ABSTRACT

With the present energy crisis in the world, there is the necessity for sugar factories to diversify their products by installing annex refineries and distilleries. As such it is very important to get the maximum recovery of energy from cane bagasse.

The individual bagasse drier is a system that uses stack gases, lowers the moisture of the mill bagasse in 10 or 15 points, increasing the steam production to 15.5% and 18.30%, respectively.

One drier is installed in each furnace, and uses 54% of installed power that the others existing bagasse driers use.

INTRODUCTION

With the present energy crisis in the world, it is important to research on new sources of energy or to improve the results that we can get from existing fuels. The raw sugar cane industry can be independent in fuels, when making only raw or white sugar, or direct ethyl alcohol. However, the factory complexes that make raw sugar and at the same time make alcohol from molasses and white refinery sugar, need to use auxiliary fuel or wood to supply the high steam demand.

In Brazil, the problem is more serious because we import 80% of our total consumption of petroleum so that now we have quotas for fuel oil and diesel oil. The new electric sugar factories that only make raw sugar or white standard sugar have an average steam consumption of 500 kg. per metric ton of crushed cane.

It is estimated that an annexed refinery in a sugar factory consumes 120 kg. per ton of crushed cane and an alcohol annexed distillery consumes 85 kg. of steam per ton of crushed cane. Then, we can say that a whole factory has a total consumption of 685 kg. of steam per ton of crushed cane.

We want to make a note that these numbers are ideal values of consumption of steam, because the majority of the factories in Brazil consumes 580 kg. of steam
per ton cane only for making white standard sugar. Still, to get a good extraction on mills, it is necessary to increase the imbibition level over 250% on fiber. This normally increases the bagasse moisture to 52% or more, making it difficult to burn in furnaces.

In Brazil the following values were considered as an average production of steam per kg. of burned bagasse:

1. Modern boilers with preheated air, spreader stockers, bagasse feeders and grates produce 2.20 kg. of steam per kg. of burned bagasse, with 50% of moisture.
2. Old boilers, with pre-heated air, but without the other equipments, obtain only 1.85 kg. of steam per kg. of bagasse.

We take as an average production of 2.0 kg. of steam per kg. of bagasse, with 50% of moisture, for the majority of sugar factories, with 13% of fibre in cane and 28% of bagasse in cane, so we will have a production of steam in about 560 kg. per ton of crushed cane, which sometimes is not sufficient to supply the crushing of a single sugar factory without an annexed refinery of distillery.

To obtain self sufficiency in fuel in the most complex sugar factories, or to get some bagasse left in the single factories, the most convenient solution that we find is to dry the bagasse after the mills, decreasing the moisture from 59% or 52% to 40%.

To get these results the different ways of drying the bagasse were studied; and most manufacturers use the same way, as shown below:

1) To dry at the same time all the available bagasse.
2) To return the dried bagasse with conveyors and feed different boilers.

This conventional procedure presented several problems that increased the cost of installation and operation, as follows:

a) High cost of initial investment
b) Difficulty in enlarging the installation.
c) The necessity of a big space for the equipment
d) High power consumption per kg. of dried bagasse
e) The necessity to install new auxiliary conveyors for the bagasse

We believe that, because of these reasons, the bagasse drier installation are not used much yet.

**EXPERIMENTAL PROCEDURE**

With the objective of avoiding the above-mentioned problems, we began to
try drying the bagasse separately, that is, to dry bagasse in each furnace of the same boiler.

The system shown in Fig. 1 was used at first.

FIGURE 1. Separate drying of bagasse

In this case, we used the existent bagasse feeder in the boilers to obtain uniform quantity of bagasse destined for the dryer, and to avoid the entry of cold air into the dryer. We used a baffle plate, that can turn around 70 degrees, and makes a by-pass for the bagasse for the conventional system of burning. The stack flue gases were taken by a fan, after the pre-heated air, and blown through a mixture box. There, the gases are mixed with the bagasse, and have a pressure of 5 mm. of water gauge. A fan pulls the mixture across a tubular column 15 meters high to a cyclone where it separates the wet gases from the dried bagasse. Afterwards the dried bagasse falls down on the existing spreader — stoke, feeding the furnace. The wet gases are brought in proper tube to the middle of the stack, to get advantage on the existing draught.
We employed this system in a furnace for two months and we found several problems that presented problems in its extensive use. They are:

a) High consumed power with two fans, with 11 kw and 15 kw, is a dryer bagasse with 4,500 kg. of bagasse per hour.

b) Problems of damage and obstruction in the second fan.

