ENERGY CYCLE IN CANE SUGAR MILLS: CONTROL AND OPTIMISATION

By

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Abstract

ENERGY has become one of the most sensitive costs in industry. Cane sugar production is no exception. Real time energy control systems (RETEC) are the ideal tools for cutting down generation and production costs, and also preventing downtime and expensive repair jobs, improving savings. Information so obtained can be used for predictive maintenance purposes. When the energy control model was fed with real time data (standard analysis available in the mill), information was processed instantly, showing steam generation and consumption data, the whole energy cycle. As the model improved, it gradually became a guideline for controlling the process, resulting in lower incidence of low steam pressure and improved sugar production processes. On the equipment side, analysis allowed modifications and tuning on the run. The system also enhanced training of operators and engineers. Obtained benefits are: developed energy control system helped achieve more stable milling, as a better quality of steam was generated; energy specific consumption reduced from 0.810 to 0.461 tonnes of steam per tonne of cane; auxiliary fuel was unnecessary; Savings obtained were almost 10% of sugar price; less stressed boiler operation resulted in reduced amount and intensity of repairs, generating a second stage benefit; developed model defined some new energy indexes, for better understanding and control of energy generation. The stack became clear as combustion improved, reducing emissions of CO_2 and CO. A factory can adopt RETEC in its own way and obtain significant savings in fuel and repairs and less air pollution.

Introduction

Energy costs have increased in recent years as a result of global warming, oil prices and environmental regulations. Bagasse is the preferred fuel option, reducing fuel costs for a mill.

Today many applications are available to add value to sugarcane processing. Trash and tops are also burned. Diversifying bagasse utilisation is becoming a new profitable business.

With green harvesting and proper milling of trash and other crop residues, more bagasse can be processed for other applications and less greenhouse gases are introduced to the atmosphere. The Kyoto Protocol has established conditions for this ‘green’ market.

This paper proposes five systems and technologies for improving energy efficiency.

Systems and technologies for improving energy efficiency

Combustion adjustment

The way to improve a boiler’s performance is to set all air and fuel controls in such a way that every dampener and valve responds to control with precision and repeatability to allow the best possible operation, keeping combustion at its best efficiency at all possible generating loads. Flue gas analysers are used to determine the positions of air dampeners and fuel valves.

Very low excess air combustion based on CO/O_2 control

As bagasse and residuals vary in their oxygen demand, combustion control based on fuel characterisation does not allow very low excess air operation.

CO increases as oxygen content in flue gases diminishes. High CO content results in a significant energy loss as only 72% of carbon energy is liberated. O_2 and CO measurement are the basis of combustion control. Figure 1 shows an energy relation between O_2 and CO content in flue gases.

Very low excess air operation requires intelligent online O_2 and CO analysers to control combustion of fuels with different and variable air demand. Figure 2 shows the location of analysers inside a boiler.

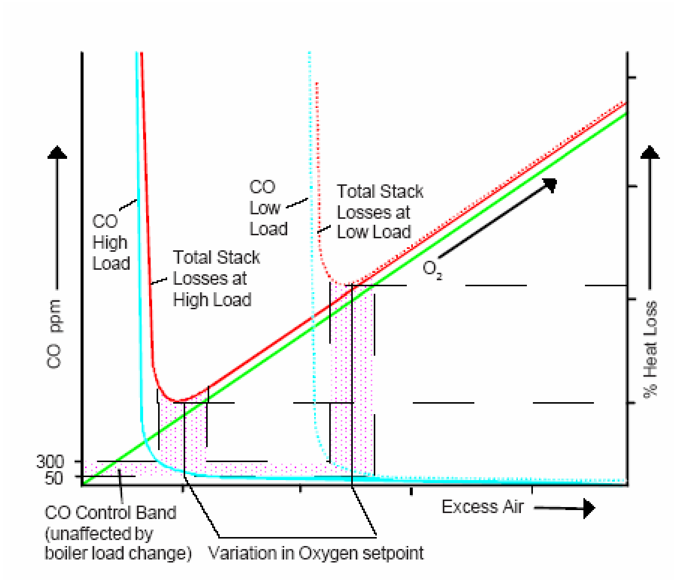

Fig. 1—CO, excess air and heat losses.

