MILLING CONTROL DATA WITH REFERENCE TO A MORE INTENSIVE METHOD OF SAMPLING AND ANALYSIS

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Milling control data with reference to the extraction of individual units was introduced to the South African Sugar Industry in 1931.

A brief description of the methods of sampling is as follows:

1. The bagasse and juice are sampled each hour from only one mill, starting with the crusher and ending with the fourth mill after five hours.
2. One mill is sampled hourly over a period of four to eight hours.
3. One mill is sampled hourly over a period of 24 hours.
4. All the mills are sampled simultaneously over a short period of say one hour.

From the above methods it can be observed that each unit is only sampled during a portion of the available time during a week's run, in order not to unduly increase the amount of work beyond the limitations of the laboratory. Although mill work analysis figures as supplied by the laboratory are used to a great extent by the mechanical staff, at the best they are only produced weekly, and only give general indications of the work performed.

It must also be remembered that however accurately the laboratory staff do the necessary analyses and compute the results to two decimal places, the final result is nevertheless only as accurate as the degree to which the samples taken represent the cane being crushed.

A recent survey at Z.S.M. into the sampling and analysis done in our laboratory, showed that 126 determinations were done daily to control the efficiency of the milling plant, compared with 428 other determinations necessary for factory control as apart from milling, with the exception of the last mill which is sampled for the hourly determinations of polarisation and moisture of the bagasse, and the analysis of the last expressed juice.

When it is considered that an 84-inch milling train complete with carriers, cranes, etc., costs approximately £500,000, and for such a milling unit to produce 100,000 tons of sugar from 119,000 tons of sucrose in cane, purchased from growers for approximately £1,700,000, the inevitable conclusion must be reached that the work done in our mill laboratory is not commensurate with the huge capital expenditure for the purchase of sucrose and maintenance of the milling train involved.

We believe that the correct answer to this is to establish a chemico-engineering laboratory, quite apart from the ordinary routine control laboratory, in which all the time and equipment will be devoted solely to all classes of milling problems.

As a commencement to this scheme, it was decided to introduce a more intensive system of mill work analysis so that accurate results could be produced daily, or even if so desired, for 12-hourly periods. Such a chemico-engineering laboratory should be, for proper control, quite apart from the routine testing laboratory.

Building and Equipment required for the Bagasse Laboratory

A room 20 ft. × 12 ft. was fitted with suitable concrete benches to house the necessary equipment.

The equipment amounted to:

1. Two Gallenkamp drying ovens for moisture determinations of the bagasse.
2. Ten hotplates.
3. Ten bagasse digestors and condenser lids.
4. One hot water geyser of 30 gallons total capacity.
5. One balance.
6. One Facit calculator.
7. The necessary accessories such as beakers, funnels, hydrometer jars, Brix hydrometers and buckets, etc.

The cost of the above equipment and necessary innovations to the laboratory, except for one oven and the Facit calculator, amounted to £590.

Staff required

3 testers, 3 G.2 assistants, 3 labourers for sampling bagasse, 3 labourers for sampling juice and 3 labourers which were shared with the mill laboratory.

Facilities provided for Sampling

The imbibition trays were so arranged that they faced towards the last mill in the opposite direction from the travel of the bagasse leaving the discharge rollers, in order not to upset the continuity of the imbibition system during sampling, and giving ample space to enable the sampling of the bagasse during normal crushing conditions without interfering with the milling operations in any way.

Suitable platforms were provided near the discharge of each mill to enable the samples of bagasse to be taken as conveniently and quickly as possible by means of long-handled tongs.

Period and method of Sampling

The bagasse and juice were sampled simultaneously every ten minutes from each unit, starting with the crusher and ending with the fourth mill.

At the end of each hour all the samples of bagasse from the respective mills were sub-sampled and taken to the laboratory for analysis. The amount of the bagasse sampled hourly across the discharge of each mill is of the order of 2.25 cu. ft. approximately, and the samples were taken up to a depth of 6 inches below the surface of the blanket of bagasse in the carrier.

The juice was sampled across the discharge roller of each mill.

In Table I the mill work analysis is shown daily for the month of November, together with the average results for each week.

In an attempt to show the difference between sampling and testing all the mills every hour and the old method of sampling and testing only one mill hourly, the analyses for the month of November have been averaged out in the same order that the sampling would have been done if the old method had been used, and the weekly results tabulated for comparison in Table II.

