sugar factories where quintuple effects are used at the evaporation stations with bleeding from these vessels and where the fiber contents of the cane ranges between 13.0 and 13.5 %, one should expect a surplus of ± 10 kg. of B.D. fiber per M.T. of cane.

Taking into consideration the big size of the Egyptian sugar cane factories where three of them will crush 1.5 million tons of cane each during the season 1975, and that the oil resources of the country are superior to the local needs, it is quite evident that bagasse should be considered as the most appropriate ligno-cellulosic material for the future expansion of paper and board industry in UAR.

Bagasse & the required characteristic for use in the manufacture of Panels

The particle board industry originated with a view to utilising cheap industrial wood waste. Expanding plant capacities and the demand for products of higher quality have changed the picture, and an increasing number of plants are using round wood or waste wood from the forests. Market requirements, both in the furniture and building industries, have also forced the producers to manufacture high quality multi-layer boards which can be made only of engineered particles or properly classified waste material such as flax shives or bagasse. Interest has been centered on sugar cane bagasse for two main reasons:

a. It is an industrial by-product of relatively low value; in countries where the fiber contents of the cane are higher than 15%, the surplus of bagasse represents a problem to the sugar factory.

b. It is generally produced in countries and regions of the world which are short of wood resources.

Although bagasse as a raw material for particle board has the advantages maintained above, it has also shortcomings. When leaving the sugar mill, the material is reduced to indeterminate particle sizes & shapes and contains a large fraction (25 - 30%) of a non-fibrous substance, the pith, which is detrimental to the board quality and must be removed. The particle sizes and shapes of the material depend mainly on the system of cane preparation and sugar extraction. The interest of the sugar factory is a thorough preparation of the cane to attain the maximum sugar extraction. Knives and shredders or knives and crushers are used before the cane passes a series of five or six mills. During the last eight years, a new system for sugar extraction from cane has been developed; it is expected to replace the classical crushing and milling system in the future. The new principle is to extract sugar from cane with hot water in a counter-current system where the part played by the mills is restricted to partial extraction and to bagasse dewatering; one extracting mill and one dewatering mill are used together with water extracting system. In certain cases, the extracting mill is replaced by a cane disintegrator.

The pith fraction being objectionable to the board industry, as mentioned above, and as all depithing systems cannot distinguish between pith and fine fibers, deep disintegration of the cane prior to extraction would yield a bagasse of relatively fine particle size; consequently, a higher fraction of fibers will be separated along with the pith. The new system for cane extraction would be the most appropriate from the view point of board manufacture, provided no disintegration of the cane is practiced before the extractor.

Hereafter, is the average screen classification of bagasse in two different factories:

	Kous	Edfu
Extraction system	hot water extraction	straight milling
Cane preparation	knives	knives & shredders
Retained over		
ASTM No. 7	37.00	30.00 %
" " 10	16.30	17.20 %
" " 14	15.00	10.30 %
" " 20	18.00	13.20 %
" " 25	6.10	7.40 %
" " 30	4.60	9.50 %
Pass through ASTM No. 30	3.00	12.30 %

The records of the last five years show that particle board yields from depithed bagasse, when cane is shredded, are at least 10 % less than those where no shredding is practiced.

Fresh bagasse at the outlet of the mills has the following composition:

Sucrose	1.6 - 2.5	%
Reducing sugars	± 0.2	%
Ash	± 1.5	%
Cane lipids	± 0.2	
Moisture	50	%
Lignin, cellulose & pentosans	± 45	%

Before it is processed in the board mill, the bagasse should be dried to an average moisture content of 10 - 15%. In the Egyptian plant where a three layer , board is manufactured, the surface material usually contains ± 12 % moisture while the core material should be further dried to a moisture content of 6 %. A question now arises as to whether the bagasse from the mills is to be artificially dried or preferably subjected to natural drying. To adopt either of the two methods, one has to decide first whether the board industry would be seasonal and run parallel with the sugar mill, or it would run the year round on stored bagasse. It is obvious that the decision should be for a board mill running all the year round in order to avoid excessive capital costs, social problems resulting from a seasonal industry, problems of storing huge stocks of panels and the difficulties of establishing an appropriate programme of production to face the actual needs of the market. It is clear that artificial drying has no justification and that natural drying of bagasse is the only solution. Under the climatic conditions prevailing in Upper Egypt, where the rainfall is quite rare, the moisture contents of baled bagasse stored in the open drop to 30 % after the first month, to 22 - 25 % after the second month and to 10 - 15 % after the fourth month. This means that at the beginning of the cane crushing season, which lasts for 140 days, the panel plant should have in its stores a quantity of dried bagasse sufficient for its needs during the same period.

