THE PROBLEM OF ADDITIONAL FUEL

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Introduction

This paper comprises an attempt to impress upon all concerned that the industry is now consuming a vast and increasing amount of additional fuel, which is not negligible in comparison with total manufacturing costs. Examples are given, causes discussed and remedies proposed in the hope that a spirit of "fuel consciousness" may prevail so that the use of additional fuel may be drastically reduced and, eventually dispensed with.

Present Situation

Overall Figures

The final results for the 1961-62 and former crops reveal that a majority of our factories are regularly using additional fuel to supplement their supply of bagasse. These results also indicate that the total amount of additional fuel used by these factories is increasing every year.

TABLE 1. — CROP 1961-62

QUANTITIES AND COST PER FACTORY AND COST PER TON SUGAR PRODUCED, OF ADDITIONAL FUEL CONSUMED

Factory	Coal, Tons used for Crop	Wood, Tons used for Crop	Total Tonnage Consumed, Crop. Coal and Wood	Total Cost at R5 per Ton (Durban). Not including Freight R	Total Tons Sugar Produced All Types *Nearest Ton*	Average Cost per Ton Sugar in Additional Fuel R.c
PG	2,889	85	2,974	14,850	53,891	0.27½
UF	25,494	8,040	33,534	167,670	111,378	1.50½
ZM	5,620	3,863	9,483	47,415	94,488	0.50
FX*	Nil	Nil	Nil	Nil	N/A	Nil
EN	203	1,216	1,419	7,095	13,350	0.53
AK	2,127	1,918	4,045	20,225	64,255	0.31½
DK	Nil	3,960	3,960	19,800	29,848	0.66
GD	Nil	2,790	2,790	13,950	11,543	1.21
DL	79	492	571	2,835	116,160	0.02½
GL	7 758	1,989	9,747	48,735	77,060	0.63
MV*	1,033	910	1,943	9,715	30,907	0.31
CK	364	410	764	3,820	21,182	0.02
TS	9,313	500	9,813	49,065	123,523	0.40
NE	25,656	Nil	25,656	128,280	90,720	1.41
IL	10,004	2,078	12,082	60,410	50,818	1.19
RN	Nil	Nil	Nil	Nil	N/A	Nil
SZ	4,528	Nil	4,528	22,640	75,603	0.30
UK	Nil	98	98	490	30,572	0.02
TOTALS and AVERAGE	95,068	28,349	123,417	617,095	995,278	0.62

* Adjusted, for the two factories diverting bagasse to secondary industries

Table 1 shows that the total of additional fuel so consumed amounted to the staggering quantity of 103,573 tons of coal and 28,349 tons of wood. To calculate the cost of the additional fuel, a Durban price for coal of R5.00 per ton has been assumed. It is difficult to obtain firm figures for the cost of wood at factory. However, hewing, stacking, haulage, unloading, handling and firing seems, by general agreement, to amount to about R5 per ton.

After making an estimated allowance for the factory supplying bagasse for paper manufacture and also deducting an agreed, calculated amount in respect of the factory producing Molameal, the South African crop total of additional fuel consumed in 1961-62 was:

95,068 tons coal and 28,349 tons wood.

Thus, the total extra fuel bill for all factories has been estimated at R617,095 and this amount does not include the freight charges for coal from Durban to the factories.

The cost of extra fuel per ton of sugar produced is also shown in Table I. This averages 62 cents per ton sugar. Particularly disconcerting is the fact that the cost for individual factories varies over a very large range, i.e. from nil to R1.50½ per ton sugar produced and it is suggested that a thorough investigation into the causes of the very high figures is extremely desirable.

A warning was sounded in the 36th Annual Summary of Chemical Laboratory Reports of South African Sugar Factories, Season 1960-61, page 4, section H. Here, Mr. Chas. Perk says — and I quote — "as the Natal factories have always had more than sufficient bagasse to cover their fuel demands, there has never been the same necessity for controlling instruments in the boiler house as in those countries where the fibre content of the cane is low and the sucrose content high. Also, since sufficient steam could be raised to meet the factory demands, no special measures were introduced to reduce the steam consumption" — and — "nowadays we cannot say anymore that there is an abundancy of natural fuel at *all* factories".

That this last condition exists at some factories is clearly obvious but even then their cane fibre content position is much more favourable than that of many other factories elsewhere in the world.

Numbers of these factories also produce white sugar, operate distilleries and other enterprises, using only the natural bagasse as fuel, with an average fibre content of cane one to two per cent lower than in South Africa.

Causes of the Present Unsatisfactory Situation

In order to obtain comparable results, fuel, B.T.U.'s and steam data should always be related to the tonnage of brix in raw juice worked and this has been done in the calculations to be discussed later. First, however, we shall discuss items which may be of general importance.

In the past, when cane fibre content was even higher than it is now, no factory wished to accumulate an embarrassing surplus of bagasse. Therefore, most of it was burnt as it was produced, at low boiler efficiencies, in order to get rid of it. Small amounts of coal and wood were also used for starting up at the commencement of the crop and often after the weekly shutdowns. Now, over the years, the crushing rates of the factories which used additional fuel, have increased considerably, so that nobody seemed concerned or disturbed when the additional fuel bill rose with the crushing rate. It is necessary, however, to examine to what extent the prevailing low, average Boiler Efficiencies and general waste of steam unwittingly permitted at many factories have also played a role.

Factors affecting the efficient use of existing fuel and also causing waste of steam are: wet bagasse, low furnace and boiler efficiencies in some cases, live steam and exhaust steam used in excess while vapour (or heat) is wasted in other ways, low brix syrup and over-high volume (cu. ft.) massecuites per ton cane. A very important factor could have been a possible drop in fibre content of the cane in the last few years.

The average fibre content per cent cane has dropped, it is true, from 16.1 per cent in 1952 to 14.52 per cent in 1961-62. Some factories, however, show negligible decreases (see Table 2) but substantial increases in additional fuel used. The greatest decrease in fibre content between any two years of the last ten was in the season just concluded — from 15.22 to 14.52 or 0.70 per cent. It is interesting to note that this did have a marked effect on the quantity of additional fuel used. Had the fibre content remained at 15.22 per cent cane, the industry would have benefitted generally by an extra 65,689 tons of fibre for combustion (0.70 per cent of the 9,384,090 total tons cane crushed).

In terms of bagasse at crop average for 1961-62 of 52.54 per cent moisture and 2.43 per cent pol, this fibre would have appeared as 100,201 tons of average bagasse, of 3,089 B.T.U.'s per lb. L.C.V. The equivalent amount of coal, of a L.C.V. of 12,000 B.T.U.'s per lb., is 26,418 tons and, other things being equal, it is reasonable to expect an increase in extra fuel consumption for last crop of about that amount. The increase did not reach this amount, but was 22,495 tons net equivalent in coal (from 80,628 tons to 103, 573 tons, see Table 4).

In other respects, the fibre deficiency over the years does not account for the heavy increase in additional fuel, which was out of all proportion to any loss of combustible matter due to a small fibre content drop. Furthermore, it does not help us as to why factories here use so much additional fuel when their counterparts in other countries, producing refined sugar from cane of lower fibre content, do so without the use of any additional fuel whatsoever.

TABLE 2.

