A PRACTICAL APPROACH TO ENERGY MANAGEMENT IN A SUGAR FACTORY

By G. F. MANN

(C G Smith Sugar Limited, Sezela Mill)

Abstract

Any attempt at Energy Management in a sugar factory is constituted of two basic aspects: the installation of suitably energy-efficient equipment in the factory, and the energy-conscious operation of the factory. The paper deals essentially with the second, ie the operational aspects, and proposes a strategy using the "Management by Objectives" approach to optimising energy efficiency by minimising unnecessary energy consumption. Wherever possible standard factory control parameters are used in monitoring the programme, obviating the need for large numbers of flow measuring devices, and making report generation simple.

Introduction

In some way or other energy management is of concern to every sugar factory, be it because of the need to dispose of excess fuel (bagasse), or because of the need to import supplementary fuel. The proposals on a simple energy management approach which follow are applicable specifically to factories which have a bagasse fuel deficit and are required to buy-in additional fuel; but the principles applicable to energy conservation (provided adequate factory equipment is available) may be put to good use in factories where excess fuel is a concern.

When an energy management programme is instituted a number of different approaches are possible. One is the rigorous monitoring of energy levels entering the factory, and monitoring the energy consumption levels at the various stages of production, with a view to being able to account for energy expenditure and so work towards reducing the overall energy account. In another, and this is the subject of this paper, attention is focused not on how much energy is expended where, but rather on minimising energy expenditure in areas where this is under the control of the factory operators.

Both approaches have advantages and disadvantages. In the first approach the actual energy efficiency of sections of the factory is measured. This inevitably requires the measurement of numerous mass flow rates with the associated expense and manpower requirement. In the proposed approach only the controllable components of the efficiency calculation are measured, something which is easily done and most of which is part of normal routine factory control data.

Setting up the energy management programme

Any attempt at improving the energy efficiency of a plant such as a sugar factory requires that two interdependent aspects be afforded individual attention. The first aspect is the intrinsic energy efficiency of the individual items of equipment in the factory, and the second is the manner in which the equipment is operated.

The subject of installed energy efficiency of machinery is very broad and will not be covered here except to mention the significant impact on energy consumption of high-efficiency boilers, high efficiency prime movers, sound thermal insulation, and the extended use of vapour bleeding and vapour recompression. In general, sugar factories have equipment spanning wide ranges of energy efficiencies, and any progress made in improving on equipment efficiency tends to be capital intensive, and spans a long time period.

On the other hand decisions aimed at improving factory operating energy efficiencies tend to be inexpensive are continually reviewed, and are made by the factory operators. Operating criteria which impact on energy efficiency can easily be identified and acted on, but not all energy-related criteria are within the control of the factory operators, and many of them have other influences of greater importance than the energy efficiency considerations. Examples are the imbibition rate and moisture % bagasse, and in these instances it is necessary either to compromise or to exclude the parameter as an energy indicator altogether.

Energy management by objective

The basis of this approach to Energy Management entails the isolation of the various factory operations which consume energy in any form, identifying the control criteria used which are operator influenced, and finally setting ever improving target values for the operators.

Having embarked on such a strategy one may be assured of the following:

1. Operators are aware of the need for energy conservation, and have regular tangible feed-back on their achievements in the form of frequently measured values.
2. Although absolute values of energy efficiency are not measured, where energy consumption is in the hands of operators as much as possible is being done to ensure efficient energy use.

Energy centres and the associated control parameters

Boiler station

There are a number of operating parameters under the direct control of the boiler operators which impact on the overall efficiency of the boiler station, but those which are considered most important are as follows:

(a) Flue gas analysis: The monitoring of either the carbon dioxide or the oxygen content of flue gas may be used as an assessment of combustion efficiency. High oxygen levels indicate excessive draught through the boiler with resultant high flue gas heat loss, while low oxygen levels indicate incomplete combustion with resultant high losses in ash. In the case of carbon dioxide the opposite is true, ie high carbon dioxide levels indicate incomplete combustion, and low levels excessive draught. In this instance a range of values considered most suited to each individual boiler installation should be given as a target to the boiler operators.

(b) Unburnt Carbon in Ash: This is a good measure of combination of factors such as fuel-to-air ratio and grate speed/dumping frequency. A target range should be set for this value, (1–2% in the case of a bagasse fired boiler, and 10–15% in the case off coal firing). Care should be exercised not to go below the minimum value, as below this figure the gains in combustion efficiency are more than likely outweighed by the losses in excessive draught through the furnace.