Natural drying of bagasse has another great advantage that is the destruction of its sugar content by fermentation during storage. In order to destroy the sugar content of the bagasse, it is recommended that the bagasse should not dry rapidly.

The following table shows the changes in the composition of bagasse during storage in the open:

	Fresh Bagasse	After 20 days of storage	After 50 days of storage	After 100 days of storage
Date	9/4/67	1/5/67	30/5/67	18/7/67
Moisture %	51.8	39.5	16.0	10.0
Sucrose % B.D.	4.79	0.24	0.16	0.10
Reducing sugars % B.D.	0.40	0.67	0.27	0.16
Water soluble % B.D.	9.4	3.0	2.9	1.9
Pith % B.D.	21.6	19.3	20.4	19.7
Fibers % B.D.	69.0	77.7	76.7	78.4

Actual & Potential end uses of Bagasse

During the last season, the Egyptian cane sugar factories produced ± 700,000 tons of B.D. bagasse, 94 % of which was used as fuel to produce steam and electric energy necessary for the sugar industry. Taking into consideration the heating value of bagasse, the quality of bagasse used as fuel corresponds to ± 250,000 tons of fuel oil worth £ 1,875,000 at a price of fuel oil of £ 7.5 per ton at factory. Planning for a future expansion of paper and board manufacture from bagasse, all the steam generating units which have been installed during the last 15 years are designed to burn bagasse or oil.

The first trial to use bagasse as a substitute for wood board products was the installation of a particle board plant annexed to Kom Ombo sugar factory which started operation in 1961. The plant was designed with a basic capacity of 40 M.T./day of three-layer boards of 19 m/m and having the possibility to produce boards of 6 to 25 m/m; densities range between 0.5 to 0.75. Kom Ombo factory has been chosen on the basis that it would crush 1.5 million tons of cane by 1973; by then, all the needs of the particle board plant will be covered by the surplus of bagasse. Fresh bagasse from the mills is depithed, baled and stored in the open to dry. At the panel plant, bagasse with moisture contents of ± 15 % is shredded by hammer mills, pneumatically classified to four fractions: coarse to be returned to the hammer mills, core material; surface material and fines, mainly pith which is burned together with the trimmings and sanding dust to generate superheated water for the plant. Electric power is supplied to the plant from the sugar factory. Urea-formaldehyde is used as glue and the plant is equipped with a multiplaten press of 12 openings to produce panels of 4 x 12 feet. The total annual exchange savings of the project amount to £ 400,000.

In 1965, a pulp mill using bagasse as raw material started operation; it is annexed to the Edfu sugar factory (cap. of 1.0 million M.T. cane/annum) and is planned for an annual throughout of 18,000 M.T. unbleached bagasse pulp by the sulphate process.

With the exception of the chemical recovery furnace and ancillaries & green liquor caustisizing outfits, which were planned to suit double the pulp mill capacity, the rest of the process stations were designed to suit a production level of 60 M.T./day unbleached sulphate pulp. With regard to bagasse depithing, a two-stage depithing system is in operation at Edfu mill: Stage 1, known as wet depithing, handles the fresh bagasse from the sugar mill; the pith fraction is returned to the sugar mill while the up-graded fiber fraction is baled and stored to cover the needs during the off-season of the sugar mill. However, a part of it is directed to the 2nd stage depithing station, known as moist depithing, where the fiber content of the "accepts" advanced to around 90 %. The "accepts" are then metered to a Pandia kettle. Washed pulp from the brown stock filters is screened in successive stages and clean pulp from the screening station is dewatered in a vacuum filter and processed to a disc press to advance the dryness of the pulp to around 35%, then it is processed through a high speed fluffer and a flash drier.