FIBRE PER CENT. CANE, 1952-62

FACTORY	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62
ES & PG	15.72	—	12.85	12.69	14.17	14.53	13.77	13.94	13.86	13.77
UF	12.95	13.40	12.83	13.48	14.86	14.19	13.95	13.50	13.41	12.78
ZM	17.36	17.13	16.91	16.82	17.18	16.74	17.51	16.85	15.80	14.92
FX	16.43	16.33	15.72	15.97	17.99	15.51	16.09	16.33	15.71	15.38
EN	15.92	16.33	15.83	15.62	15.55	14.17	14.47	14.91	13.79	13.63
AK	17.71	17.49	16.47	16.05	16.36	16.01	17.29	16.68	15.62	15.37
DK	16.42	17.22	16.19	15.48	15.01	14.51	15.12	15.24	15.85	14.68
GD							15.45	15.81	15.68	15.79
DL	16.67	16.42	16.04	15.78	15.57	15.01	16.04	16.53	15.09	14.81
GL	16.72	16.90	16.61	15.92	15.12	14.79	15.38	15.34	15.09	14.45
MV	15.90	16.07	15.93	16.25	15.44	15.23	15.74	15.72	14.48	14.32
CK	16.82	16.77	16.19	15.70	15.39	14.99	15.19	15.18	15.29	13.78
TS	15.61	16.04	16.11	15.51	15.51	14.46	15.00	15.33	15.13	14.41
NE	15.86	16.76	17.73	16.57	16.38	16.29	16.86	16.56	16.20	15.33
IL	17.30	18.05	16.50	16.06	15.83	15.45	15.96	16.13	15.07	13.51
RN	16.01	16.80	17.08	16.06	16.75	16.48	16.38	17.03	16.25	14.25
SZ	16.26	16.75	16.67	16.97	16.77	16.58	17.30	17.46	16.37	15.18
UK	15.36	16.33	15.04	15.05	15.66	15.46	16.00	16.00	15.93	14.73
Averages (1)	16.10	16.31	16.03	15.74	15.81	15.38	15.92	15.83	15.22	14.50
Average—10 years ..	15.66									
Lowest (2)	12.95	13.4	12.85	12.69	14.17	14.17	13.77	13.5	13.41	12.78
Highest (3)	17.71	18.05	17.73	16.97	17.99	16.74	17.51	17.46	16.37	15.79
L.C.V. Bagasse	3064	3136	3029	3003	3014	3021	3000	3000	3023	3089

Comparisons with Overseas Factories

Factories Remelting Sugar and operating their own Refineries

Some factories now remelt all or part of their sugar in order to improve the final product. This has undoubtedly increased the fuel consumption of some of those factories but it is a common practice elsewhere, and in factories which do not enjoy such a high percentage of fibre content as in Natal. Many operators of this type of factory in Natal consider that the use of additional fuel is inevitable and are resigned to a heavy annual coal and wood outlay. That this need not be so will be shown later by comparison with factories elsewhere which, milling cane of similar or lower fibre content and remelting their "A" sugars, not only operate refineries but often a distillery as well, without the use of any additional fuel during crop operations. Moreover, it does not explain why certain raw sugar factories here have lately started to consume additional fuel in increasing quantities. Two of our factories here each burn sufficient coal to operate a large beet sugar factory for one crop. One such beet factory processed 675,155 short tons beet last crop, produced 91,800 tons of direct consumption white sugar and consumed 25,655 tons of coal and no other fuel whatsoever.

Few branches of the sugar industry have become so acutely "fuel-cost minded" or "fuel conscious" as the beet sugar producers in the U.S.A. and, more particularly, the beet sugar factories in Sweden and Britain. Every conceivable method and device is employed to conserve steam, vapour and hence fuel. In the early days of the industry in Britain, 1924 to 1936, one of the larger factories then processed 2,000 long tons beet daily and often consumed over 300 tons of coal per day (15 per cent on beet). It is now slicing 2,400 tons per day, producing refined sugar and uses 92 tons of coal or only 3.8 per cent on beet. This is their most economical plant on fuel consumption but there are two others using only 4.4 per cent coal on beet.

Another of the Natal factories used additional fuel (coal equivalent in B.T.U.'s) at the rate of 7,818 tons for the crop, costing some R39,090 at Durban price. This amount of fuel was more than was required to operate the entire plant of the Selby beet sugar factory, which produces 80 long tons white sugar per day, operates coal-fired pulp driers and used only 6,964 long tons coal (or 7,800 short tons).

These comparisons with the performances of "fuel-conscious" beet sugar factories are quite fair, particularly when we consider that in the beet sugar industry the average draft water applied is about 105 per cent on beet. Hence, they have to evaporate more water than we do in the cane industry. This being so, if we take the hypothetical case of a cane factory which, for some special reason, burnt only coal as its fuel, it should be possible to operate that factory by burning less coal than a beet factory of similar output. Two of our factories burn, purely as additional fuel, far more coal than two large beet factories whose output is much greater in terms of both Brix-processed and (refined) sugar produced.

The inflated price of coal overseas, combined with the excellent incentive scheme for fuel saving introduced by one large company has combined to effect remarkable economies in fuel and steam consumption since serious measures were taken from 1946 onward.

Analysis of South African Fuel Figures

The additional fuel figures quoted for our industry are emphasized and illustrated in the accompanying tables and graphs.

Table 3 indicates tons brix processed, all factories, over the last ten years — i.e. it pictures the expansion of the industry's production. Table 4 indicates the additional fuel used over the same period, in tons. Figures 1 and 2 illustrate both and it is at once obvious that the rise in tonnage of additional fuel is out of all proportion to the rise in production, although the fibre content had only decreased by 1.58 per cent as previously outlined.

However, not all the factories covered in Tables 3 and 4 and used additional fuel during the ten year period. Therefore, it is worth considering the situation of those which have done so since 1952. Then, only six factories officially submitted crop returns in which any additional fuel was included.

One of these now supplies bagasse to a secondary industry and we therefore deal with the other five. Table 5 sets out 1952-53 crop to 1961-62—

(*a*) Available B.T.U.'s in Total fuel consumed per pound Brix in mixed juice.

(*b*) Available B.T.U.'s in bagasse per pound Brix in mixed juice.

(*c*) Available B.T.U.'s in additional fuel per pound Brix in mixed juice.

(*d*) Column (*c*) above, expressed as a percentage of Column (*a*).

Figures 3 to 6 illustrate these results by graphs and, it is suggested, the curves produced are worthy of a little study.