A perusal of this Table shows that the more intensive system of sampling and testing gives more consistent results than the old system, where only about one-fifth of the samples were taken and tested, especially where fluctuations in the results can be shown, which are not due to poor milling but to other causes, such as improper sampling and fluctuations in the sucrose content and quality of the cane at the time of sampling.

In the comparison it must be borne in mind that all the sampling was done every 10 minutes (six samples per hour). If, however, only one sample was taken per hour, the fluctuations in the results might have been more marked.

A similar comparison is given in Table III for a longer period of a month, when it will be observed that the differences will be less marked. In fact, the results will be seen to agree fairly closely, and if a comparison could be made over a season, the differences would probably be negligible.

However, waiting longer periods for results would defeat the whole object of milling tests, in so much as up to date information could not be given when required to be of any practical use.

We can quote an example where the individual milling data were of assistance in helping to rectify a sudden drop in the extraction.

During the night of the 28th September, 1959, an 18-lb. hammer went through the mills and the extraction dropped from 92.58 for the previous day, to 91.95 for the 12-hour night run mentioned above.

On instructions from the General Manager, the data for the extraction of the individual mill units were calculated for the twelve hours' run during the night, and showed that the total extraction up to and including the fourth mill was 88.99 compared with 88.59 the previous day. However, on comparing the results of the last or fifth mill, the extraction for the unit showed a drop from 3.99 to 2.96 and the efficiency (sucrose per cent sucrose entering unit) had dropped from 35.02 to 26.84.

The mill was shut down and investigations disclosed that the openings of the mills had been spread on one side due to the adjusting bolts having been forced into the bearings, and that damage had been done to the last mill trashplate.

The necessary repairs and adjustments were carried out and the mill was crushing again within two hours.

The following day the extraction was back to normal and showed 92.81 for the 24-hour run.

The data for the mill work analysis during the above mentioned periods are given in Table IV.

Conclusion

This new method at Z.S.M. has proved itself to be of the greatest assistance to engineers and technicians.

TABLE I

THE DAILY AND WEEKLY AVERAGE WORK OF THE INDIVIDUAL UNITS OF THE MILLING TRAIN
for the Month of November, 1959

