Mauritius Research Council

Stabilization of the moisture level in bagasse prior to its combustion in thermal power plants

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Address:

Level 6, Ebene Heights
34, Cybercity
Ebene

Telephone: (230) 465 1235
Fax: (230) 465 1239
E-mail: mrc@intnet.mu
Website: www.mrc.org.mu

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Stabilization of the moisture level in bagasse prior to its combustion in thermal power plants

Stabilisation du taux d'humidité de la bagasse avant sa combustion dans les centrales thermiques

D. Philogène
Sotratech ltée

S. Oree
Université de Maurice

Introduction

La canne à sucre

Fibres: 16% (12 à 18 %)

eau: 69 %

Brix: 15%

La bagasse est le résidu du broyage de la canne

1 tonne de canne	**=**	**335 kgs de bagasse (teneur en eau 47.5%)**

Introduction

Composition de la Bagasse

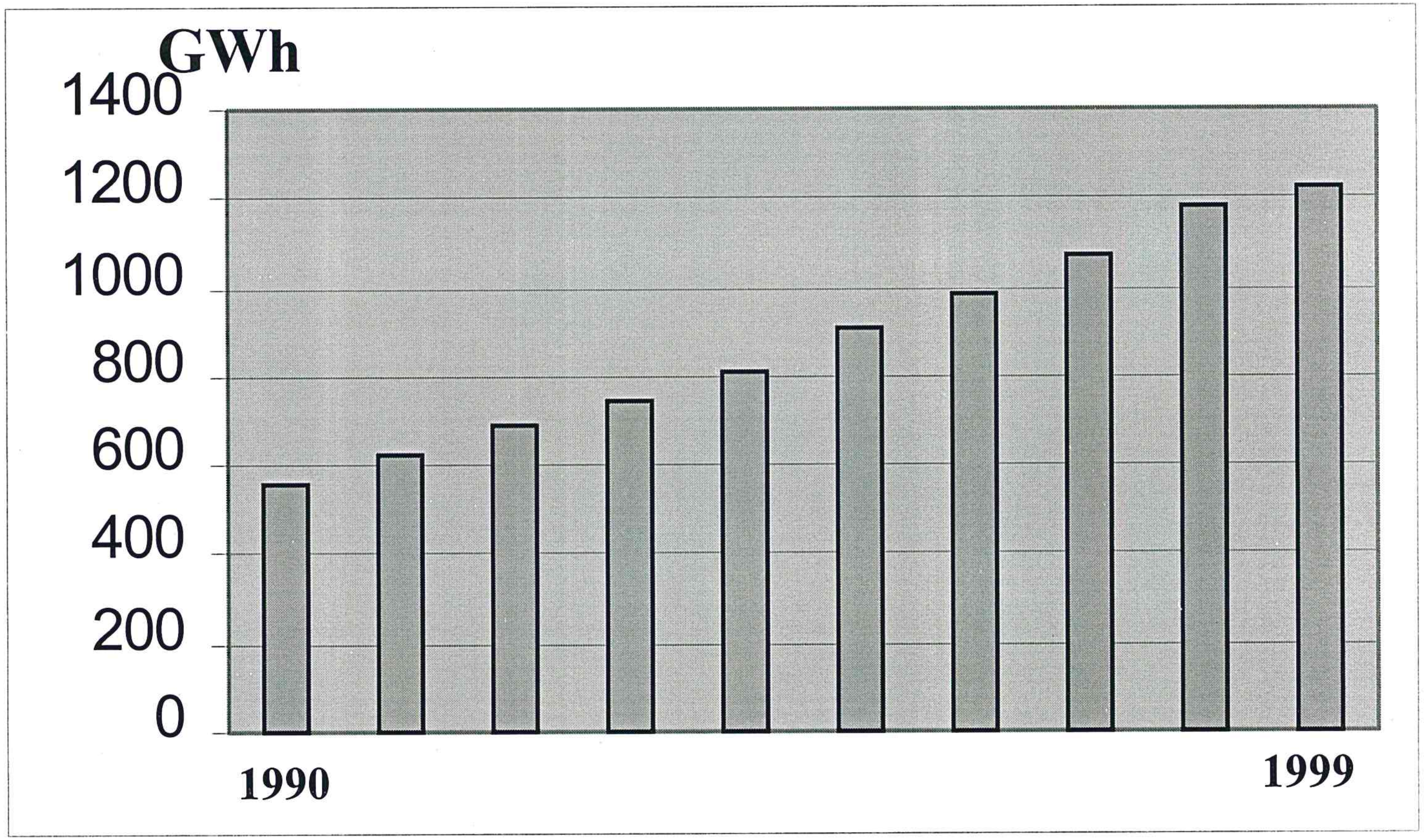
Particules de cellulose: (43 - 52 %)