TABLE 3

TONS BRIX PROCESSED 1952-62

FACTORIES	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62
	CROP YEAR									
ES & PG	23,922	—	22,982	45,970	54,283	57,213	56,117	78,070	68,161	68,682
UF	83,724	107,813	106,542	111,086	109,066	104,687	120,145	134,204	143,155	150,206
ZM	59,434	64,405	86,280	102,953	93,058	98,951	109,308	79,731	110,712	121,650
FX	74,583	69,830	76,872	95,075	89,439	110,637	136,895	107,398	104,463	106,996
EN	8,383	8,568	10,156	9,651	7,763	12,716	16,192	15,629	15,328	16,644
AK	73,736	68,600	77,623	83,763	70,750	78,349	92,298	75,240	82,383	83,241
DK	19,174	19,553	23,901	24,858	250,84	27,259	45,889	41,707	33,627	37,688
GD	—	—	—	—	—	12,234	16,376	18,958	12,445	15,081
DL	79,280	116,775	128,532	143,295	116,904	141,955	171,661	139,741	124,350	146,351
GL	54,367	62,835	63,390	75,522	69,202	84,067	103,579	95,082	83,735	96,762
MV	21,082	21,419	27,226	35,631	28,174	37,220	43,071	36,428	35,523	38,677
CK	31,616	31,012	31,190	32,023	25,461	30,077	34,482	31,333	29,189	27,131
TS	109,739	117,846	127,433	133,227	130,780	145,412	171,624	161,836	142,420	152,805
NE	98,962	104,549	113,531	129,548	116,093	119,975	136,326	126,714	111,513	122,951
IL	27,356	27,100	34,432	34,880	39,213	41,963	54,950	39,981	45,957	66,127
RN	22,096	29,078	28,369	27,788	26,112	29,822	37,330	33,312	27,933	30,635
SZ	43,350	68,766	74,353	79,553	66,438	82,582	105,734	103,215	86,459	93,439
UK	11,896	10,960	14,946	14,859	15,757	21,529	28,192	34,199	33,120	37,370
TOTALS OF ALL FACTORIES	830,804	929,109	1,047,758	1,179,682	1,083,577	1,236,648	1,480,169	1,352,778	1,290,473	1,412,436

TABLE 4

TONS ADDITIONAL FUEL CONSUMED EACH CROP, 1952-62

(The first figure in each case, "C" refers to coal, the second, "W" to wood consumed)

FACTORY		1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62
PG	C	N/O	N/O	1,564	2,721	1,350	770	490	2,105	1,680	2,889
	W			300	Nil	200	130	22	140	80	85
UF	C	331	1,109	231	411	290	1,390	1,111	7,260	23,105	25,494
	W	6,035	3,752	4,657	4,064	2,695	4,348	1,850	5,510	9,690	8,040
ZM	C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	3,940	5,620
	W	2,680	1,859	2,297	2,100	2,821	4,527	5,050	7,749	6,929	3,863
FX	C	883	2,373	3,627	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	W	2,500	1,713	2,115	Nil	Nil	Nil	Nil	Nil	Nil	Nil
EN	C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	248	203
	W	2,735	1,633	2,092	3,024	1,634	2,118	2,260	Nil	2,063	1,216
AK	C	190	440	45	1,230	2,844	5,577	3,457	3,299	3,314	2,127
	W	940	2,584	2,995	Nil	1,204	1,015	640	1,250	2,161	1,918
DK	C	30	70	24	4	Nil	Nil	Nil	Nil	Nil	Nil
	W	1,208	541	2,401	1,989	2,711	3,875	5,700	1,247	5,771	3,960
GD	C	—	—	—	—	—	—	Nil	Nil	Nil	Nil
	W	—	—	—	—	—	—	2,267	Nil	Nil	2,790
DL	C	689	231	170	2,367	3,408	4,873	3,526	1,480	109	79
	W	2,167	980	1,055	2,210	2,812	2,568	1,479	,1452	1,616	492
GL	C	—	—	—	—	—	—	2,685	2,634	4,618	7,758
	W	—	—	—	—	—	—	2,401	3,211	2,604	1,989
MV*	C	144	380	90	245	1,954	2,514	3,741	,1643	2,795	1,033
	W	455	1,612	810	910	1,268	1,052	633	510	1,050	910
CK	C	—	No figures submitted			—	—	—	—	—	364
	W	—				—	—	—	—	—	410
TS	C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	5,834	9,313
	W	80	60	Nil	100	80	250	400	330	1,609	500
NE	C	—	No figures submitted			—	—	—	—	16,075	25,656
	W	—				—	—	—	—	Nil	Nil
IL	C	—	No figures submitted			—	—	—	—	4,740	10,004
	W	—				—	—	—	—	3,068	2,078
RN	C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	W	Nil	640	140	[illegible]20	175	80	70	Nil	Nil	Nil
ES	C		N/A	N/A							
	W	561									
SZ	C	Nil	Nil	Nil	Nil	Nil	1,633	635	1,620	3,032	4,528
	W	327	340	680	[illegible]93	582	Nil	105	144	150	Nil
UK	C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	W	68	268	49	55	55	80	278	180	335	98
TOTALS ..	C	2,267	4,603	5,751	6,[illegible]78	9,846	16,757	15,645	20,041	69,490	95,068
TOTALS ..	W	19,756	15,982	19,591	15,[illegible]65	16,237	20,043	23,155	21,723	37,126	28,349

*Adjusted in Tons Coal for factories supplying Bagasse for Paper Mill and "Molameal"

equivalent as coal of 12,000 B.T.U.'s/lb. of total wood consumed

		1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62
		5,927	4,795	5,877	4,[illegible]70	4,871	6,012	6,946	6,517	11,138	8,505
Add Coal (Net TOTALS)		8,194	9,398	11,628	11,[illegible]48	14,717	22,769	22,591	26,558	80,628	103,537

Thus, the last line, net total all additional fuel in terms of equivalent coal, is that used for the purposes of the graph, Fig 2.

Total Coal used as Additional Fuel over ten crops	246,446 tons
Total Wood used as Additional Fuel over ten crops	217,437 tons
or, Total Coal used as Additional Fuel over ten crops adjusted for factories supplying bagasse elsewhere	311,704 tons

TABLE 5

HEAT VALUE, FUELS CONSUMED PER POUND BRIX IN MIXED JUICE, CROPS 1952/53 TO 1961/62 FOR FIVE FACTORIES USING ADDITIONAL FUEL OVER THAT PERIOD

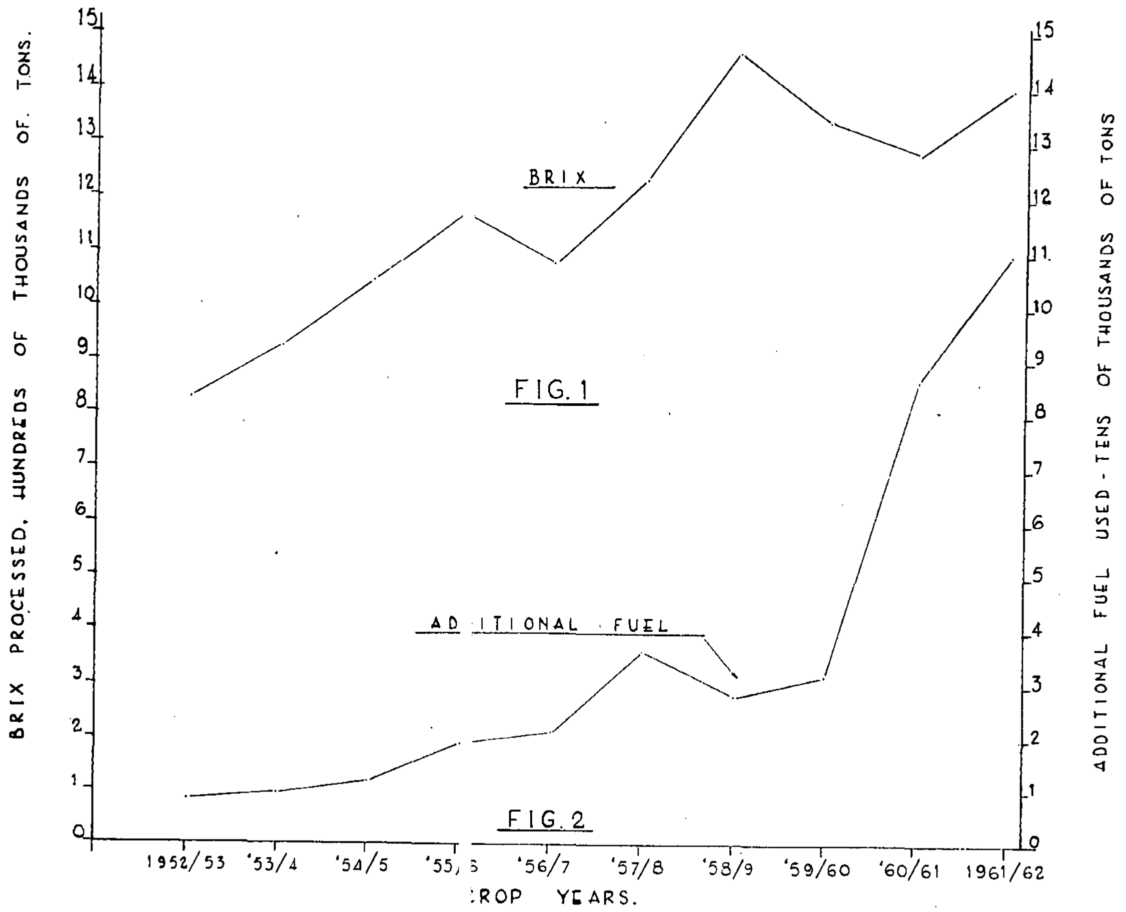
Each Column "A" = Available B.T.U.'s in Total Fuel consumed per pound Brix in mixed juice.