DATE	*TOTAL EXTRACTION (up to Unit)*						*EXTRACTION BY UNIT*						*EFFICIENCY (Suc. % Suc. entering Unit)*					
	Crusher	*First*	*Second*	*Third*	*Fourth*	*Fifth*	*Crusher*	*First*	*Second*	*Third*	*Fourth*	*Fifth*	*Crusher*	*First*	*Second*	*Third*	*Fourth*	*Fifth*
2/11/59	51.37	67.99	76.38	83.13	88.37	92.39	51.37	16.62	8.39	6.75	5.24	4.01	51.37	34.22	26.21	28.57	31.10	34.58
3rd	54.15	70.15	77.50	83.06	88.69	92.62	54.15	16.00	7.35	5.56	5.33	3.93	54.15	34.89	24.63	24.71	33.26	34.72
4th	49.92	68.29	76.92	83.05	88.14	92.53	49.92	18.37	8.63	6.13	5.09	4.39	49.92	36.68	27.22	26.58	29.99	36.99
5th	49.92	69.52	77.14	83.10	89.09	92.12	49.92	19.60	7.62	5.96	5.99	3.03	49.92	39.14	25.01	26.04	35.43	27.75
6th	48.91	67.86	75.51	82.42	88.09	91.94	48.91	18.95	7.65	6.91	5.67	3.85	48.91	37.09	23.79	28.22	32.25	32.34
7th	52.82	67.98	76.35	82.75	88.43	92.10	52.82	15.16	8.37	6.40	5.68	3.67	52.82	32.13	26.12	27.07	32.91	31.77
Weekly average ...	51.33	68.59	76.63	82.91	88.45	92.29	51.33	17.26	8.04	6.28	5.54	3.84	51.33	35.47	25.59	26.88	32.39	33.12
9th	53.07	68.73	77.63	83.44	88.65	91.74	53.07	15.66	8.90	5.81	5.21	3.09	53.07	33.36	28.48	25.95	31.46	27.25
10th	51.30	70.63	78.14	83.93	89.39	92.67	51.30	19.33	7.51	5.79	5.44	3.30	51.30	39.69	25.58	26.49	33.84	31.02
11th	47.47	67.35	76.45	82.76	88.30	92.49	47.47	19.88	9.10	6.31	5.54	4.19	47.47	37.86	27.86	26.77	32.15	35.81
12th	44.41	67.90	75.48	82.06	87.63	92.42	44.41	23.49	7.58	6.58	5.57	4.79	44.41	42.26	23.62	26.84	31.03	38.72
13th	49.64	67.64	76.57	82.28	88.21	92.53	49.64	18.00	8.93	5.71	5.93	4.32	49.64	35.74	27.59	24.37	33.49	36.66
14th	52.06	68.92	77.18	83.36	88.98	92.38	52.06	16.86	8.26	6.18	5.62	3.40	52.06	35.16	26.57	27.76	33.79	30.80
Weekly average ...	49.83	68.44	76.93	82.93	88.53	92.39	49.83	18.61	8.49	6.00	5.60	3.86	49.83	37.10	26.88	26.03	32.79	33.47
16th	49.90	67.94	76.15	83.64	88.60	92.19	49.90	18.04	8.21	7.49	4.96	3.59	49.90	36.01	27.95	31.39	30.33	31.45
17th	50.29	68.44	76.54	83.71	88.89	91.86	50.29	18.15	8.10	7.17	5.18	2.97	50.29	36.50	26.67	30.58	31.75	26.74
18th	49.64	67.44	77.24	84.21	89.00	92.43	49.64	17.80	9.80	6.97	4.79	3.43	49.64	35.35	30.08	30.62	30.36	31.14
19th	50.30	67.70	76.84	84.33	89.35	92.38	50.30	17.40	9.14	7.49	5.02	3.03	50.30	35.01	28.30	32.35	32.01	28.51
20th	50.45	68.62	76.41	84.10	89.19	92.50	50.45	18.17	7.79	7.69	5.09	3.31	50.45	36.66	24.82	32.62	31.98	30.68
21st	49.57	68.93	76.76	84.15	89.03	92.36	49.57	19.36	7.83	7.37	4.88	3.33	49.57	38.39	25.21	31.78	30.82	30.30
Weekly average ...	50.00	68.06	76.70	84.04	89.02	92.32	50.00	18.06	8.64	7.34	4.98	3.30	50.00	36.12	27.04	31.52	31.20	30.11
23rd	45.42	66.40	75.14	83.14	88.61	91.64	45.42	20.98	8.74	8.00	5.47	3.03	45.42	38.44	26.00	32.17	32.45	26.62
24th	49.72	69.63	76.88	83.70	89.40	92.45	49.72	19.91	7.25	6.82	5.70	3.05	49.72	39.59	23.89	29.47	35.03	28.72
25th	46.46	68.12	78.38	83.68	89.14	92.20	46.46	21.66	10.26	5.30	5.46	3.06	46.46	40.45	32.19	24.52	33.17	28.13
26th	48.89	70.08	77.38	84.30	88.78	92.45	48.89	21.19	7.30	6.92	4.48	3.67	48.89	41.46	24.41	30.59	28.53	32.69
27th	45.78	67.93	76.81	84.03	88.95	92.37	45.78	22.15	8.88	7.22	4.92	3.42	45.78	40.85	27.70	31.11	30.80	31.00
28th	51.11	69.44	78.68	84.92	89.19	92.61	51.11	18.33	9.24	6.24	4.27	3.42	51.11	37.49	30.22	29.27	28.33	31.59
Weekly average ...	48.00	68.66	77.19	83.97	89.03	92.31	48.00	20.66	8.53	6.78	5.06	3.28	48.00	39.74	27.22	29.72	31.55	29.92