In a boiler fired on coal, ash collected off the grate would give a satisfactory sample, but in the case of bagasse, it being largely burnt in suspension, the ash recovered from flue gases ought to be monitored as well, with a target range of 40 to 50% unburned carbon.

(c) Boiler Steaming Rate: A boiler generally operates at its highest efficiency when steaming at or near to its MCR. It is of course difficult for the boiler operators to adjust the total steam demand of a factory, but in instances where a number of steam generating units are employed attention to this detail may allow the shutting down of one unit altogether as the load is distributed to the other units.

Power station

The efficiency of electricity generation is largely governed by the design of the equipment availabile and there is not much that can be done by the operators in ensuring optimum efficiency other than to operate each machine as near to its rated capacity (in terms of power output) as is practically possible.

Processing operations

In any factory where it is necessary to let-down live steam to the exhaust range the determinant of the overall steam requirement of the factory is (to all intents and purposes) the factory backend where the principal activity is the evaporation of water. It therefore follows that significant energy conservation gains may be achieved by reducing the amount of water added to the various product streams. In many instances this water is added to improve sugar recoveries, in others it is added to improve sugar quality, and in others still it is added as a convenience to operators. Whatever the reason all these streams should be monitored carefully, but it is not proposed that each stream be measured separately — on the contrary it is often more expedient to measure added water indirectly as product brix, especially in instances where processing interests are in conflict with energy conservation interests.

The following measurements are considered useful in assisting in the reduction of water added to process:

Raw house

(a) Imbibition rate. An imbibition rate which best fits the balance between maximising extraction and minimising additional high pressure steam let-down should be determined according to the situation at the particular factory, and set as a fixed target for the operators.

(b) Evaporator feed make-up. Any make-up of water to the evaporator feed tank (clear juice tank) should be measured and reported against a target of zero. It may be argued that the volume of make-up required is a function of the number of mill stops and as such is out of the control of the evaporator operator, but there are a number of steps the pro-active operator can take to reduce the overall evaporation rate, such as reducing the steam flow to the last 2 or 3 effects, shutting off steam to the clear juice heaters, in the case of multiple vessel first-effects shutting off steam to one of the vessels, or perhaps even increasing the syrup brix.

(c) Syrup Brix. Multiple effect evaporation as in a conventional evaporator station is far more efficient than single effect evaporation as in a pan, and it therefore follows that evaporator syrup brix should be at the highest level possible. It is believed that a good target syrup brix is 70 as this allows for a small error in over-brixing, and further, anything much above 70 brix will generally lead to an increase in the amount of movement water required on the A strike pans.

(d) Filtrate Brix. Measuring the volume of filter wash-water, be it related to cane crush or whatever else, is not considered as good a measure of control of the use of wash water as is the brix of filtrate. Filtrate brix is a function of the volume of wash water added and clear juice brix, and so a target filtrate brix a number of units lower than the clear juice brix may be set, or if it is assumed that the lower the clear juice brix the less wash water is required (for a constant pol % cake) a fixed value for filtrate brix may be preferred. Improving the efficiency of wash water application will enable higher target values for filtrate brix to be set, while maintaining a constant pol % cake.

(e) Pan Movement Water. The use of movement water on refined, A, B, and C pans should be monitored separately and related to the volume of massecuite produced.

(f) A and B pan feed. Where A and B molasses blow-up facilities are used, target brix values for the two products should be set. It is believed that 70 brix should be used in both cases as this will require minimal movement water use, and provided the molasses temperature is correct (70°C) it is safe to assume that all crystal in the molasses will have dissolved.

(g) Remelt. The brix of remelt is affected by water or clear juice added to B and C sugars be it for initial magma production or for melting itself. In addition it is common practice for floor washings in the vicinity of the centrifugal station to be pumped into the melter, so all water used for washing will also be measured as remelt brix. As is the case for syrup, a brix of 70 is considered a good target.

It is not advocated that centrifugal wash water volumes be measured because the over-riding determinant of the quantity of water used is the quality of sugar the operator wishes to produce. Also, water added on the A and B centrifugals will ultimately be compensated for in the blow-up process, and the quantity of water added on the C centrifugals is determined more by the desired C sugar quality than by energy considerations.

(h) Sweet-water. Water used in the sugar drier dust arrestors must be minimised. If the sweet-water is not used for B and c sugar melting its brix should be monitored and maintained as high as the system will permit.