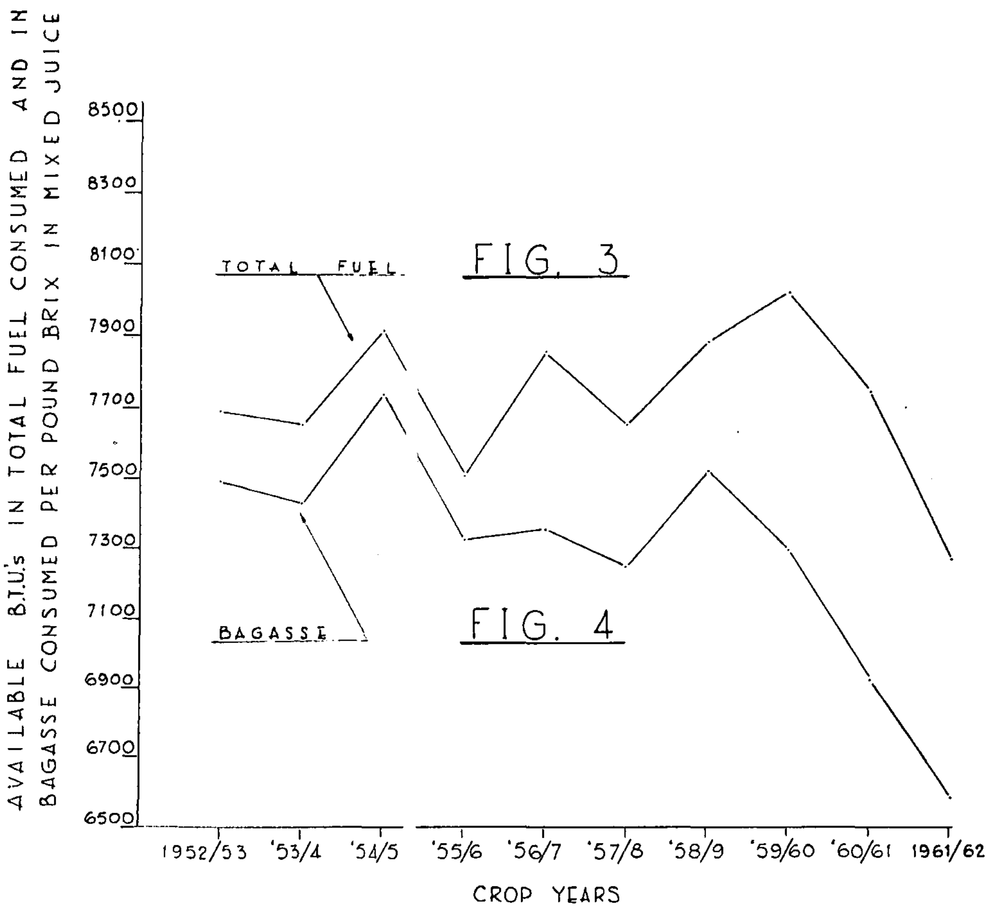
Each Column "B" = Available B.T.U.'s in Bagasse per pound Brix in mixed juice.

Each Column "C" = Available B.T.U.'s in Additional Fuel per pound Brix in mixed juice

Each Column "D" = "C" expressed as a percentage of "A".

	Factory 1				Factory 2				Factory 3				Factory 4				Factory 5				Averages, Five Factories			
Crop Year	A	B	C	D %	A	B	C	D %	A	B	C	D %	A	B	C	D %	A	B	C	D %	A	B	C	D %
1952-53	6,474	6,167	307	4.74	8,282	6,868	77	0.93	7,943	7,698	245	3.08	8,198	7,996	203	2.48	7,549	7,389	160	2.12	7,689	7,224	198	2.57
1953-54	6,431	6,182	249	3.87	7,412	7,200	213	2.87	8,341	8,237	104	1.24	8,015	7,961	54	0.67	8,026	7,542	484	6.03	7,645	7,424	221	2.90
1954-55	,6031	6,118	182	2.89	8,183	8,037	146	1.78	8,775	8,415	374	4.26	8,215	8,170	45	0.55	8,073	7,926	147	1.82	7,909	7,733	179	2.26
1955-56	6,412	6,236	176	2.74	7,516	7,463	53	0.70	7,813	7,524	290	3.71	7,657	7,403	254	3.32	8,102	7,927	174	2.15	7,500	7,311	189	2.52
1956-57	7,127	7,019	108	1.51	8,217	7,673	544	6.62	7,771	7,382	389	5.01	7,655	7,219	436	5.70	8,462	7,468	994	11.74	7,846	7,352	494	6.30
1957-58	6,982	6,674	308	4.41	8,484	7,583	901	10.62	7,860	7,348	512	6.51	7,636	7,159	477	6.25	8,383	7,471	912	10.88	7,869	7,247	622	7.90
1958-59	6,497	6,331	166	2.55	8,688	8,213	474	5.45	7,765	7,317	447	6.11	7,942	7,664	277	3.49	8,701	7,606	1096	12.59	8,009	7,426	492	6.14
1959-60	7,097	6,300	797	11.23	8,190	7,604	586	7.15	7,396	7,288	108	1.46	7,745	7,580	164	2.12	8,262	7,671	592	7.16	7,738	7,289	449	5.80
1960-61	8,442	6,262	2180	25.82	7,717	7,206	528	6.84	8,251	7,635	618	7.49	6,843	6,787	57	0.83	7,898	6,846	1050	13.30	7,830	6,947	887	11.33
1961-62	8,103	5,873	2230	27.52	7,461	7,072	390	5.22	7,264	6,886	378	5.20	6,575	6,557	18	0.27	6,912	6,507	405	5.86	7,263	6,579	684	9.42


BRIX PROCESSED, HUNDREDS OF THOUSANDS OF TONS.
ADDITIONAL FUEL USED - TENS OF THOUSANDS OF TONS
BRIX
FIG. 1
ADDITIONAL FUEL
FIG. 2
1952/53 '53/4 '54/5 '55/6 '56/7 '57/8 '58/9 '59/60 '60/61 1961/62
CROP YEARS.