TABLE II

A WEEKLY COMPARISON OF THE RESULTS OF THE NEW AND THE OLD METHODS OF SAMPLING

	TOTAL EXTRACTION (up to Unit)						*EXTRACTION BY UNIT*						*EFFICIENCY (Suc. % Suc. entering Unit)*					
DATE	*Crusher*	*First*	*Second*	*Third*	*Fourth*	*Fifth*	*Crusher*	*First*	*Second*	*Third*	*Fourth*	*Fifth*	*Crusher*	*First*	*Second*	*Third*	*Fourth*	*Fifth*
W/E. 7/11/59																		
New Method... ...	51.33	68.59	76.63	82.91	88.45	92.29	51.33	17.26	8.04	6.28	5.54	3.84	51.33	35.47	25.59	26.88	32.39	33.12
Old Method	51.64	68.89	76.25	83.23	88.57	92.29	51.64	17.25	7.36	6.98	5.34	3.72	51.64	35.67	23.66	29.40	31.81	32.41
W/E. 14/11/59																		
New Method... ...	49.83	68.44	76.93	82.93	88.53	92.39	49.83	18.61	8.49	6.00	5.60	3.86	49.83	37.10	26.88	26.03	32.79	33.47
Old Method	48.59	68.89	77.21	84.04	88.10	92.39	48.59	20.30	8.32	6.83	4.06	4.29	48.59	39.48	26.74	29.98	25.41	35.89
W/E. 21/11/59																		
New Method... ...	50.00	68.06	76.70	84.04	89.02	92.32	50.00	18.06	8.64	7.34	4.98	3.30	50.00	36.12	27.04	31.53	31.20	30.11
Old Method	49.24	67.64	76.88	83.85	89.52	92.32	49.24	18.40	9.24	6.97	5.67	2.80	49.24	36.25	28.55	30.15	35.08	26.80
W/E. 28/11/59																		
New Method... ...	48.00	68.66	77.19	83.97	89.03	92.31	48.00	20.66	8.53	6.78	5.06	3.28	48.00	39.74	27.22	29.72	31.55	29.92
Old Method	46.99	69.36	77.18	84.12	89.32	92.31	46.99	22.37	7.82	6.94	5.20	2.99	46.99	42.20	25.52	30.41	32.76	28.01

TABLE III

COMPARISON OF THE RESULTS OF THE NEW AND OLD METHODS OF SAMPLING for the Month of November, 1959

	Crusher	*First*	*Second*	*Third*	*Fourth*	*Fifth*
	TOTAL EXTRACTION (up to Unit)					
New Method	49.89	68.44	76.87	83.49	88.75	92.33
Old Method	49.01	68.70	76.87	83.79	88.90	92.33
	EXTRACTION BY UNIT					
New Method	49.89	18.55	8.43	6.62	5.26	3.58
Old Method	49.01	19.69	8.17	6.92	5.11	3.43
	EFFICIENCY (Extraction per cent Sucrose entering Unit)					
New Method	49.89	37.02	26.69	28.62	31.87	31.84
Old Method	49.01	38.61	26.08	29.94	31.53	30.90

TABLE IV

A COMPARISON OF THE WORK OF THE INDIVIDUAL MILLS DURING THE PERIODS WHEN THE HAMMER WENT THROUGH THE MILLS

	28/9/59 Before hammer went through	*29/9/59* 12 hour run When hammer went through	*29/9/59* 24 hour run When hammer went through	*30/9/59* Day after hammer went through
Total Extraction (up to Unit)				
Crusher	53.29	57.72	55.85	57.21
First	67.37	70.24	69.76	70.87
Second...	77.60	78.58	77.74	78.40
Third	84.60	84.90	84.77	84.74
Fourth...	88.59	88.99	88.83	89.02
Fifth	92.58	91.95	91.79	92.81
Extraction by unit				
Crusher	53.29	57.72	55.85	57.21
First	14.08	12.52	13.91	13.66
Second...	10.23	8.34	7.98	7.53
Third	7.00	6.32	7.03	6.34
Fourth...	3.99	4.09	4.06	4.28
Fifth	3.99	2.96	3.14	3.79
Efficiency (Suc. % Suc. entering Unit)				
Crusher	53.29	57.72	55.85	57.21
First	30.13	29.62	31.51	31.93
Second...	31.36	28.02	26.38	25.85
Third	31.26	29.48	31.57	29.36
Fourth...	25.87	27.12	26.67	28.04
Fifth	35.02	26.84	28.14	34.48

The President in thanking Mr. Phipson for his paper said that the imbibition system had been altered to enable samples to be taken without interfering with the flow of bagasse. He had always been of the opinion that imbibition should be applied immediately after a mill so as to allow better absorption. Another point in the paper was that the extraction after the hammer went through was better than before.

Mr. Phipson agreed that the maceration should be applied as soon as possible after the bagasse emerged from the mill.

Dr. Douwes-Dekker explained that the point at which imbibition was applied would make very little difference to its absorption by the bagasse. He complimented Mr. Phipson on the work carried out at Z.S.M. He felt that not sufficient figures were usually obtained on the milling work, and that if Mr. Phipson's contribution brought about more intensive testing of bagasse and juices in the mills, this would lead to better understanding of the performance of the mills. The sampling of juice was not very difficult but to get a representative result from the bagasse was difficult. Bagasse should be sampled over the total depth of the layer. Usually imbibition was applied to the bagasse as near as possible to the discharge opening with the idea that a better mixing of the imbibition liquid with the residual juice in the bagasse occurred. He was sceptical that this was so. When the determinations done in the past in various countries were examined, it was found that little liquid was absorbed except in the top few inches wherever the imbibition liquid was applied. He had seen figures showing that when imbibition was applied immediately before the next mill there was no difference in absorption. We can understand this if we realise that the imbibition liquid does not penetrate right through the bagasse. He said that a major cause of poor extraction was the poor mixing of imbibition and the residual juice in the bagasse.