Eau (46 à 52% en théorie)

Substances solides (2 - 6%)

Résidus minéraux

Ventes d'énergie électrique à Maurice par la CEB



Production d'énergie électrique à Maurice

Chiffres de 1998

Puissance totale générée: 1360 GWh

Ventes: 1178 GWh

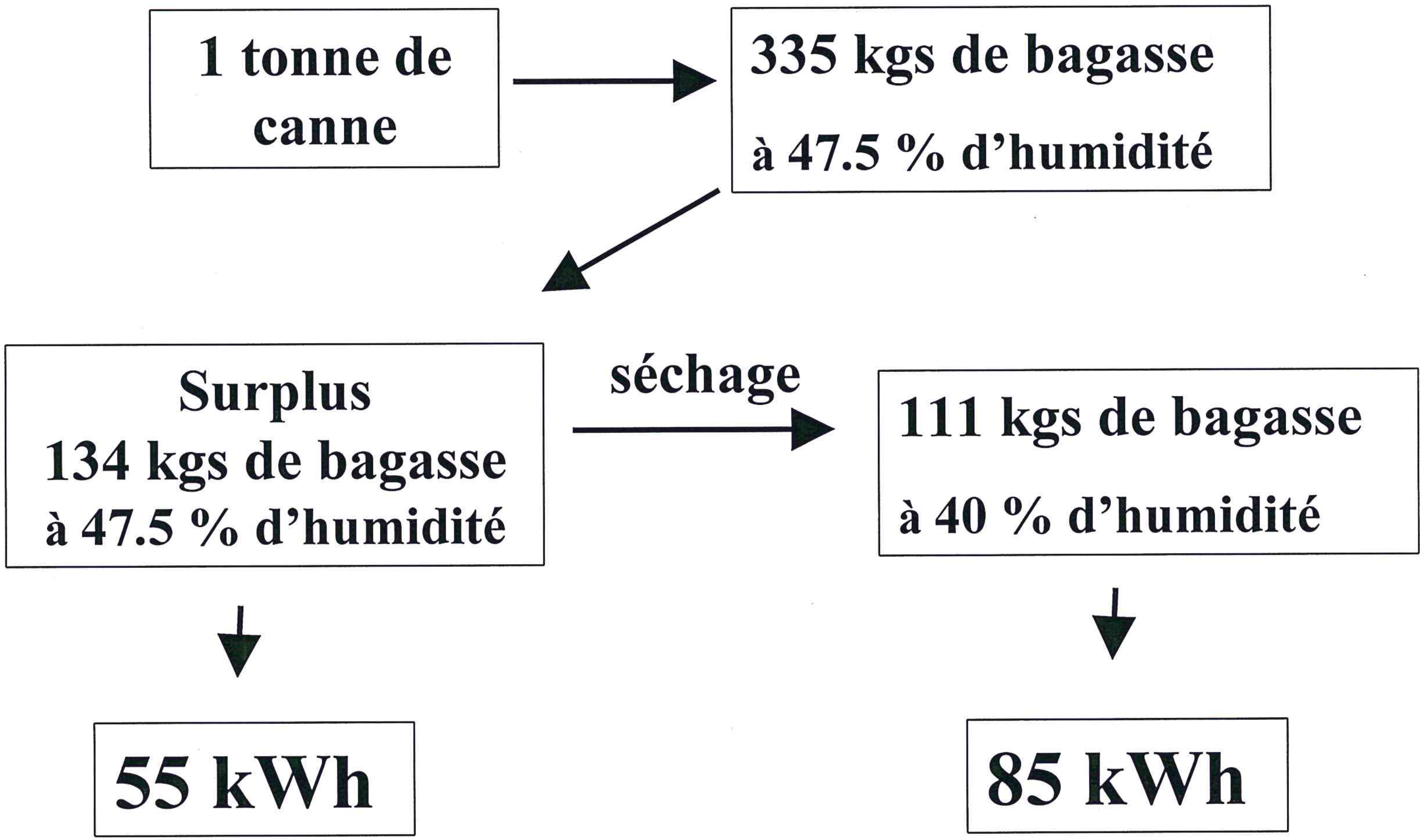
Bagasse 18.7 % **Charbon 4.3 %**

Croissance de la demande par 6% annuellement

2000: Station de Belle Vue

Charbon + bagasse = 38%, Hydro électricité = 6 %

Valeur énergétique dans une installation classique



Le taux d'humidité en sortie des moulins est variable

Raisons possibles

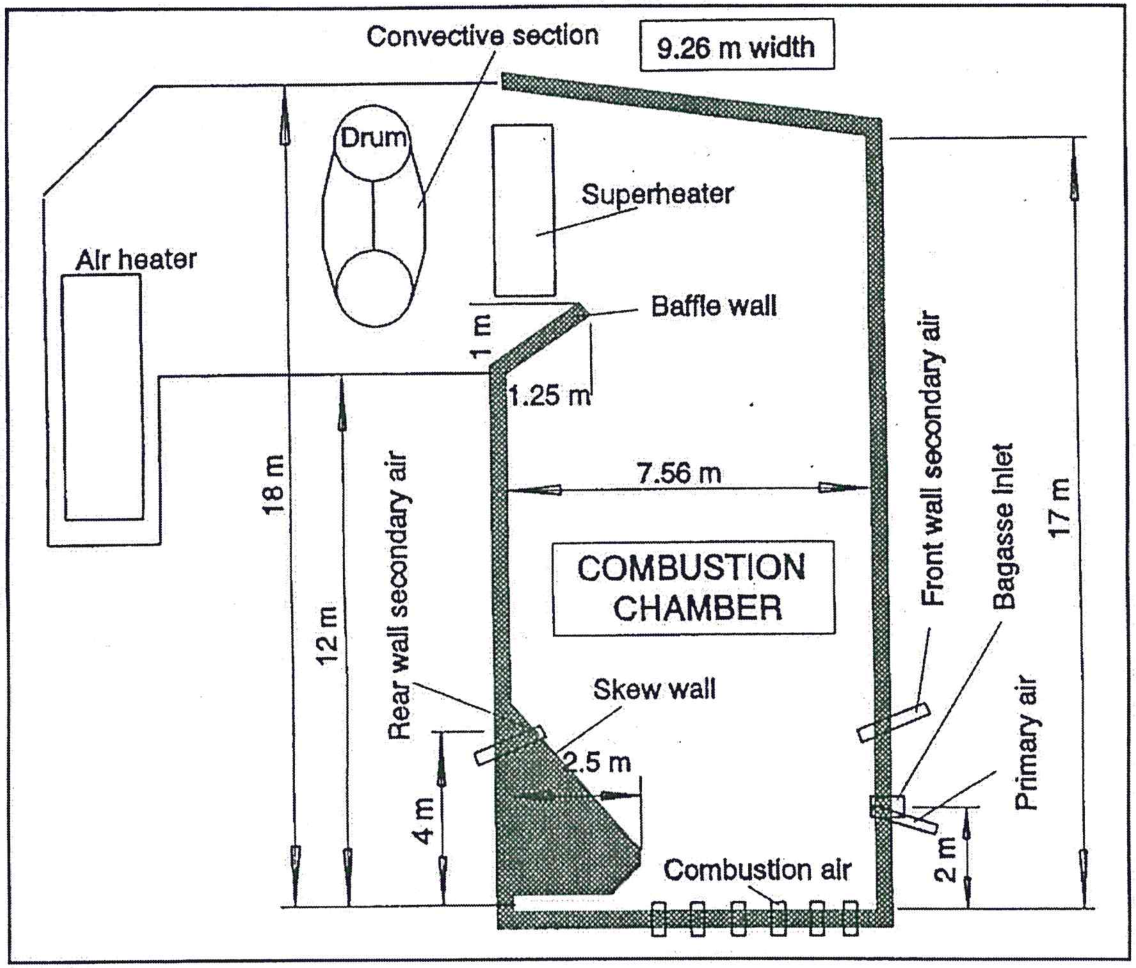
Vitesse variable des moulins

Changement dans la teneur en fibres de la canne

Variations dans la disponibilité de la canne

Contraintes d'ordre purement opérationelles

chaudière à bagasse



Rendement d'une chaudière donnée

Dépend principalement de deux facteurs

Caractéristiques du souffle d'air, Température, positionnement, Réglages

Taux d'humidité de la bagasse

Effet de l'humidité de la bagasse sur la chaudière

Si le taux d'humidité est supérieur à 56 %: Instabilité

Si le taux d'humidité est inférieur à 35 %: Dépots vitreux

Une diminution de la teneur en eau entraine:

une augmentation du rendement par rapport au kilo de masse sèche

moins d'imbrulés

Si de plus le taux d'humidité est stable, la combustion devient plus stable

Brevets de Bouvet, de White et de Voorheis préconisent:

séchage de la bagasse de 6 à 20%.