AVAILABLE B.T.U.'s IN TOTAL FUEL CONSUMED AND IN BAGASSE CONSUMED PER POUND BRIX IN MIXED JUICE
TOTAL FUEL
FIG. 3
BAGASSE
FIG. 4
1952/53 '53/4 '54/5 '55/6 '56/7 '57/8 '58/9 '59/60 '60/61 1961/62
CROP YEARS

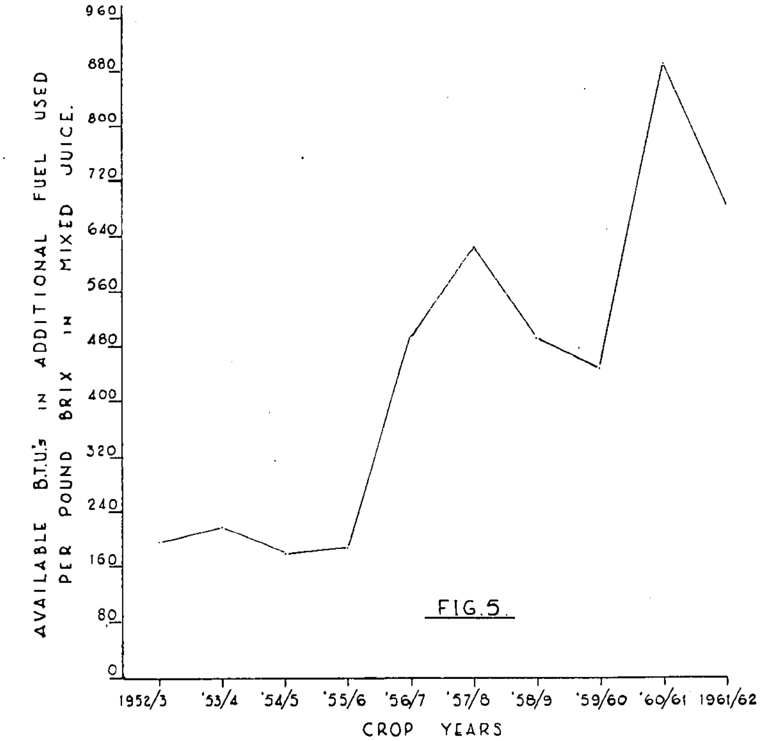


FIG.5.

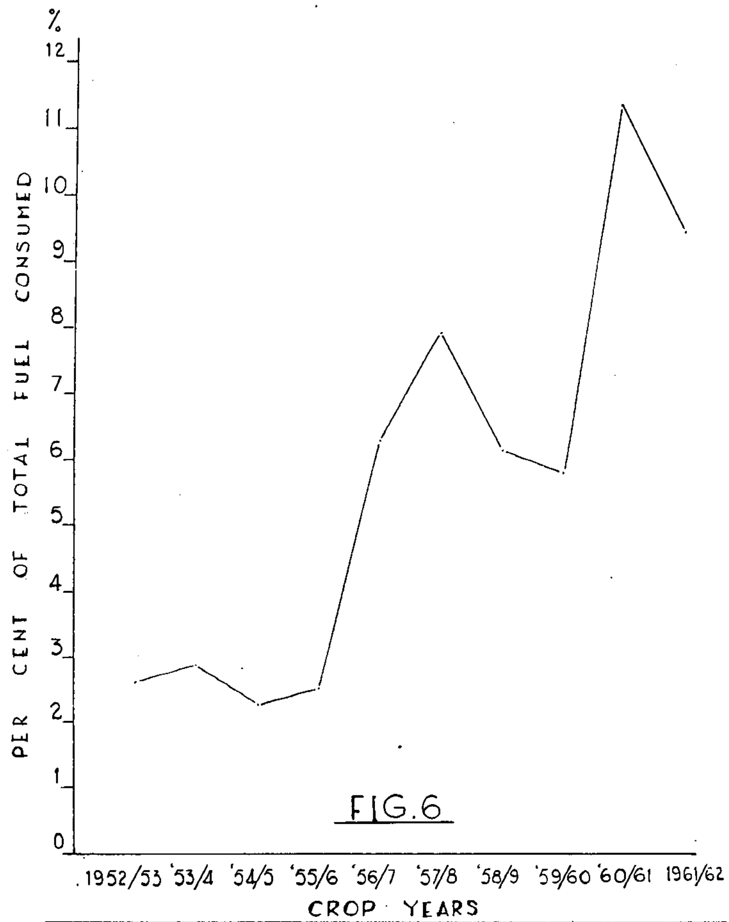


FIG.6

PERCENTAGE OF ADDITIONAL FUEL IN TOTAL FUEL CONSUMED OVER TEN YEARS, ON BASIS OF B.T.U.'s PER POUND BRIX IN MIXED JUICE.

How to remedy the situation?

To remedy this costly situation, there are many courses which may be followed, some expensive initially, some not and others peculiar only to certain factories. For example, a factory which is producing 69 per cent steam on cane and which is also producing only 81 per cent of the steam which its total bagasse should produce, but all with the aid of 25,000 tons of coal is in a different position to the factory which burns a few hundred tons of coal and wood per crop because its boiler efficiency is a little low and its processing heat balance requires attention.

There are examples of each in Natal. Although the remedy may be very different in each case, each suffers from the same shortcoming, either inefficient generation of steam, inefficient utilization of that steam, or both. It was for these reasons that Oliver Lyle asserted ("The Efficient Use of Steam") that "Ninety per cent of *all* steam-using factories can save 15 per cent of their steam in two or three years, as a result of taking out a proper steam or heat balance and then embodying the reforms or modifications indicated".

In reviewing the action to be taken if we are to achieve speedy results in dispensing with the use of additional fuel, we will first deal with the obvious and inexpensive modifications. During the S.A.S.T.A. Congress of 1939, when it had appeared that fibre content would continue to drop more than it has to date, Mr. Patrick Murray pointed out "the study of steam economy has become of increasing importance as the supply of bagasse fuel has decreased — or as bagasse may be used for by-product industries".

Therefore, commencing with the fuel freely available to us, bagasse, this is often too wet to ensure efficient combustion. Three factories here return a crop figure of over 54 per cent moisture, while only one shows a figure of less than 50 per cent, at 49.44. The average, 52.54, can only be considered as too wet for efficient combustion. Often, this condition is caused by heavy imbibition which, although it may effect a small gain in extraction, can cost more in additional fuel than the value of the extra sugar extracted. The extraction figure of the factory with 49.44 per cent moisture in bagasse, at 94.21 compares well with those turning out wet bagasse of over 53.5 per cent moisture.

Methods of reducing moisture in bagasse are outside the scope of this paper but they are many and well-known and belong strictly to milling technique. However, the Bureau of Sugar Experiment Stations, Queensland, has shown in its Laboratory Manual that a 1 per cent drop in moisture of bagasse (around 50 per cent) is roughly equivalent to 1 per cent more fuel from the same quantity and quality of cane.