The total consumption of energy, about 26 kw to dry 4,500 kg. of bagasse per hour, shows that 325 kw would be necessary to a total of 56 tons/h of bagasse from a factory that crushes 200 tons of cane per hour.

After much effort and research, we found a system that we consider the ideal to dry the bagasse.

The basic system for a furnace of boilers is shown in Figure 2.

**FIGURE 2.** Basic system for a furnace of boilers.

In the system we utilize the bagasse feeders and the spreader-stokers that are installed on the boiler.

The basic difference between this system and the first one is that the bagasse is transported by an induced draught, and this eliminates the fan with the 15 kw
drive that presented some problems. In this new system we use the draught made by the existing induced draft fan. It became necessary to put a new special feeder in the discharge of the cyclone.

The excess air necessary for combustion of the dry bagasse is reduced so there is no increasing of power consumption in the fan, even with a raising in the specific weight of the stack gases, due to the increasing of its moisture contents.

Thus, to dry all the bagasse from a sugar factory that crushes 200 tons of cane per hour, we need 225 kw. This corresponds at about 70% of power consumption in the first system, and justify the use of the new system used for drying the bagasse. We tested this new dryer in a furnace for 30 days, and we did not find any important problem. We are sure that by September 1979, we have 20 units of this type, working to dry 76 ton/hour of bagasse with 50% of moisture, and we expect that the power consumption will be about 285 kw.

RESULTS

When the new bagasse dryer was working, drying 4,500 kg/hour of wet bagasse, the following results were obtained:

a) The results of drying using with several moisture and using flue gases with 200°C are presented in Table 1.

<table>
<thead>
<tr>
<th>Initial moisture</th>
<th>Final moisture</th>
<th>Weight of initial dried bagasse</th>
<th>Weight of water taken out bagasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>55%</td>
<td>46%</td>
<td>83.3%</td>
<td>166.6 Kg.</td>
</tr>
<tr>
<td>50%</td>
<td>40%</td>
<td>83.3%</td>
<td>166.6 Kg.</td>
</tr>
<tr>
<td>46%</td>
<td>35%</td>
<td>83.07%</td>
<td>169.2 Kg.</td>
</tr>
</tbody>
</table>

b) Some tests were made with the flue gases that were obtained after the air-heater with 220°C, and other tests, where the gases were obtained before the air-heater at 300°C.

We observed that the efficiency of drying bagasse using the hotter was increased by about 68%.

c) In the tests with the highest temperature (330°C.), the bagasse left the dryer 40°C, and the wet gases at 100°C. Thus, we see that flue gases from a bagasse drier have a temperature 50% lower than the flue gases from a conventional air-heater.
d) The control of this system is very easy, since it only requires a negative pressure on the exit of the cyclone. This control is made using a hand disc valve on a duct which transfer the wet gases to the chimney fan.

e) The total costs of this system is equal to 60% of the price of the majority of the existing dryers, and the power consumption is about 54% of those dryers. But, we get the same efficiency as the existing dryers.

f) It can be installed on any existing boiler, and it is possible to dry a portion of the bagasse, or all the bagasse used in the boiler, it isn’t necessary to use any auxiliar bagasse conveyor.

g) The systems consumes about 50% of the flue gases from the boiler, in which it is installed.

Flue gases taken after the air-heater or the hottest ones taken before it can be used and we can decrease the bagasse moisture between 10 or 15 points respectively.

**DISCUSSION**

Theoretically, and using formulas from Hugot, Peck, Perry, Badger, and Banchero, we can mention the following advantages to dry the bagasse:

a) In Table 2, we can see the increase of gross calorific value and the net calorific value when we dry the bagasse, with 50% of moisture to 40% and 35%.