For the coming years, three main projects are actually under consideration:

1. To increase the capacity of Edfu pulp mill to 42,000 M.T./year of unbleached sheet pulp. After extension, the annual needs of the pulp mill will amount to 100,000 tons of B.D. depithed bagasse.

2. To build two plants for the production of 15 million moulded crates to pack fruits, vegetables and soft drinks; urea-formaldehyde will be used for fruit crates while phenol formaldehyde will be used for soft drinks crates. The expected annual consumption of depithed B.D. bagasse for the two plants is 45,000 M.T.

3. To build a newsprint paper mill with an annual capacity of 100,000 M.T. of paper. This mill will be annexed to Kous sugar factory (annual grinding cap. 1.5 million M.T. of cane) and will consume all the accepted fibers from the above mentioned sugar mill and will be supplemented by depithed bagasse from a near factory.

When these three projects are realised, 30 % of the bagasse produced by the sugar industry will be consumed by the board and paper industry.

Price of Depithed Bagasse

For the time being the only user of bagasse is the sugar industry, either as fuel or as raw material for board and pulp manufacture.

Under local conditions prevailing in UAR where the panel plant is owned by the sugar industry and annexed to the sugar mill, and taking into consideration the climatic and economic factors, the most appropriate procedure for bagasse handling would be the following:

1. Fresh bagasse from the sugar mill is depithed and the pith fraction is returned to the steam generating plant of the sugar factory.

2. Depithed bagasse is baled and stored in the open for a period of at least four months to destroy its sugar contents and reduce the moisture content to the level which needs a minimum artificial drying

of the material before processing.

Although the bagasse consumed by the panel plant could be partially or totally a surplus of the sugar factory, especially if its grinding capacity exceeds one million M.T. of cane per annum, it is accounted for its fuel replacement value plus running costs and investment cost. The following table shows the split-down cost per ton of depithed and baled bagasse on B.D. basis. Fuel replacement value is calculated from a heating value for B.D. bagasse of 3800 kg cal/kg and a price of fuel oil of £ 7.5 per ton at the sugar factory. Power for the panel plant is purchased from the sugar factory for £ 0.009 per KWH.

Cost of Depithed Bagasse
(Bone Dry Basis)

Depithed bagasse M.T./year	15000
Power for depithing - KWH/M.T.	52
	£ / ton
- Fuel replacement	2,850
- Power for depithing station	0,468
- Power for baling	0,090
- Binding wire for baling	0,558
- Repairs & maintenance	0,077
- Transport to stacks & piling	0,052
- Labour & overhead charges	0,427
- Capital costs	0,300
Total production costs	4,822

In the UAR, the only competitive raw materials for the manufacture of panels other than bagasse are flax shives used by two plants manufacturing particle board, and rice straw used by one plant manufacturing hard board.

Below is a table showing the comparative prices of the three raw material in £ per M.T. at the panel plant.

	Bagasse (B.D.)	Flax shives	Rice straw
Price per M.T. £	4.82	4.40	2.50 - 4.20

The price of rice straw, which is used for both the paper and hard-board industry, is largely dependent on transport costs from field to factory.

Taking into consideration that flax shives have a moisture content of ± 10 %, the price would be almost identical to that of depithed bagasse with moisture content of 10 %.

Transport of Bagasse from Sugar Mill to Panel Mill

It has been planned for the actual bagasse panel mill, within the limits of available possibilities, to minimize the transport problems of the raw material.

The bagasse storage area is located about 1.5 km. from the depithing and baling stations, both of which are built next to the bagasse conveyor from the sugar mills. The panel plant is located 500 m. from the nearest stacks. Baled bagasse is loaded on trucks which pass over a weighing bridge before delivering their loads to the storage area. The crushing season of the sugar factory lasts for ± 140 days; to cover the needs of the panel plant, an average of 100 M.T. of B.D. bagasse should be baled per day. However, due to the fact that the fiber content of the cane increase gradually with the progress of the crushing season, the quantities of baled bagasse follow the same pattern, attaining a peak during the last two months of the season (15 March - 20 May) when 200 M.T. of B.D. depithed bagasse are baled per day.