Natal Boiler Efficiencies

There should be sufficient apparatus and instruments available so that proper efficiency tests can be carried out on all boilers operating in the industry, at least once per crop. A common factor in lowering efficiency is that of excess air, admitted in enormous quantities in some Natal bagasse furnaces, much of it through the bagasse feed chutes and flaps. The latter can often be seen permanently open.

A reasonably efficient boiler was selected at random by the Queensland Bureau of Sugar Experiment Stations (vide Op. Report 51/3). Unburnt fuel investigations then revealed that, due to over-excess air, 80 lbs. of carbon per hour was being lost up the stack. This represented 1.75 per cent of the heat value of the bagasse fired. It was equivalent to 20 tons wood (50 per cent moisture) per week (of 144 hours), 6 tons of Natal coal or 25 tons of average Natal bagasse at 52.54 per cent moisture, for one boiler. It should be mentioned, perhaps, that "carbon" refers to carbon solids emitted in the flue gases, 80 lbs. being the average of several tests. Fly ash, flue dust, etc. were separated from the samples.

This carry-over, of course, was only one of the many evils caused by over-excess air or secondary air, apart from air entering cracks and other "unauthorized" apertures in the fabric of the furnaces. Most if not all bagasse-fired boiler furnaces require air pre-heaters of a durable type, with properly balanced forced and induced draught and secondary air. All boilers and furnaces should be in 100 per cent condition with no brickwork leaks or defects. Correct CO_2 and CO content of flue gases, temperatures of furnaces, passes, flues and stack base with the minimum of combustion, stack and radiation losses. Feed water should be heated and metered, all followed by a boiler efficiency test for the whole range of boilers.

Fuel Target

No large surplus[5] to be envisaged but no wood nor coal to be the target. Bagasse moisture target, 48.5 per cent to 50 per cent. Any surplus, worth baling or briquetting with coal dust for use in locos, or for domestic purposes, could be stored but not transported.

Steam Lines

Live steam. Shortest route to each prime mover and power station should be followed or, where this is not possible, the ring main principle can be used with advantage. Insulation of these lines should be 100 per cent complete and of the most efficient medium.

Steam Consumption

Once the matter of efficient combustion and steam production has been settled — and no very high or ambitious target is necessary — it will still be found, in some cases, that additional fuel is being consumed, if on a lesser scale. In these instances, it is even more important that a proper heat balance should be taken out for the factory as soon as possible. This done, it will be easy to ascertain not only where the steam and vapour is going but where it should go.

Plant and piping can then be arranged accordingly. This may be expensive in some factories and would therefore be spread over two or three years but it is a matter for doubt as to whether all the modifications required would amount to the cost of additional fuel for two years at the present rate.

Reasonable, not super boiler efficiencies and use of steam is all that is required for the present. Otherwise, some factories will be threatened with an embarrassing surplus of bagasse and the cost of its removal or disposal. This is not easy since, even if there were more secondary industries using bagasse as a raw material, the railways would be unable to move it in any quantity. Their contention is that, since they transport cane, molasses and supplies they would only be able to spare for baled bagasse that number of waggons which might be freed by a decrease in the industry's coal consumption.

A reasonable target of fuel and heat efficiency would be that which is standard for several modern factories in, say, the West Indies, where coal is so expensive that it is rarely seen and fuel oil costs more than it does here.

Table 6 sets out typical performance figures for two such factories, for two crops. One is a raw house, the other operates a remelt refinery. It will be noted that their fibre content is lower than that of Natal, their bagasse drier, their imbibition much lower and their extraction never below 94 per cent.

It would not be difficult to model our coal-burning factories or their steam economy on the lines of these two factories.

They are not isolated examples, there are many others and in other territories making white sugar, remelting all or part of their "A" sugars, operating distilleries and other adjuncts, often with a surplus of bagasse. Factory "B" in Table 6 now has a bagasse disposal problem. Their surplus is baled in two presses, making 60 lb. bales at the rate of 145 bales per hour per press. For use as fuel, this is passed through a disintegrator to tear the bales apart and fired in one boiler to operate the distillery for a further 100 days or so after the crop. Large amounts were once used to make a fertilizer for potash deficient soils, mixing and fermenting the bagasse with dunder. Briquettes were made and issued as fuel to native employees, for locos and other purposes. Despite these measures, they have lately had to instal a bagasse incinerator. Their boiler efficiency figures are not so high as are frequently obtained elsewhere, firing bagasse only, but their heat balances and steam and vapour utilization are of a high order. Some of the

TABLE 6 — TWO MODERN B.W.I. FACTORIES (JAMAICA)

Operating Data (Short tons)	1957 CROP Factory "A"	1957 CROP Factory "B"	1959 CROP Factory "A"	1959 CROP Factory "B"
Fibre per cent Cane	13.3	13.6	13.32	14.18
Tons Cane/Hr.	181.4	205.0	184.8	178.9
Tons Fibre/Hr.	24.19	28.0	24.6	25.37
Imbibition per cent Fibre	141.0	141.5	107.0	125.59
Extraction per cent	94.6	94.25	94.09	94.24
Bagasse, per cent Cane	28.5	28.27	29.5	29.33
Bagasse Pol per cent	2.28	2.45	2.14	2.23
Bagasse Moisture per cent	48.42	47.38	51.8	48.55
Syrup, Brix°	57.76	54.43	55.87	60.04
Sugar, Raw—Tons	50,400	93,821	57,062	94,259
Sugar Refined—Tons	15,680 (24%)	—	15,500 (27%)	—
Distillery, gallons Rum	258,790	488,125	531,038	368,094
Additional Fuel	Nil	Nil	Nil	Nil
Surplus Bagasse	100 tons	4,424 tons	120 tons	2,016 tons
Boiler Efficiency	66.82%	64.92%	67.3%*	65.93%

Note: Both factories employ Feed Water Heating.
Factory "A" has air preheaters to all boilers.
Factory "B" has air preheaters to half its boilers.
Neither factory uses exhaust steam on Pan Floor.
Both factories have full instrumentation on Boiler House and Steam Flowmeters on all steam and vapour lines.
Each operates a large distillery.
*Boiler efficiency later increased 4.5 per cent by heating Feed Water to steam temperature.
One operates a refinery, for which it remelts 27 per cent of its raw sugar (1959).

modifications which could be embodied in certain of our factories are set out for discussion — many of them being accepted as standard practice in "fuel-conscious" factories elsewhere. The first four were regarded as the four general principles for maximum heat economy and they are:

(1) Expand *all* h.p. steam from the boilers to exhaust steam pressure, via turbines for preference, or steam engines, using reducing valves only if unavoidable. All other live steam users to be prohibited, particularly pans, heaters, injectors, etc.

(2) Use *all* the exhaust steam in the first effect or effects. No exhaust steam to be supplied to pans nor heaters except by special arrangement and only if unavoidable.

(3) Do all possible evaporation *in* the evaporators, maintaining a standard so far as possible of 70° Brix, regarding 63° as a minimum.

(4) For all factory heating — pans, heaters, melters, etc., use the lowest possible vapour pressure (except that from the last effect). Where possible, using a balanced, ring main vapour line to supply the various consumers. (Factory "A", Table 6, has three separate balanced ring mains for vapours, each maintained at its correct pressure by regulators, fed by exhaust steam when necessary. Otherwise, all exhaust steam goes to first effects.