From Hugot, we have:

\[
\begin{align*}
\text{G.C.V.} & = 4,600 - 12.5S - 46. W \\
\text{N.C.V.} & = 4,250 - 12.5S - 48.5W
\end{align*}
\]

**TABLE 2. Variation in Gross Calorific Value (G.C.V.) and Net Calorific (N.C.V.) of bagasse with 50% moisture dried to 40% and 35%**

<table>
<thead>
<tr>
<th>Weight</th>
<th>G.C.V. Kcal/Kg</th>
<th>N.C.V. Kcal/Kg</th>
<th>Increase N.C.V.</th>
<th>Corrected N.C.V.</th>
<th>Weight of dry bagasse</th>
<th>Increase N.C.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>W = 50%</td>
<td>2270</td>
<td>1800</td>
<td>0</td>
<td>1800</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>W = 40%</td>
<td>2730</td>
<td>2300</td>
<td>+27.8%</td>
<td>1915</td>
<td>83.3%</td>
<td>+6.4%</td>
</tr>
<tr>
<td>W = 35%</td>
<td>2960</td>
<td>2525</td>
<td>+40.3%</td>
<td>1944</td>
<td>77%</td>
<td>+8%</td>
</tr>
</tbody>
</table>
b) Decreases the excess air necessary for combustion, from 60% and 50% to 20%.

c) Increases the furnace temperature to about 20.5% and 30%, as we can see in Table 3.

### TABLE 3. Combustion temperature in bagasse furnaces

<table>
<thead>
<tr>
<th></th>
<th>m = 1.5</th>
<th>m = 1.3</th>
<th>m = 1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>W = 50%</td>
<td>1040°C</td>
<td>1120°C</td>
<td>-</td>
</tr>
<tr>
<td>W = 40%</td>
<td>1165°C</td>
<td>1254°C</td>
<td>1300°C</td>
</tr>
<tr>
<td>W = 35%</td>
<td>1210°C</td>
<td>1280°C</td>
<td>1350°C</td>
</tr>
</tbody>
</table>

d) Increases the velocity of combustion and of absorption of heat in the water walls of the boiler.

e) As we saw, there is a good increase in the temperature of the furnaces. However, there was an important decrease of heat losses in flue gases, because the dry bagasse needs only 20% or 25% of excess air, and 50% of the weight of the flue gases, are used to dry the bagasse and they leave the dryer at about 100°C.

f) Decreases in losses by imperfect burning of the bagasse, because with dry bagasse the combustion is almost complete, and due to the recovery of solids unburnt by the cyclone of the dryer.

### TABLE 4. Volume of gases $m^3$/Kg of bagasse

<table>
<thead>
<tr>
<th>m$^3$/Kg</th>
<th>Weight of Bagasse</th>
<th>m = 1.5 $t = 220°C$</th>
<th>m = 1.3 $t = 220°C$</th>
<th>m = 1.2 $t = 220°C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>W = 50%</td>
<td>1</td>
<td>7.75</td>
<td>6.95</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8.87</td>
<td>7.89</td>
<td>7.41</td>
</tr>
<tr>
<td>W = 40%</td>
<td>0.833</td>
<td>7.39</td>
<td>6.57</td>
<td>6.17</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>9.41</td>
<td>8.36</td>
<td>7.84</td>
</tr>
<tr>
<td>W = 35%</td>
<td>0.77</td>
<td>7.24</td>
<td>6.44</td>
<td>6.04</td>
</tr>
</tbody>
</table>
g) Decrease of the pollution due to the lower volume of flue gases and lower quantity of solids unburnt, when burning a dry bagasse, as we can see in Table 4. This was calculated using the formula $V_g = 4.45 (1 - W) . m + 0.572 . w + 0.672$, and making the necessary weight correction when we dried the bagasse.

h) Increases in the quantity of steam can be obtained from a unit weight of bagasse burnt, as we see in Table 5, calculated using the formula $M_v = (4,250 - 1,200.S' - 4,850.w - qw) . B.M.$