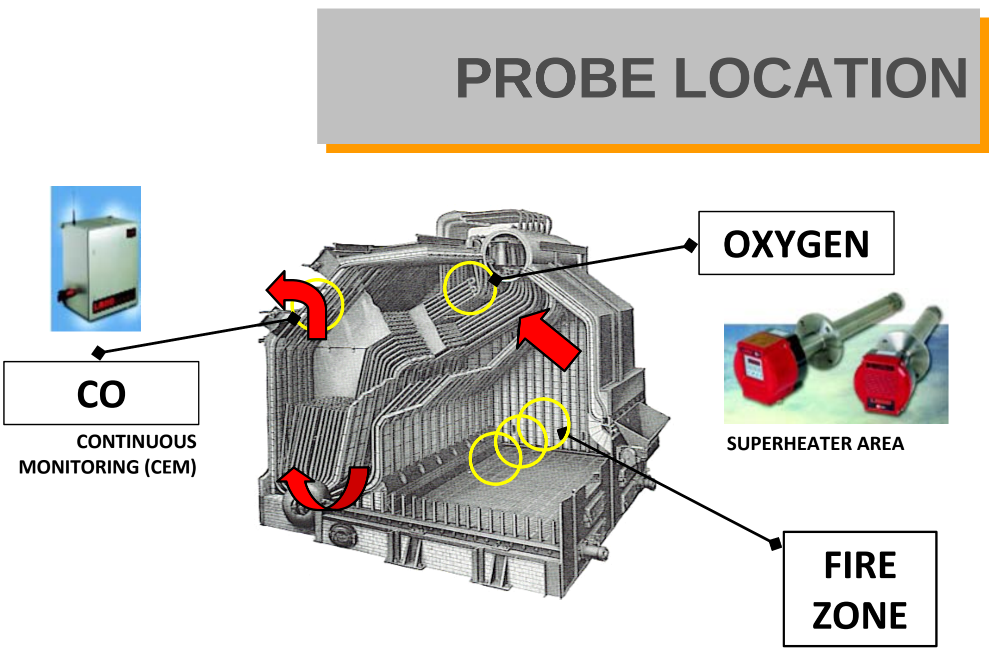

Fig. 2—O_2 and CO analysers inside a boiler.

Post combustion process

Traditional processes burn up to 70% of pith, as small particles cannot be retained in the boiler's furnace for enough time to be completely burned. Energy losses are high. Pith has 19.2 MJ/kg and long fibre 15.1 MJ/kg. As result of incomplete combustion, average caloric value drops from 17.4 to 14.2 MJ/kg.

Incinerating pith in a Heavy Fuel Oil (HFO) pilot flame increases the caloric value from 14.2 MJ/kg to 16.7 MJ/kg, providing 17.9% of additional heat.

Thermic reforming of bagasse

With properly set fluidised bed air, bagasse burning temperature can rise enough to convert lineal carbon chains into benzene rings, liberating some hydrogen atoms that burn at a much higher temperature inside the boiler's furnace, increasing steam generating speed rate and capacity. It is shown as a temperature jump of about 300°C. The boiler's efficiency is then improved.

Real Time Control (RETEC).

The RETEC operates with four different fuels: solid, viscous liquids, light liquids and gas; continuously reducing O_2 when steam consumption is stable until the CO maximum limit is achieved. Very low excess air operation, post combustion and reforming are integrated to RETEC.

The RETEC includes control algorithms for Post combustion and Thermic reforming processes.

The RETEC monitors and controls each boiler and the equipment using steam, advises when equipment requires maintenance before failure, preventing undesirable shut downs.

Analyses conducted once a month:

- Caloric values and elementary analysis of bagasse, large fibre and pith, other vegetable residue,
- Caloric value and elementary analysis of auxiliary fuel,
- Isokinetic analysis of flue gases

Analyses conducted each hour and required process data:

- Bagasse moisture content,
- Flue gases composition, and
- Fibre exiting factory (bagasse and/or fibre and/or pith).