To implement (4), we can well copy from the beet sugar industry, as many operators have in the West Indies and elsewhere. For example, the evaporator feed, for maximum fuel economy should, theoretically, be heated in a series of heaters or heat exchangers. The first heater in the series being on lowest vapour and the last on first vapour. At Factory "A", Table 6, with a quintuple effect, mixed juice is heated with fourth vapour and then with third vapour, juice from liming station or Carb. tanks with second vapour and clear juice on its way to the first effect with second vapour and then with first vapour. This is possible only when the juice temperature to first effect is lower than that of the first vapour. In this manner — or some similar arrangement — one pound of steam from the boilers can be used four, even five times. There is not much difference in fuel cost in using vapour instead of exhaust steam but there *is* an appreciable saving in exhaust steam and hence fuel (or additional fuel). As an example, when a heater is changed from exhaust steam to vapour the reduction in use of exhaust steam can be found by using the formula $R=\frac{V}{E}S$, where R is the reduction or saving in exhaust steam, V is the kind of vapour proposed (for second vapour, V=2, etc.) E is the number of evaporator effects in use, and S is quantity of steam or vapour used in the heater. Thus, if a heater condenses 1,500 lbs. of exhaust steam per hour, what would be the exhaust steam saving if the heater were placed on first vapour from a quadruple effect evaporator? Or on third vapour? Exhaust steam saving with first vapour:

$\frac{1}{4}\times 1{,}500=$ 375 lbs. exhaust steam per hour,
or with third vapour,

$\frac{3}{4}\times 1{,}500=$ 1,125 lbs. exhaust steam per hour.

As replacements are made to existing plant, steam and vapour pressures should be increased and, due to the heavier loading on the first two or three effects caused by vapour heating, these effects tend to be larger than the last effects in many recent replacement units or in new factories.

Once proper use has been made of the steam and vapour available, assuming that the steam raising side has been previously rendered efficient, it is most likely that no other modifications or outlay will be necessary in our factories which burn additional fuel. A large surplus of bagasse is to be avoided until such time as there arises a demand for this material and it can be transported readily.

However, if a reduced amount of coal or wood should still be found necessary after effecting alterations similar to those outlined, there are many other, if lesser methods of conserving steam and fuel.

Heat exchangers have not had much application in Natal factories. A notably thermally-efficient factory, Clewiston, in Florida, uses condensate from its third effects, for imbibition water. On its way to the mills, it passes through a heat exchanger which raises the temperature of the raw juice by 20°F, prior to vapour heating for all juices. Incidentally, this factory uses hot air for combustion in its furnaces, drawn from the tops of the boilers at average temperature of 167°F. Their boiler efficiency is just over 80 per cent, they have no carbon or a negligible amount in ash and chimney, where the temperature is 472°F at base of stack.

Large quantities of useful hot water, mostly condensate, are wasted in some Natal factories. A cheap method is to direct the whole of this surplus through a heat exchanger before allotting some other use for it.

Most of the thermally efficient factories instanced, including those in Queensland, keep their massecuites proportion to cane (cubic ft. per ton cane crushed) at about 5.75 to 6, rarely exceeding 6. One of our factories has recorded over 10, which involves up to 50 per cent increase in steam or vapour required for treating massecuites.

In some cases, it may be far too expensive to improve the furnaces and boiler performance so that a higher efficiency is obtained. This difficulty arose in Queensland where most producers are very "fuel and steam economy minded". The Bureau of Sugar Experiment Stations there, discovered in these cases, that the following boiler ratings were minimum figures for operation without using extra fuel, assuming that insulation was good and there was no waste of steam in the process.

Quadruple effect, no bleeding..	61% steam on cane
Quadruple effect, with vapour bleeding..	58% steam on cane
Quintuple effect, no bleeding..	57% steam on cane
Quintuple effect, with vapour bleeding..	55% steam on cane

These figures refer, of course, to Raw factories which do not remelt any "A" or "B" sugars. They operate the defecation process.

In Natal, with our higher fibre content, any of these figures are easily attainable without use of additional fuel.

By the implementation of some of the remedies mentioned and others, we may see an end to that distressing sight — a sugar factory with exhaust steam and vapour roaring through the roof, hot water pouring down the drains, while coal and wood in huge quantities are being fed to the furnaces along with the bagasse and a handsome slice of the profits.

It will be generally agreed, it is hoped, that any and every effort which can be made to improve the thermal economy of all the factories affected should receive top priority in the attempt to retain within our industry for its own good, the large fortune which is being paid out each crop for additional fuel.

Finally, a plea for Natal's and Zululand's trees. If it is essential to use some additional fuel, then coal is probably no dearer than wood, its heat value is 3.3. times greater and it is less bulky. Wood is becoming more difficult to obtain and, without any compulsory re-afforestation scheme, the picturesque countryside in the sugar areas is becoming stripped of wood — a situation which can bring other evils in its train.

A substantial reduction in the total of additional fuel used is looked forward to in the 1962-63 crop if factory owners and operators will co-operate to become "fuel-economy minded".

References

Perk, Chs. G. M. 36th Annual Summary of Chem. Lab. Reports of S.A. Sugar Factories, Proc. S.A.S.T.A. April, 1961.

McCulloch, A. F. A Review of Bagasse Fuel Quality Trends and of Recent Boiler Efficiency Tests, Proc. S.A.S.T.A., 1953.

Walsh, W. H. A Review of the Development of Boiler Plant in the S.A. Sugar Industry, Proc. S.A.S.T.A., April, 1954.

Murray, P. Steam Economy, Proc. S.A.S.T.A., 11th April, 1939.
Lyle, O. The Efficient Use of Steam.

McGinnis, R. A. Beet Sugar Technology.

Bureau of Sugar Experiment Stations, Queensland, Bulletins 51/3 Laboratory Manual, Bulletins 1953.

Shillington, A. The economical combustion of Bagasse, I.S.J. Vol. 1939, p. 258.

Acknowledgments

The Institute and the writer wish to thank the Managements and Staffs of the factories concerned for their prompt and ready co-operation. The writer is also indebted to Messrs. British Sugar Corporation Ltd., The West Indies Sugar Co. Ltd. and Caroni Ltd. for their assistance in gladly supplying data and operating results additional to that regularly received here.

Mr. Hulett, in the chair, said that if sugar engineers followed just a few of the suggestions the author had made, some of which of course would involve capital expenditure, but others, such as increasing the brix of the syrup up to 70° instead of the usual 55 to 60°, would not involve extra expenditure, some progress would be made.

On the other hand some factories now found it difficult to dispose of the surplus bagasse and he could not see that improvement in their steam position would be of help to them.

Dr. Douwes Dekker said Mr. Buck had provided figures and graphs which gave the impression that improvement in the fuel consumption position in Natal was possible. The question was how it was possible to attain this improvement? It was realised that not all factories were in the same position.

The first thing to do was to obtain more accurate figures on the consumption of fuel, the raising of steam and the consumption of steam. In those factories interested, a steam balance should be drawn up. That involved much work and the S.M.R.I. would not be able to do that at more than two or three factories next season. All factories however could co-operate in a plan to initiate a mutual control system similar to the Mutual Milling Project. In that we might increase our knowledge of what was happening at the various factories. He hoped to call together engineers interested to find out what possibilities existed for collecting more data on the steam position at the various mills, with a view to effecting improvement.