### TABLE 5. Increase of heat transmitted to steam per kg. of bagasse

<table>
<thead>
<tr>
<th>Kcal/Kg.</th>
<th>Weight of bagasse</th>
<th>m = 1.5</th>
<th>t = 220°C.</th>
<th>m = 1.5</th>
<th>t = 220°C.</th>
<th>m = 1.5</th>
<th>t = 220°C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>W = 50%</td>
<td>1</td>
<td>1274</td>
<td>1301</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W = 40%</td>
<td>1</td>
<td>1819</td>
<td>1845</td>
<td>1858</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.833</td>
<td>1471</td>
<td>1497</td>
<td>1510</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2061</td>
<td>2085</td>
<td>2098</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W = 35%</td>
<td>0.77</td>
<td>1530</td>
<td>1555</td>
<td>1568</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

i) Increases the quantity of steam per unit weight of bagasse. Table 6 shows the various coefficients when we consider the boiler feed water with 90°C., and when we discount the decrease in the weight of bagasse that is, being dried.

j) With the dried bagasse, we can theoretically get the increase in steam production of about 15.03% or, an excess of bagasse of about 12.7%

l) Mr. William P. Boulet², says that the practical results that we can obtain with the dried bagasse before the feeding of furnaces, is 47% higher than the results reported by Prof. Kerr in 1910.

In our presentation we intend to present the practical results of 4 months operation with the dried bagasse, in a factory that crushes 270 T.C.H., and with a decrease of bagasse moisture from 50% to 40%.
TABLE 6. Weight of steam produced per unit weight of bagasse, for different moisture and excess air

<table>
<thead>
<tr>
<th>Steam</th>
<th>$W = 50%$</th>
<th>$W = 50%$</th>
<th>$W = 40%$</th>
<th>$W = 40%$</th>
<th>$W = 35%$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$m = 1,5$</td>
<td>$m = 1,3$</td>
<td>$m = 1,3$</td>
<td>$m = 1,2$</td>
<td>$m = 1,2$</td>
</tr>
<tr>
<td>$t = 220^\circ C$</td>
<td>$t = 220^\circ C$</td>
<td>$t = 220^\circ C$</td>
<td>$t = 220^\circ C$</td>
<td>$t = 220^\circ C$</td>
<td></td>
</tr>
<tr>
<td>16 Kg/cm²</td>
<td>2.21</td>
<td>2.25</td>
<td>2.59</td>
<td>2.62</td>
<td>2.72</td>
</tr>
<tr>
<td>20 Kg/cm²</td>
<td>2.20</td>
<td>2.25</td>
<td>2.59</td>
<td>2.61</td>
<td>2.71</td>
</tr>
<tr>
<td>30 Kg/cm²</td>
<td>2.02</td>
<td>2.06</td>
<td>2.37</td>
<td>2.39</td>
<td>2.48</td>
</tr>
<tr>
<td>300°C</td>
<td>1.95</td>
<td>1.99</td>
<td>2.29</td>
<td>2.31</td>
<td>2.40</td>
</tr>
<tr>
<td>400°C</td>
<td>1.87</td>
<td>1.91</td>
<td>2.20</td>
<td>2.22</td>
<td>2.30</td>
</tr>
</tbody>
</table>

CONCLUSION

Last November (1979) we installed a bagasse drier in a Dedini boiler, in Santo Antonio Sugar factory in Alagoas Brazil.

The boiler has the following characteristics:

1. Heating surface of the boiler = 1500m².
2. Steam Production = 40,000 Kg of steam per hour.
3. Working pressure = 21 Kg/cm² and produces saturated steam.
4. It has 5 horse shoe furnaces.
5. It has a fan with 20CHP installed at the chimney basis, that can make 80mm of induced draught.
6. The 5 furnaces can burn about 20,000Kg of wet bagasse per hour.
7. The moisture of the used bagasse has an average of 52%.
8. The average of temperature in the fitness is about 1,055°C.
9. It has a Preheated air with heating surface of 1,200m², that heats the combination gases to 160°C.
10. The temperature in the flue gases is about 220°C.
11. We use an excess air for the combustion to about 50%.
12. The theeritical volume of flue gases, at 220°C is 173,000m³/hour.
13. The CO₂ content of flue gases has an average of 13%.