Real time data:

- Cane entering mills;
- Flow, pressure and temperature fed to each boiler of generated steam and water; auxiliary fuel and air (primary and secondary);
- Flow, pressure and temperature of steam in: main; to each turbine; to juice heaters, pans, crystallisers, centrifuges, sugar dryers and others;
- Flow of sugar exiting dryers.

Energy ratios obtained from collected data are the basis of efficiency analysis and can explain cost variations:

CenM: Energy per milled cane, [kJ/tonne].

CenAz: Energy per produced sugar, [kJ/tonne].

Cesp: Generated steam per milled cane, [steam tonne/cane tonne].

EnVa: Fraction of energy converted to steam, [%].

VaAz: Generated steam per produced sugar, [steam tonne/sugar tonne].

CoM: Auxiliary fuel per milled cane, [litres/cane tonne].

CoAz: Auxiliary fuel per produced sugar, [litres/sugar tonne].

These ratios are to be analysis guidelines, either solving problems or improving processes, and helpful in understanding energy costs of each alternative.

Using an Energy Balance Board, engineers and operators can see at a glance energy inputs (fuels) and outputs (steam and losses) per source, and bagasse surplus (fibre or fibre plus pith). An example computer screen board is shown in Figure 3.

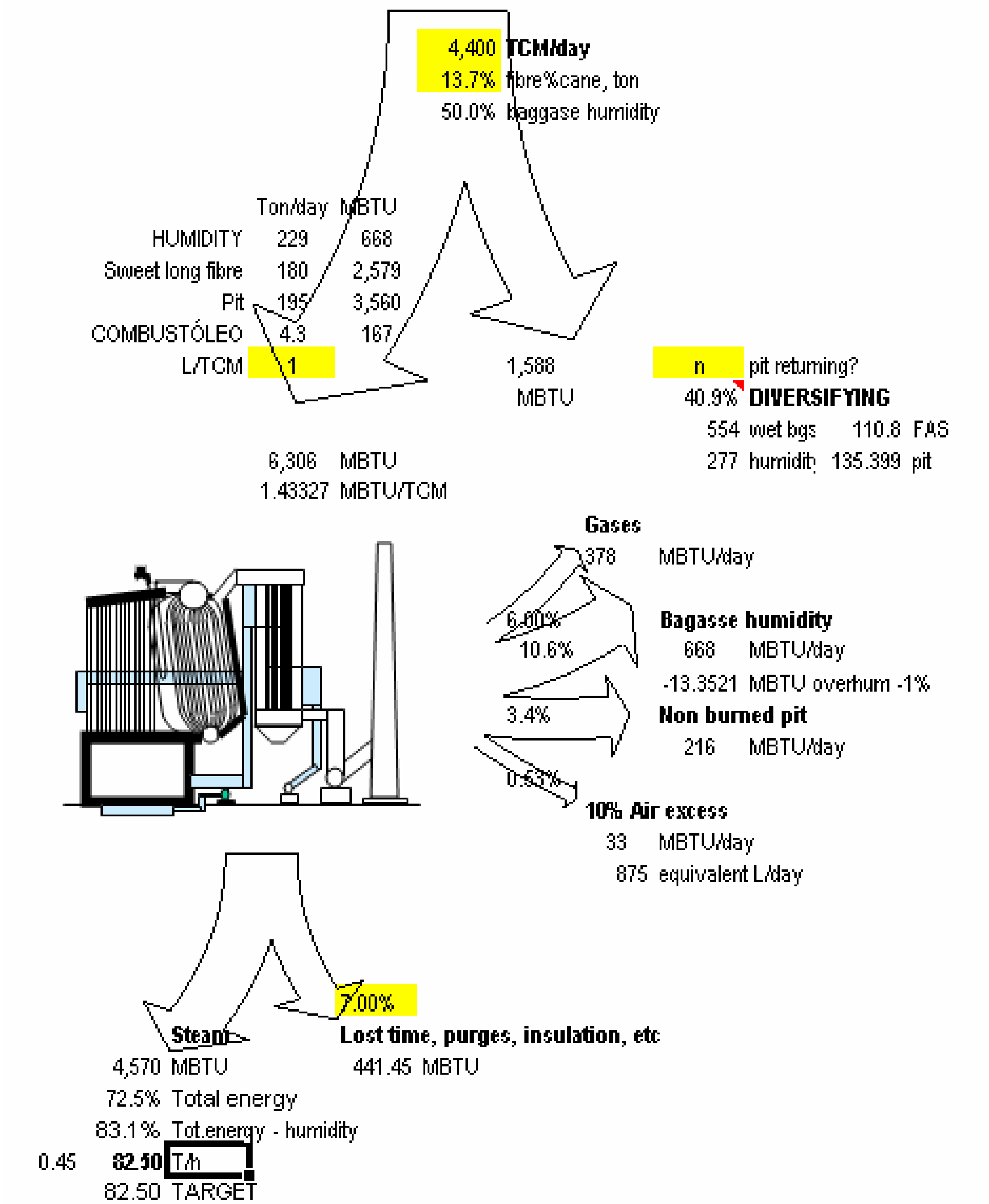

Fig. 3—Energy balance screen.

Using a Mass Balance Board, all fluids entering and exiting boilers, steam flow balance can be observed (Figure 4).

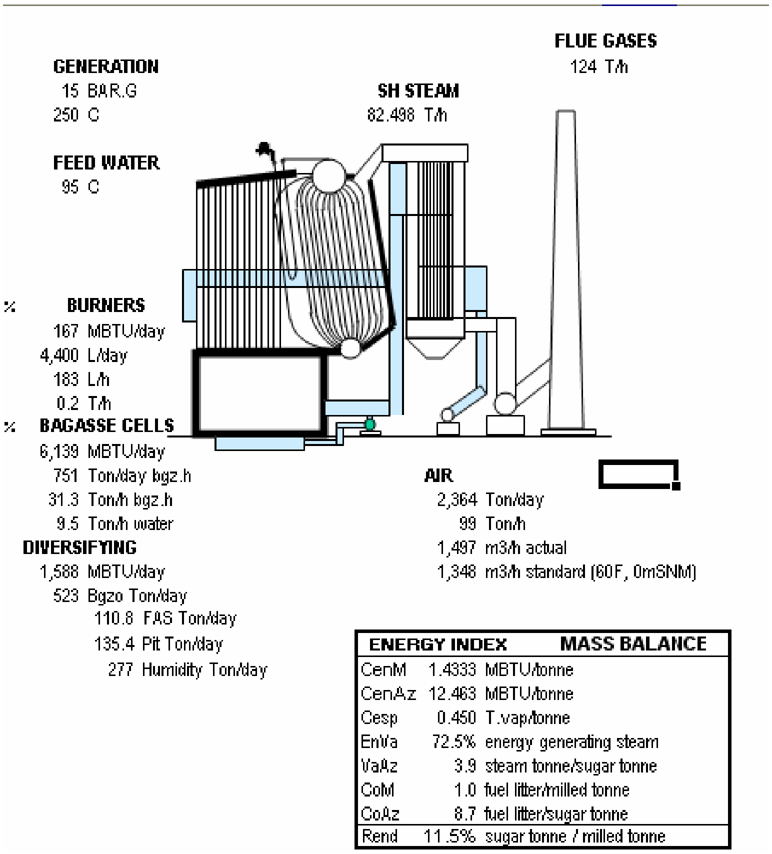

Fig. 4—Mass balance screen.

An application of the energy efficiency techniques

In Santa Clara cane sugar mill after Combustion Adjustment and Post Combustion System, excess air reduced to 20% (Figure 5) and achieved 94% pith burning. Efficiency improved dramatically.

Fig. 5—Santa Clara boiler stacks after post combustion implementation.