Mr. Dick said he championed, where applicable, the use of a "Vapour Cell" using exhaust steam say from turbo generators, many of which are designed for operation at back pressures of 12 to 15 p.s.i.g. This permits operating the vapour space of the "Cell" at least to 4 p.s.i.g., which is suitable for providing vapour for primary *and* secondary juice heating and when suitably designed for capacity, could also provide vapour for a certain number of vacuum pans.

The vapour cell so used ensures "double effet" use of much exhaust steam now used only in "single effet".

Several factories in Natal had installed or altered existing evaporators to incorporate the "Vapour Cell" idea described with beneficial results in steam and in fuel economy.

Entumeni and Sezela factories had so benefited, and as there are delegates from these factories here today, an expression of opinion regarding their experiences with a "Vapour Cell" will no doubt be of interest to the other delegates present.

Mr. Lindemann maintained that the water tube boiler was not an efficient heat exchanger. A test he had carried out at the old Central Factory proved that the water tube boiler could be improved by crossing the back tubes. He considered that 80 per cent of the additional fuel now being used could be saved by doing this. In a steam engine one took T_1 minus T_2 divided by T_1 as the thermal efficiency.

This was also a quick way of arriving at the efficiency of a steam generator. If a pyrometer was placed in a furnace it would probably be found that one side had a higher temperature than the other. Using the formula, and by taking the furnace temperatures and the stack temperature, one could obtain a reasonable estimate of boiler efficiency.

Mr. Buck remarked that unfortunately not many factories were equipped with pyrometers but he hoped to carry out such tests in the near future. He agreed the water tube boiler was not perhaps a very efficient exchanger, but the point was they were used in this Industry, and in others, without the necessity of burning additional fuel.

Mr. Rault asked if the beet factories the author had indicated stopped for the week-end.

Mr. Buck replied that many now shut down on Sundays for about 6½ hours only. Some did not stop at all because they had reduced their evaporator cleaning to such a fine art that they rarely stopped on Sundays for this cleaning.

Mr. Dedekind said that since the refinery started at Sezela steam trouble had always been experienced. In 1959-60 1,620 tons of coal were burned, mainly due to the disastrous floods experienced. In 1958-59 600 tons were burned, the explanation being that in that year the tons of fibre going to the boilers per hour was 24.24 tons and the sugar output averaged 322 tons per day. In 1961-62 the tons of fibre available for fuel was 22.54 per hour and the average tonnage of sugar was 420 tons per day. The position was that the intake of fibre had decreased some 10 per cent and the sugar output had increased by 13 per cent.

It was not possible to get more out of the boilers, but the installation of a vapour cell made it possible to carry on last year.

Forcing a boiler 24 hours of the day could not be done. On the other hand when the refinery was shut down, bagasse became a problem. In spite of shutting down boilers, gangs of labour were required to shovel the bagasse away and this indicated that when the boilers were put on economical rate, surplus bagasse accumulated.

Mr. Buck said the Sezela figures reflected great credit on all concerned but it appeared the factory was under-boilered. Once that position was put right it was possible that there would still be a surplus of fuel.

Mr. Saville said at Entumeni tests were made to find out where the steam was going. It was found that steaming out a pan resulted in the terrific loss of 5,000 lbs. of steam per hour. Another big consumption was steaming at the centrifugals, especially with the old type of centrifugal. Losses such as these were often overlooked.

Mr. Boyes related that some of the coal used at Tongaat gave 35 per cent ash which materially affected the quantity of coal consumed and this might be one reason why the amount used had increased. He wondered if the figure of 12,000 B.T.U.'s given might not be too high.

He asked Mr. Buck if he could go into the relative merits of fuel oil against coal. He felt there was almost a case for use in its sugar factory furnaces in South Africa.

Mr. Buck said he had been given the figure of 12,000 B.T.U.'S by the collieries as being average for good washed Natal coal, but of course this did not reveal how much dross might arrive at a factory. The figures he had used were obtained from power stations where they had been cross-checked.

A figure he could not check on was how much coal was actually used for the factory purposes.

As far as the use of fuel oil was concerned, he agreed that there might be a case for its use. His experience was that when he had used it, the boiler efficiency had to be reduced to about 60 per cent to avoid burning the brickwork. In some factories in the West Indies and in Louisiana where there was no natural gas available, oil was used.

Mr. Hulett stated the problem at Darnall, where no coal or oil was used, was to get rid of the surplus bagasse. As Mr. Buck had shown, we waste thousands, perhaps millions, of B.T.U.'s every year which we should get out of the bagasse, but the problem of disposing of surplus bagasse was a very real one.

Mr. Boyes stated that there were certain factories which made power and sold it and used the surplus in that way. As he had seen in Hawaii, oil was very useful in starting up a factory after a shut-down.

Mr. Hulett said his criticism of that was oil was so very easy to switch on and so it was difficult to control its excessive use.

Mr. Lindemann said that with a small plant using 3,000 to 4,000 lbs. of steam per hour, when oil had to be substituted for coal, the extra cost was only 10 per cent.

Mr. Hill referred to the early days of the South African Sugar Technologists' Association when a boiler committee was formed under the chairmanship of the late Mr. Patrick Murray. This committee assessed the boiler capacities of the various factories. In those days they found that 400 square feet of boiler heating surface per ton of cane per hour was necessary. Today that figure had been reduced to 300 sq. ft. in raw sugar factories. This pointed to an increased efficiency in both boilers and furnaces which were inter-dependent.

At Renishaw no extra fuel was used, but he pointed out that the week-end requirements of power were bought from the Electricity Supply Commission and also, except for the non-European quarters, the village was not supplied with current. A number of factories supplied power outside of the actual factory requirements and this should be taken into account when a table of additional fuel used was drawn up.

Mr. Buck said these factors were taken into consideration as far as the information was available. Many factories bought power to start up after the week-end stop, and all factories export some power. The factories listed in the table all exported power.

Mr. Hulett pointed out that Darnall had less than 200 sq. ft. per ton of cane per hour of boiler heating surface but burned virtually no extra fuel. Because of a shortage of exhaust steam a lot of live steam was by-passed through a reducing valve into, or past, the steam accumulator into the exhaust range. If that steam could be put through a turbine this could generate quite a lot of power, but that was not necessary. Where there was a shortage of exhaust and a large surplus of live steam the latter could be used in a thermo-compressor, draw vapour from the 1st or 2nd vessel of the evaporator, return it back into the exhaust steam line and so save steam in spite of bleeding.

Mr. Gunn asked if the author could quote figures to show the saving of fuel when Wissington switched over from semi-automation to full automation of the evaporator station.

Mr. Buck replied that in 1946, he was informed that, Wissington was using 5 per cent coal on beet. Wissington was selected for automation because it was difficult to attract labour to its isolated location. During the last crop the labour units were reduced down to 32 per shift. Before automation, or rather semi-automation, it showed 9 per cent of coal on beet and this has now been reduced to 4.4 per cent.

Mr. Byard said that at the Z.S.M. factory $2\frac{1}{2}$ tons of extra bagasse was required per hour to avoid using extra fuel. Unfortunately the mill turbines had to be run from boilers generating steam at 180 p.s.i.g. which resulted in a high steam consumption, and could account for the extra fuel used.

Mr. Hulett hoped that the Industry would afford enthusiastic support to Mr. Buck and the S.M.R.I. He was sure that this support would ensure the Industry making a big reduction in the enormous expense of additional fuel.