The air-dried bagasse is transported from the bagasse stores to the bale breaker of the panel mill by tractors and trailers which are weighed before unloading. Some 80 M.T. of dry bales are always kept at the bale breaker to secure non-stop running of the panel mill.

Although the above mentioned solution has the drawback that panels have to be transported some 800 km to the main end users, it has the advantage of cutting down the transport costs by ± 50 % had the panel mill been built near Cairo and bagasse transported from the sugar factory to the panel mill. These savings are mainly due to the following reasons:

1. the relative shipping volume of baled bagasse to finished panels is of the order of 2 : 1.
2. the expected losses of bagasse during transport and double handling.

The problem of transporting bagasse over long distances will rise with the new project of manufacturing moulded crates for fruit packing as it will be impractical to transport millions of empty crates for hundreds of kilometers; consequently, the bagasse should be transported to the site of the crates mill. The only solution would be to compress the bagasse bales to a miximum density to reduce transport costs.

Pre-processing of Bagasse

a. Depithing

As stated at the beginning of this paper, the pith fraction is objectionable to particle board manufacture and should be removed. The high specific area of the pith & its selective adsorbtive power affects the mechanical properties of panels. Furthermore, as pith is a non-fibrous material, it tends to absorb moisture and swells. Due to its high specific area and adsorbtive power, the pith increases the consumption of glue and the panels manufactured from bagasse containing pith are instable towards moisture absorption and dimensional changes; and since the glue represents the most costly item, the presence of pith will seriously affect the manufacturing costs. With regard sugar to content the records of the Egyptian bagasse particle board mill show that in fresh bagasse sugars are evenly distributed in both fractions: fibers & pith.

Three different methods for bagasse depithing are discussed hereafter:

1. Dry depithing: Whole bagasse is baled and the air-dried bagasse is handled in a hammer mill followed by pneumatic sorting or screening for pith separation before further processing. This method, having been tested now several times on an industrial scale at Kom Ombo mill, has the disadvantages of producing considerable quantities of pith & fines superfluous to the fuel needs of the panel mill thus creating the problem of disposal of such bulky and inflamable material. The only possible use of the pith fraction would be to mix it with molasses for fodder preparation.

2. Wet depithing: As in the former method, whole bagasse is baled. After drying, the bagasse is thoroughly wetted and the slurry is treated in a depithing machine where by rubbing the pith gets loose from the fibers, and pith dirt and water-soluble substances are separated. In this method, both the fibers and pith have high moisture contents. To render the pith useful, it should be dewatered and dried; if the fibers are to be processed into particle board, they should also be artificially dried, which would be a heavy burden on the economics of the panel mill.

3. Moist depithing: In this method, fresh bagasse from the sugar factory is handled at a hammer mill where pith is broken loose and separated from the fiber fraction. The pith fraction which amounts to 20 - 25 % of the whole bagasse is returned to the steam generating plant of the sugar factory and the fiber fraction which still con-

tains some 5 - 8 % pith is baled. It should be emphasized that the pith fraction contains some 20 - 25 % of fine fibers accepted by the screen orifice of the machine.

The evaluation of the above mentioned three methods shows that the third method, namely moist depithing, is the most appropriate and most economical for panel manufacture from bagasse.

Another important feature of depithing 'mill run' bagasse is the reduction of baling, transport and handling cost by 20 % of cost if whole bagasse is baled. Furthermore, if 20 % of the pith is removed prior to baling, field losses in handling bagasse, which amount to 10 %, will be reduced by 20 %.