Because of the increased efficiency, a bagasse surplus was achieved. Benefits of excess bagasse included starting the milling season with no auxiliary fuel, selling electricity to the grid; and providing bagasse to new biotechnology processes to obtain cellulose without chemicals.

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CYCLE ENERGETIQUE AUX MOULINS A CANNE: CONTROL ET OPTIMISATION

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MOTS-CLEFS: Moulins, Contrôle, Optimisation, Cycle d'Énergie.

Résumé

L'ÉNERGIE est devenue un des coûts industriels importants et la production du sucre ne fait pas exception à la règle. Les systèmes de contrôle d'énergie en temps réel (RETEC) sont des outils pour réduire les coûts de génération et de production, et également pour éviter les interruptions de service et les réparations onéreuses, amélioration ainsi les économies. Les informations obtenues peuvent être utilisées à des fins de maintenance prédictive. Lorsque le modèle de contrôle d'énergie fonctionne avec des données en temps réel (analyses standards de l'usine), les informations sont traitées instantanément, montrant des données de production et la consommation de vapeur, donc le cycle entier d'énergie. Comme le modèle s'améliore, il permet le contrôle du processus: cela réduit les incidences de vapeur de basse pression et la production du sucre est meilleure. Pour l'équipement, l'analyse a permit des modifications. Le système a également amélioré la formation des opérateurs et ingénieurs. Les avantages obtenus sont les suivants: Un bon contrôle d'énergie, une opération stable aux moulins et une meilleure qualité de vapeur générée; la consommation spécifique d'énergie réduite de 0.810 à 0.461 tonnes de vapeur par tonne de canne; pas de carburant auxiliaire; économies de presque 10% du prix du sucre; chaudières moins stressées réduisant l'intensité des réparations, donc un deuxième avantage; le modèle a défini certains nouveaux indices d'énergie, pour mieux comprendre et contrôler la production d'énergie.; les gaz de cheminée sont devenus clairs grâce a la combustion améliorée, réduisant les émissions de CO_2 et CO. Une usine utilisant le RETEC peut obtenir d'importantes économies de carburant et de réparations et peut réduire la pollution de l'air.

CICLO ENERGÉTICO EN INGENIOS AZUCAREROS: CONTROL Y OPTIMIZACIÓN

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**PALABRAS CLAVE: Ingenio Azucarero,
Control, Optimización, Ciclo Energético.**

Resumen

LA ENERGÍA se ha convertido en uno de los costos más sensitivos en la industria. La producción de azúcar de caña no es la excepción. Los sistemas de control de energía en tiempo real (RETEC) son las herramientas ideales para recortar los costos de generación y producción, y también para prevenir paradas y costosos trabajos de reparación, mejorando el ahorro. La información obtenida puede ser usada para fines de mantenimiento predictivo. Cuando el modelo de control de energía se alimentó con datos de tiempo real (análisis estándar disponible en el ingenio), la información se procesó instantáneamente, mostrando datos de generación de vapor y consumo, el ciclo energético total. En la medida que el modelo se mejoró, se convirtió en una guía para el control del proceso, resultando en menor incidencia de eventos de baja presión y procesos mejorados de producción de azúcar. Por el lado del equipo, el análisis permitió modificaciones y sintonía sobre la marcha. El sistema permitió el mejoramiento del entrenamiento de operarios e ingenieros. Los beneficios obtenidos fueron: el sistema desarrollado para control de energía contribuyó a obtener una molienda más estable con una mejor calidad del vapor generado; el consumo específico de energía se redujo de 0.810 a 0.461 toneladas de vapor por tonelada de caña: no fue necesario el consumo de combustible auxiliar; los ahorros alcanzados fueron casi del 10% del precio del azúcar; la operación menos esforzada de las calderas representó menor cantidad e intensidad de reparaciones generando beneficios de segundo nivel; el modelo desarrollado definió algunos nuevos índices energéticos, para una mejor comprensión y control de la generación de energía; en la medida que la combustión mejoró se redujeron las emisiones de CO_2 y CO. Una fábrica puede adoptar RETEC a su manera y obtener ahorros significativos en combustibles y reparaciones con menor contaminación del aire.