Eventuellement la péllétisation dans certains cas.

Chaudières classiques difficilement utilisables

Nécessité de grands espaces de stockage

Investissements couteux

A` Maurice (et ailleurs) on a écarté ce scénario

Controle de l'humidité à un taux fixe (40 - 42 %)

Pour pouvoir controller, il faut d'abord savoir mesurer en temps réel.

Le capteur informerait le système de controle de la teneur en eau, ce qui servirait à calculer le séchage nécessaire

Pas de capteur "on-line", mais des mesures en labo dans les usines.

Il faudrait développer des mesures indépendantes de la densité et de la température pour la bagasse

Mesure du taux d'humidité de la bagasse par capteur micro-ondes

Mesure en espace libre

- Atténuation dans le matériau

- déphasage lors du passage dans le matériau

Traitement de données

Correction pour la température

Formulation indépendante de la densité

X

Utilisation des micro-ondes pour ramener le taux d'humidité à 40 - 42 %

Dans la hagasse il ya deux types d'eau

L'eau liée (les permiers 10 à 25%)

L'eau libre (le surplus d'eau)

l'eau liée est plus difficile à évaporer

Pour évaporer 1 kg d'eau libre par micro-ondes :

0.75 à 1 kWh électrique

Pour faire passer 335 kgs de bagasse à 47.5 %

vers 40 % (310 kgs) il faut éliminer 25 kgs d'eau

L'élimination de 25 kgs d'eau implique une consommation électrique de 20 à 25 kWh

310 kgs de bagasse @ 40 % produit 212.5 kWh