At Kom Ombo factory, the needed quantity of bagasse is deviated from the main bagasse conveyor to another one loading to an electro-magnet separator and fed to three depithing machines in parallel. The fiber fraction is further conveyed to the baling station while the pith fraction is pneumatically conveyed to a cyclone; the separated pith falls on the main bagasse conveyor feeding the steam boilers.

b. Baling

Due to considerations of the layout of Kom Ombo sugar factory in relation to that of the bagasse storage area and the panel mill, depithed bagasse has to be baled for convenient transportation. Bagasse is pressed into bales of 30 x 30 x 60 cm of 0.35 density (B.D. fiber basis) which are secured with tie wires. The tie wire represents the main item of the baling cost. Although the moisture content of fresh bagasse is ± 50 %, the moisture content of freshly depithed and baled bagasse is ± 45 % due to "windage" effect during depithing. Bagasse bales are stacked in the open to dry for a period of 3 to 4 months. Sufficient air gaps between bales are provided to allow the escape of evolved heat and alcohol vapours produced during the fermentation of sugars.

c. Fiber sorting & drying

When the moisture content of the bales drop to 15 %, the material can be processed into panels and the first step is to take off the tying wires and get the bales through a bale breaker followed by a hammer mill to break down the fibers to the desired dimensions. The fibers are then classified into four fractions, namely:

a. Coarse particles which are returned to the hammer mill.
b. Core material.
c. Surface material.
d. Pith & dust which are conveyed to the superheated water generator for use as fuel.

The surface fraction does not need any further drying provided that its moisture content does not exceed 15 %. However, the core material is dried to a moisture content of 6 % in a rotary drier using superheated water.

Problems of Storage

Both the board and pulp mills of the Sté. des Sucreries & Distillerie d'Egypte rely on the classic system of baling depithed bagasse and storing in stacks. Each stack is 14 x 29 x 6 m; ample distances should be kept between stacks to leave sufficient air gaps to allow the escape of alcohol vapours and heat resulting from the fermentation of sugars; the volume of gaps represents about 25 - 30 % of the total volume of a stack. Records on bagasse storage in UAR show that a stack built without sufficient air gaps has completely decayed after five months of storage; in the center of the stack, the fibers turned dark brown and contained 6 % of free volatile acidity calculated as acetic acid. The heat build-up from the exothermic decomposition of sugars produced a kind of destructive decomposition of cellulosic material.

The bagasse attaining such degree of alteration is of no value to panel or paper manufacture. On the contrary with properly built stacks, the bagasse is preserved quite satisfactorily and its discoloration is negligible. Laboratory prepared boards carried out with artificially dried fresh bagasse and with stored bagasse do not show any significant difference in mechanical properties of the panels.

Another problem which might arise during storage is mould growth, especially while the moisture content of the bale is still high. The following main moulds have been isolated: Aspergillus sp., Pencillium sp., Fusarium sp. and Rhizopus nigricans; the first being the most dominating. Investigations showed also that such growth on depithed bagasse is much less than on whole bagasse and that all mould growth stops when the moisture content of the bale attains 23 %. Bagasse resulting from hot extraction in counter-current, known as diffusion process, is much less susceptible to mould growth than bagasse resulting from the classic cane milling process. In the former process, the bagasse is almost sterilised during a retention time of 30 minutes at ± 70°C. It was also found that the addition of borax to fresh bagasse at the concentration of 0.5 % B.D. material checked all mould growth. However, as mould growth is limited to the external parts of the stacks, and as it stops after the first month of storage, it was found unnecessary to use any fungicide.

The greatest danger of baling and dry storing is the danger of fire. Dry bagasse is inflamable; once fire starts in a stack it is inevitably very difficult to stop it and the only possible measure is to try to isolate the burning stacks to prevent the fire from spreading to the whole storage area. The danger of fire does not only mean the loss of the raw material, but also the shutting down of the mill for a period proportional to the quantity of raw material lost. The following precautions are necessary:

1. A distance of 25 m. should be kept between stacks and a distance of 40 m between two rows of stacks to prevent fire spreading and to permit easy circulation for fire fighting.

2. The space between stacks should be kept clear of any bagasse or weeds.

3. To provide a net of water pipes kept always under pressure and accessible to all stacks.

A more elaborate system for fire protection is used at Kom Ombo panel mill where each stack is lodged inside a retaining thin wall 'L' shaped. At the top of the wall are fixed water pipes with jet nozzles to flood the top of the stack with water in case of fire; another set of nozzles would form a water screen between two stacks. The capital cost for the fire fighting system together with the insurance cost for the bagasse stores increases the production cost of panel by ± 2 %.

