

A PRACTICAL STEAM BALANCE

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General

For the design of the new Amatikulu Mill, two steam balances were drawn up. The first one aimed at a high degree of steam economy with a consequent surplus of bagasse, while the second was calculated for a lesser degree of steam economy so as to eliminate an embarrassing excess of bagasse.

As the latter represents the conventional approach to the problem, only the first one will be dealt with.

The scheme to be discussed includes electrically driven mills, a high degree of vapour bleeding, partial heating of cold mixed juice with the aid of condensates and the application of thermo-compression.

The capacity of the new mill will be 250 t.c.h. and 60 per cent imbibition on cane is to be applied.

Provision has been made for the remelting of all B and C sugars with a view to improving the quality of the raw sugar.

Available Steam

(450 p.s.i.g.—700°F TT)

The Lower Calorific Value of bagasse with a sucrose content of 2 per cent and a moisture content of 51 per cent amounts to:

$$7650 - 18 \times 2 - 86.4 \times 51 = 3208 \text{ B.Th.U./lb.}$$

Although for the modern type of bagasse-fired boiler an efficiency of almost 82 per cent is guaranteed, a value of 77.5 per cent is taken to calculate the B.Th.U.'s transmitted to the boiler feed. This quantity will then be 2486 B.Th.U./lb.

The total heat of steam at 450 p.s.i.g.—700°F TT is equal to 1358 B.Th.U./lb.

For boiler feed water at 228°F, the B.Th.U.'s to be transmitted to generate 1 lb. of steam = $1358 - (228 - 32) = 1162$ B.Th.U./lb.

Hence, $2486 : 1162 = 2.14$ lbs. of steam of above specification can be raised from 1 lb. of bagasse.

At 35 per cent bagasse on cane, the available steam will be $35 \times 2.14 = 74.9\%$ on cane or 374,500 lbs./h for a crushing rate of 250 t.c.h.

Live Steam to Prime Movers

The total power consumption of the electrically driven milling plant consisting of 2 sets of knives, shredder and seven mills, is estimated at 4610 b.h.p. which will represent 3820 k.w. at the power house switchboard.

A value of 15 k.w./t.c.h. is taken for the power required for all other purposes in mill, factory and village. This will amount to a total of 3750 k.w.

The grand total is, therefore, 7570 k.w. and at a steam consumption of 20 lbs. per k.w. the steam required will be $7570 \times 20 = 151,400$ lbs./h.

Process Steam Requirements

The calculations of the process steam requirements for juice heating and evaporation are based on the quantities shown on the flow sheet in Fig. 1.

I. Mixed juice heating

This heating will be done in 4 stages viz.

(a) primary heating — 1st stage from 80°—118°F in liquid liquid heat exchanger using condensates to be employed as imbibition water.

(b) primary heating — 2nd stage from 118° — 178°F with vapour II.

$$\text{Required are: } \frac{250 \times 2000 \times 151.5 \times 0.9 (178-118)}{100 \times 970}$$

$$= 42,200 \text{ lbs./h.}$$

$$\text{ex flash condensates } \underline{12,200 \text{ lbs./h.}}$$

$$\text{Actual } \underline{\underline{30,000 \text{ lbs./h.}}}$$

(c) Secondary heating from 173° — 198°F with vapour II.

$$\text{Required are: } \frac{250 \times 2000 \times 152.5 \times 0.9 (198-173)}{100 \times 970}$$

$$= 17,700 \text{ lbs./h.}$$

(d) final heating from 198° — 216°F with vapour I.

$$\text{Required are: } \frac{250 \times 2000 \times 152.5 \times 0.9 (216-198)}{100 \times 958}$$

$$= 12,900 \text{ lbs./h.}$$

II. Clear juice heating

The first stage of this heating will be done with vapour I while for the final stage steam at 15 p.s.i.g. will be used:

$$(a) \text{ first stage: } \frac{250 \times 2000 \times 132 \times 0.9 (218-200)}{100 \times 958}$$

$$= 11,200 \text{ lbs./h.}$$

$$(b) \text{ final stage: } \frac{250 \times 2000 \times 132 \times 0.9 (232-218)}{100 \times 946}$$

$$= 8,800 \text{ lbs./h.}$$

III. Vacuum Pans

For the J.A. boiling scheme (remelting of all B and C sugars) the required quantity of vapour I will be $39 \times 1.1 \times 2000 = 86,000$ lbs./h.

IV. Centrifugals, Sugar dryer and pan steaming

The required quantity of 15 p.s.i.g. steam is estimated at 14,000 lbs./h.

V. Deaerator

The quantity of 15 p.s.i.g. steam to be available for this purpose has been calculated at 9,000 lbs./h.

VI. Evaporator

A quantity of $\frac{250 \times 2000 \times 132 \times (1 - 12/65)}{100}$
 = 538,000 lbs. of water has to be evaporated per hour.