Bilan

Environ 10 - 15 % de l'énergie produite serait utilisée pour générer les micro-ondes

Le passage de 47.5% à 40% d'humidité entrainerait une gain d'environ 20 % sur la production électrique

Gain net, estimé = 5 - 10%

Ramené à un taux de broyage de 100 tonnes/heure

Il faudrait une installation Micro-onde collosale de 2 MW

Cout estimé des investissements : plus de Rs 10 millions

CONCLUSION

3/8/99 8/A

STABILIZATION OF THE MOISTURE LEVEL IN BAGASSE PRIOR TO ITS COMBUSTION IN THERMAL POWER PLANTS : A first report

A computerised search of relevant articles and monographies was conducted at the INIST data-base (French CNRS data-base) through the internet. While some of the articles and books were obtained locally from the libraries of the University of Mauritius and of the MSIRI, the SYFED centre was instrumental in obtaining other articles from abroad. This short report is based mainly on these works.

Introduction

Bagasse is a heterogeneous medium consisting of cellulose fibres (held together rigidly by lignin), water, air and a small quantity of sugar. The percentage water content is normally between 46 and 52 %.When the moisture content of bagasse is low, all the water molecules are bound to the cellulose fibres. However, at higher moisture contents, part of the water begins to collect in the pores and capillaries and is said to be in the unbound state.

Importance of controlling moisture of bagasse.