Our bagasse dryers were installed on the five furnaces, and the principal characteristics of each one is:

1. A capacity to dry 4,500Kg/hour of bagasse with 52% moisture.
2. They can use gases with 220°C or 300°C, but now we are using the gases with 220°C.
3. The total power installed is 115HP that is, one fan with 100HP and five air-locks with 3 HP each one.

While these driers are in operation we get the following results:

1. We use hot gases with 220°C taken from the air-heater.
2. The temperature from the mixture of air and bagasse, on the column has 100°C.
3. The temperature of wet gases that go to the chimney has an average of 80°C.
4. The temperature of the chimney gases has an average of 140°C.
5. The temperature in the furnaces is about 1,250°C.
6. We had an increase in temperature in the furnaces to about 200°C.
7. We are operating with bagasses that has an average of 52% moisture.
8. We get a final moisture in dried bagasse of 40% that means, a decrease in moisture of 12 points.
9. Now the contents of CO₂ in flue gases is 15.5%.
10. The excess air used for combustion is about 25%.
11. Drying all the bagasse of this boiler we get a steam of almost 48,000 Kg/hour.
12. We get a gross increase in the steam production of about 20%, and a net increase of 16%, because we have a power consumption of 102HP to dry the bagasse.

From these results we can conclude that nowadays is very important to dry the bagasse of all the sugar factories because we can get:

A net increase in steam production of 16%, or
An excess of bagasse produced in about 13%.

If we use the same words of William P. Boulet² and J.H. Furiness³, we can say, that to dry the bagasse is the best way for a sugar industry to be free of auxiliary combustibles, and to decrease the problems of air pollution.

But it is also very important that the system of drying be easy to operate and flexible to avoid unexpected stops.

Nowadays with the problem of combustibles, a dryer of bagasse that uses stack gases, can pay for itself in each 5 months, if uses exist for the excess of steam produced due to the dried bagasse.

NOMENCLATURE

G.C.V. = Gross calorific value of bagasse

N.C.V. = Net calorific value of bagasse.
\[ S = \text{Sucrose \% bagasse} \]
\[ S' = \text{Sucrose of bagasse relative to unity} \]
\[ W = \text{Moisture \% bagasse} \]
\[ W' = \text{Moisture of bagasse relative to unity} \]
\[ m = \text{Excess air = Weight of air used for combustion to weight theoretically necessary.} \]
\[ V_{gN} = \text{Volume of the gaseous products of combustion, at normal conditions of temperature and pressure, in m}^3/\text{Kg.} \]
\[ M_v = \text{Heat transferred to the steam per Kg. of Bagasse burned, in, Kcal/Kg.} \]
\[ q_w = \text{Sensible heat of flue gases given by eqn.} \]
\[ q_w = (1 - W') \cdot (1.4m - 0.13) + 0.5 \cdot t \]
\[ t = \text{Temperature of flue gases in \textdegree C.} \]
\[ \alpha = 0.98 = \text{Coefficient taking into account losses by unburnt solids} \]
\[ \beta = 0.97 = \text{Coefficient taking into account losses due to radiation.} \]
\[ M = \text{Coefficient taking into account losses due to incomplete combustion.} \]
\[ = 0.91 \text{ to } 0.96. \]

REFERENCES


SECADOR INDIVIDUAL DE BAGAZO

Luiz Ernesto Correia Maranhao

RESUMEN

Con la actual crisis mundial del petróleo, y la necesidad de las fábricas de azúcar diversificar su producción instalando refinerías y destilerías anexas, tornó-se necesario recuperar el máximo de la energía disponible en el bagazo de caña.

El secadero individual de bagazo es un sistema que aprovechando los gases de la chimenea, disminuye la humedad del bagazo salido de la molienda en 10 o 15 puntos, aumentando la producción de vapor en 15.5% y 18.3% respectivamente. Nosotros usamos un secadero para cada horno de bagazo, y la potencia absorbida total es igual a 54% de la utilizada por los otros sistemas que existen en el mercado mundial.