With the application of thermo-compression i.e. vapour II with the aid of live steam (450 p.s.i.g.—700°F TT) recompressed to 15 p.s.i.g. the following will be the total evaporation achieved by the quin-truple effect:

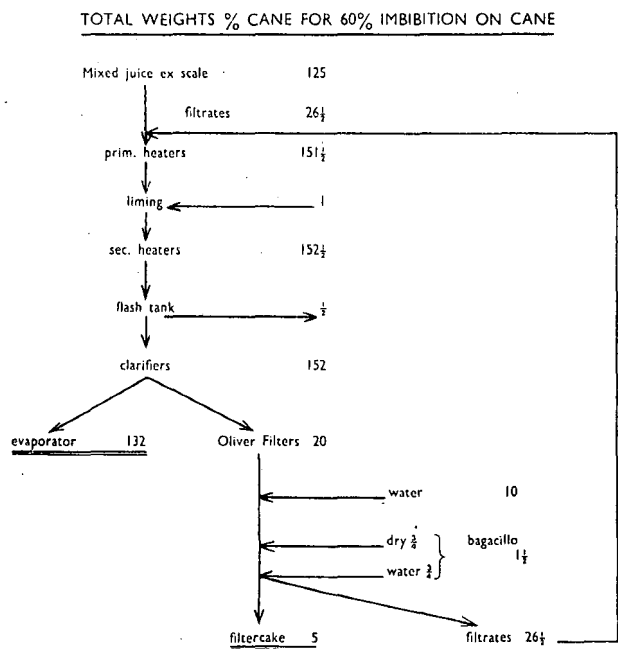
5th effect: x
 4th ,, x
 3rd ,, x
 2nd ,, x + 30,000 + 17,700 + Vap,II for T.C.
 1st ,, x + 30,000 + 17,700 + Vap,II for T.C. +
 + 12,900 + 11,200 + 86,000

$$538,000 = 5x + 205,500 + 2x \text{ Vap. II for T.C.}$$

$$x = 66,500 - 0.4 \times \text{Vap. II for T.C.}$$

Fig. 1.

**FLOW SHEET JUICE CLARIFICATION
 DEFECATION PROCESS**



Let E.S. be the quantity of available exhaust steam and L.S. the quantity of live steam required for thermo-compression.

Equating the weight of the heating steam to the weight of vapour produced in the first vessel:
 E.S. + L.S. + Vap. II for T.C. = x + 30,000 + 17,700 +
 + Vap. II for T.C. + 12,900 + 11,200 + 86,000
 or E.S. + L.S. = x + 157,800

When x is now substituted by above value:

$$E.S. + L.S. = 224,300 - 0.4 \times \text{Vap. II for T.C.}$$

As for our conditions 1.2 lbs. of live steam are required to recompress 1 lb. of Vapour II, the "live steam to T.C." can be replaced by the value of 1.2 x Vap. II for T.C. or : E.S. = 224,300 - 1.6 Vap. II for T.C.

The quantity of available exhaust steam is equal to the quantity of live steam to prime-movers reduced by radiation losses and exhaust steam required for other purposes

$$151,400 - 4,600 - 8,800 - 14,000 - 9,000 = 115,000 \text{ lbs./h.}$$

When this value is substituted in above formula it appears that the quantity of Vapour II for T.C. amounts to 68,310 lbs./h. and the live steam for thermo-compression will consequently be 1.2 x 68,310 = 81,975 lbs./h.

The steam balance can now be drawn up as in Table 1.

Expressed in terms of the thermal equivalent bagasse weight the surplus steam amounts to 29.2 tons per hour or 700 tons per day.

Conclusions

This apparently embarrassing surplus of bagasse could be used for following purposes:

1. For paper and board manufacturing.
2. An amount of approximately 13,400 k.W.h. of power could be made available to either the Electricity Supply Commission or for local irrigation. In this case no thermo-compression would be applied, the shortfall in 15 p.s.i.g. process steam to be supplied by a self governing back pressure set.
3. For remelting of additional sugar. The calculated surplus bagasse alone would be sufficient to remelt an hourly quantity of approximately 120 tons of sugar.

Summary

Of the two steam balances drawn up for the new Amatikulu Mill, the one aiming at a high degree of steam economy has been discussed. With 60 per cent imbibition on cane and remelting of all B and C Sugars, the steam consumption amounts to 50 per cent on cane. This consumption is equal to 11 per cent fibre on cane. The surplus bagasse in this scheme will be 700 tons per day which is, in itself, an impractical amount of fuel saving. However, this surplus could be used for other purposes as suggested.

Mr. Zonderland: It is not at all complicated. There is one valve on each heater and that is all. It is like a juice line supplying the heaters, going through a batch of three and then moving to the next.

Mr. Fourmond: I see that the primary heating in the first stage is in the liquid heat exchanger, and that condensate will be used for imbibition water, which will consequently have a high pH. Are you not going to dissolve more impurities from the fibre of the cane? I believe that when Mr. Wagner was at Illovo he had trouble when using condensate as imbibition water.

Mr. Wagner: That is quite true. At one stage Illovo was using water from the evaporators. At that time

Illovo was running a refinery and during that period we had a lot of filtration trouble in the refinery. After we changed over again to cold water the trouble seemed to disappear. We put it down to the fact that the temperature of the water may have been too high.

Dr. Douwes Dekker: You mean it would not filter properly because of the high temperature of the water, not the high pH?

Mr. Wagner: Yes.

Mr. Zonderland: The condensate from the last three vessels is going to be used for heating the cold mixed juice, and the temperature of the water arriving at the mill will not be more than 130° F.