Dr. Kerr on his recent visit here stressed that if we want to study the performance of the mills separately there should be adequate means for sampling and that meant the imbibition liquid had to be applied at such a distance from the discharge opening that we could sample bagasse. If we stopped the imbibition for a couple of minutes to try and get a sample of bagasse we could not be sure that we would get corresponding samples from each mill. This statement was made by a man from a country where much research was done in milling.

Mr. Beesley said that although imbibition only penetrated the top few inches of bagasse in the carrier, tumbling the bagasse off the end of the carrier into the next mill greatly improved the distribution of the imbibition. He agreed with Mr. Phipson that it was better not to stop the imbibition to (say) the fourth mill when sampling the third, as he had found that this could lead to sampling under dry milling conditions.

Mr. Rault wished to congratulate Mr. Phipson on the thoroughness of his control, and his Company for supporting him in providing the labour and expense necessary for this valuable work. He had sampled a bagasse layer and found that the top few inches only were saturated by the usual water spray system, while at the bottom such was not the case, and so he had tried to split the water application on top as well as the bottom, but the final results were no better. His experience had been that the application of imbibition water immediately before entering the mill was paradoxically just as good as at any other place. The mixing of the imbibition with the bagasse seemed to take place at the beginning of the crushing of the next mill, under the special conditions of over-capacity crushing rates, where a layer of juice was always present on top of the bagasse blanket pulled in by the top and feeding roller.

Dr. Douwes-Dekker said that he was convinced that the proper mixing of residual juice with imbibition liquid would increase extraction very considerably. Mixing of the imbibition and residual juice was our main problem. As Mr. van Hengel had indicated, in Australia the use of pushers in the mills helped with the mixing of the imbibition and residual juice. He had tried experiments in the laboratory mixing bagasse by hand but unfortunately the tests were crude and would have to be done on a better basis.

Mr. Noel said that two factories in Mauritius experimented to try to effect better mixing of bagasse with imbibition and they installed a mixer about three feet after the water was applied to the bagasse, a second addition of water being made at that point. These two mills got better milling results as a consequence. He asked if it would not be better to use a new type bagasse sucrose extractor which would enable tests to be done in a few minutes instead of the large plant employed in the laboratory at Z.S.M.

Mr. Phipson agreed that that type of apparatus would be very useful but unfortunately he did not have this at the time. He had no difficulty in using the hot water digestors because he had ample staff. He thought that more than one bagasse sucrose extractor would be required with cold water extraction. Accumulating samples might lead to drying out.

Mr. Carter said that at Tongaat where there was a lengthy chute into the mills there would be ample space for both imbibition and bagasse sampling. He asked if it were possible to make the imbibition go right through the blanket of bagasse, would that not lead to a better mixing of the imbibition and bagasse residual juice?

The Chairman said that some experiments of this nature could be carried out at Tongaat. Now they had installed an extra mill and it would be interesting to see if they could apply more imbibition than before.

Dr. Graham said that the sampling of the bagasse was the factor limiting the accuracy of the determination of extraction achieved by a mill. This error will generally be greater for the first mills in the tandem because the bagasse is not well broken up. For this reason, the method reported by Steward (Q.S.S.C.T. 1955 p. 273) for the determination of 1st mill extraction should be valuable because only the pol of first mill juice, second mill juice and mixed juice is required to calculate the 1st mill extraction.

Mr. Phipson thought that this would be an idea, but would not be practical.

Mr. Rault said that in his paper written on his experience of 25 years data on this subject, he found that the last mill unit receiving water only and not thin juice, usually put up a higher individual performance than the immediately preceeding ones. This had also been the experience at Tongaat. He could not see a similar trend in Mr. Phipson's figures.

Mr. Phipson pointed out that at Z.S.M. there was no shredder. This would probably improve extraction considerably if it were installed.

Mr. Noel said in Mauritius the cane was more easy to mill than in Natal and their low fibre cane gave them a better opportunity to get high extractions and also the mills ran more slowly than here. There was no common school of thought about milling in Mauritius where adjustment was done according to individual ideas. Many mills in Mauritius were working under capacity, but even at the factory where the roller speed was up to 55 feet per minute and the mill was pushed to its maximum crushing rate, the moisture was still down to 48 per cent.