J. Baguant and P. Hardy [1] have considered the question of bagasse combustion from an energetical point of view. Their analysis has pointed out that a high moisture level in bagasse led to a decrease in the combustion temperature ratio and consequently to a decreased energy production. They conclude that bagasse drying is a vital component in achieving better energy productivity. Confirmation of this is given by Luo *et al.* [2] who show that heat extraction rates fall with increasing humidity and that above 58% moisture content, the combustion becomes unstable.

Several patents and articles [3,4,5,6] describe processes for drying bagasse to 6 - 30% humidity using hot flue gases. However, Cruz et al. [7] argue that at such low moisture contents, the combustion temperature is so high that the ashes are softened causing the formation of vitreous slag deposits in conventional boiler furnaces. Clearly, therefore the moisture content of bagasse in such furnaces should not be decreased below 35%. Alternatively (more costly) boilers specifically designed to operate on low-moisture bagasse should be used.

Other advantages of using bagasse of controlled humidity are increased stability, faster boiler response to load changes and decreased fuel requirements per unit steam generated. In brief, there is a better control over the combustion process.

Moisture sensing

Before any attempt is made to control the moisture concentration in bagasse entering the power plant, on-line moisture content monitoring is essential to achieve full automation of the moisture leveling process. Monitoring of material moisture must be fast enough to allow automation response. It should also be accurate, continuous, independent on density or temperature and non-destructive. Therefore, an important part of this work will consist in designing a moisture sensor capable of meeting these specifications.

A microwave sensor was developed by *Kraszewski et al.* [8] for temperature-compensated and density independent moisture determination. The author tested the instrument successfully on shelled maize at temperatures from 4 to 45°C and moisture contents from 9 to 19% by weight. The method involves the transmission of a single-frequency microwave signal through a constant thickness t of the material at a known temperature T and measuring the resulting phase shift ϕ and attenuation A of the incident wave. The moisture level can then be evaluated in terms of A, ϕ, T and t. However, the measurement of the phase requires costly instrumentation. In a US patent by Walker [10] a variation of the previous method which is less costly is presented. In this case, the phase information is obtained indirectly by using the only the attenuation of microwave signals at two distinct frequencies.

For this work, we propose to extend the idea and to measure the attenuation characteristics over a range of frequencies in order to deduce moisture content. The system would consist of a transmitter and an amplitude detector separated by a layer of the material. The transmitter would be a swept-frequency microwave source (VCO) and a horn antenna, whereas the detector unit would consist of a wide-band diode-detector associated with a receiving horn antenna. Online temperature measurement (using a pyrometer) for temperature compensation is also planned. Contacts have been established with *Modco Inc.* for the supply of low-cost microwave VCO's. Also, a laboratory pyrometer has been recently purchased for the proposed sensor. It will also serve for routine measurements at the bagasse power plant.

The bagasse dryer

Once the moisture level of the incoming bagasse is known, the bagasse moisture-leveling apparatus can be switched on or off as appropriate to maintain a constant humidity level.

Because it heats preferentially areas of higher moisture content, microwaves are a preferred vector of heat transfer for high-end applications such as moisture-leveling. For example, Fanslow *et al.* [9] have used microwave power and unheated air to dry corn. Working on agar gels and sea weeds, Garcia and Bueno, have shown that combined microwave/hot air drying greatly reduces the drying time as compared to hot air alone. Moreover, the fact that instantaneous variations of microwave power levels are possible, allows the implementation and investigation of a large diversity of heating cycles. The cane harvest at Mon Désert Alma is due to start in the third week of July. Fresh samples will then be available for treatment in domestic microwave ovens.

In order to obtain an approximate idea of the required heating cycle that will be useful for the prototyping stage, simple numerical modelling must be performed. The article by Perkin [11] is an excellent introduction to the topic of mathematical modelling of heat and mass transfer during microwave heating. We have started work in this respect to develop our model at the University of Mauritius.

Fund management

So far, the MRC has proceeded with a partial payment of Rs 30 000. This sum has have been allocated to cover the following expenses (not including fees).

Purchase of pyrometer:	Rs 5303
Payment to the university:	Rs 9000
Provision for transport:	Rs 900

Consumables: Rs 1500

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