Refinery

(i) Raw sugar melt. Raw sugar melt brix should be maintained as high as the refining process employed permits, with the ceiling probably being 70° brix.

(j) Decolourised Refined Liquor. Operators should aim at minimising the drop in brix between melt and decolourised liquor. An initial target of 3 units is suggested.

(k) Fine liquor. This should be seen in the same light as syrup with similar brix targets being set.

(l) Evaporator Feed Make-up. As is the case for the raw house evaporator supply tank the target make-up requirement should be zero.

(m) Refinery sweet-water. As long as all sweet-water is used for melting or other process purposes and satisfactory product brixes are achieved, there is no need to be concerned about the quantity of sweet-water as far as energy management is concerned. If excessive amounts of sweet-water are generated operators would do well to set ever-increasing brix targets until such time as the sweet-water excess disappears or sucrose losses in filter cake become excessive.

Measuring equipment

Flue Gas Carbon Dioxide Levels

A "Fyrite" analyser may be used to give an instantaneous reading of the CO_2 level in flue gas, but a continuous on-line measurement is preferable. Instrumentation for the continuous measurement of CO_2 tends to be far more complex than that for O_2 measurement which makes CO_2 based control less attractive then O_2 based control.

Flue Gas Oxygen Levels

Instantaneous readings may be obtained using the "Fyrite" apparatus, but as with carbon dioxide, a continuous, on-line reading obtained using a zirconia cell is more useful. The continuous reading may be integrated and recorded, but its greatest value is to be found in the use of the oxygen measurement as a trim on the boiler air flow control, especially where more than one fuel type is used, or if the fuel quality is prone to change, such as is the case of bagasse at different moisture levels.

Carbon in Boiler Ash

A commercially available carbon in ash test unit which measures the electrical resistance of a ground sample of ash is best suited for this purpose. Neither sampling nor sample preparation for this determination is easy, and particular attention is required to these aspects if reliable results are to be obtained.

Water flow

There are a number of flow measuring devices on the market, varying considerably in reliability, accuracy and price, but experience has shown it worthwhile to incur the additional cost of magnetic flow meters. Whatever the case it is important that the device is correctly sized for the duty, and correctly installed.

Programme monitoring

The success of a project of this nature hinges on the quality of reporting and feedback to the operators. An easy to read report, highlighting variances from targets, is required on a regular basis and should be followed up by informal discussion between supervisory staff and operators. The report should also be a discussion point for factory management on a regular basis.

A suggested lay-out of the report is shown in Appendix I, but whatever format is chosen four essential elements need to be shown, and they are: (1) the value being measured, (2) the target agreed on for the value, (3) the measured value for the period, and (4) the measured value to-date.

Conclusion

Significant gains in energy conservation may be made by concentrating on the operator-controlled factory activities which impact on the overall energy balance. It is suggested that this is best done by involving the operators concerned in decisions made in this regard, and the management-by-objective approach is most suitable.

It must be borne in mind that other operational aspects, not under the influence of the operators, can have a significant impact on overall energy efficiency. The most noteworthy of these is the overall time efficiency — low time efficiencies are incompatible with good energy efficiencies.

APPENDIX 1

ENERGY MANAGEMENT CONTROL

BOILER STATION	Target 02	Actual 02	Target C% Ash	Actual C% Ash
Boiler No. 1	5–7	6	1–2	2
Boiler No. 2	5–7	5	10–15	11
Boiler No. 3	5–7	7	10–15	14
Boiler No. 4	5–7	3	10–15	16

	Units	Target	Actual	To-date
EXTRACTION				
Imbibition on Fibre	%	420	412	422
RAW HOUSE				
Evaporator make-up	Tons/week	0	65	36
Syrup Brix		65	68	64
Filtrate Brix		8	8	7
Movement Water A	kg/m³ mct	75	72	78
Movement Water B	kg/m³ mct	25	23	25
Movement Water C	kg/m³ mct	25	21	24
Blow-up Brix A		70	72	71
Blow-up Brix B		70	69	70
Remelt Brix		70	67	69
Sweetwater Brix		15	15	16
REFINERY				
Raw Melt		65	66	65
Decolour Liq ΔBx		3	4	3
Fine Liq Brix		65	63	64
Evaporator make-up	Tons/week	0	12	14
Sweetwater Brix		5	6	5
COAL BURNT	Tons/week	100	128	106