To sum , the disadvantages of baling storage are namely: the considerable baling costs, danger of fire, large space required and eventual deterioration of the raw material during storage if stacks are not correctly built.

Actually, deviating from the baling storage system, there are three systems for bulk storage of bagasse. The first is the Ritter process where the bagasse is impregnated with a biological liquor and the bagasse slurry is flushed to a large storage area. By the addition of small quantities of molasses, the initial culture solution is multiplied and the liquor used for flushing is recirculated. Bagasse is reclaimed in a slurried form at the bottom of the pile. As a result of such biological treatment, sugars are used by the bacteria and part of the water soluble substances contained in the bagasse are dissolved.

The second system(1) has been lately developed in [illegible] Rico where it was found that bagasse can be effectively preserved in bulk, simply by keeping it wet. The storage pile is on a sloping concrete slab and water is pumped over it. Drainage is collected and reused.

1/ New Developments in Handing and Storage of Bagasse
Dr. J. H. Payne; Sugar Journal, Jan. 1970.

The third system[2] has been developed in Louisiana where it was found that if freshly milled bagasse was piled with certain precautions and in suitably large piles, a self protective essentially anerobic storage resulted which inhibited the destructive fermentation and heat build-up.

The merits of bulk storage of bagasse over the classic bale storage are mainly

1. Less capital costs.
2. The costs for handling and storing are reduced to a minimum.
3. Better preservation of bagasse and uniformity of raw material.
4. Elimination of fire risks especially in the wet systems.
5. Less space requirements.

So far as particle board manufacturing from bagasse is concerned, the wet bulk storage systems cannot be used as the reclaimed bagasse should be dewatered and then artificially dried, which would offset the economics of such system.

The third system, namely the dry bulk storage, looks quite suitable for particle board manufacturing, provided that moisture content of the pile drops to 15 % after a reasonable storage time of three to five months. However, if bagasse is to be precessed into hard board or other types of panels using wet forming of panel, the wet bulk storing system would be most indicated.

Conclusions

1. Bagasse is suitable, as fibrous material, for panel manufacture; the pith should be removed to secure optimum mechanical properties & to cut down the glue consumption.
2. Moist depithing of the mill-run bagasse is the most recommended system as it solves the problem of pith disposal by burning it at the steam generating plant of the sugar factory.

2/ Bulk Storage of Bagasse
D.R. Bernhanrdt; Sugar Journal, March 1968.

3. Excessive disintegration of the sugar cane prior to sugar extraction would give a high proportion of fine fibers and a low yield of de-pithed bagasse as well as a low yield of panels from dried fibers due to the fact that any commercial equipment used to separate pith from dried bagasse would not distinguish pith from fine fibers.

4. A panel mill should be planned to run all the year round on stored bagasse to avoid excessive capital cost, social problems resulting from a seasonal industry and the problems of storing huge stocks of panels & the difficulties of establishing an appropriate program of production to face the actual needs of the market.

5. Natural drying of bagasse before processing into panels is the only applicable system as artificial drying would give rise to many technical and economical problems.

6. Transport problems of bagasse from the sugar factory to the panel mill could be reduced to minimum if the panel mill is built next to the sugar factory.

7. If bagasse has to be processed into particle board, it should be baled and stored in stacks & left to dry until its moisture content drop to ± 15 %. The latest innovation in bulk storage in the dry state is very appealing from both technical and economical points of view, provided it results into an appropriate drying of the bagasse. In case bagasse is processed into hard board or other types using wet forming, the wet bulk storage system would be the most appropriate.

8. When adopting the storage system of baled bagasse, great care should be given to the way of building the stacks with sufficient air gaps between the bales to preserve the bagasse against discoloration and decay due to destructive fermentation.
Great care should also be given to the fire-fighting system.

9. Bagasse is not a cheap raw material; its fuel replacement value and baling costs are the main items of its cost. However, if the panel mill is a captive plant of a sugar factory where a surplus of bagasse is available, the economical picture would be completely different.

Bulk storage would also contribute to some extent in cutting down the cost of the raw material.

10. Before processing the dried bagasse into particle board, the last pith fraction should be separated by pneumatic classification or sifting. A three-layer or multi-layer board is recommended to obtain optimum quality.

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