A NEW APPARATUS FOR MEASURING THE PREPARATION INDEX

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Abstract

The present method for the determination of the preparation index (PI) has been re-evaluated. This indicated that the method can yield precise values if all the experimental steps are adhered to rigidly. A new apparatus, in which most of the steps have been automated, is described. The results obtained with this new PI machine, in initial tests and under industrial conditions, are presented.

Introduction

The preparation index (PI) is used to indicate the degree of cane preparation. Its determination involves measuring the brix which can be washed from ruptured cells in the prepared cane, and expressing this as a percentage of the total brix in the cane. The washing procedure is empirical and must be carried out precisely to obtain meaningful results.

The present tumbling method for the PI determination was developed by Buchanan[1] and Markham[2] and has worked well for a number of years. It offers simplicity of design and portability but the results obtained are highly operator dependent.

Although the tumbler has worked well, it has shortcomings especially in an industrial environment. The tumbling method of analysis requires that the cane/water mixture is tumbled for exactly 30 minutes before a sample is taken. As the method is based on the principle of diffusion/leaching and is time dependent until equilibrium is reached, the sample has to be taken immediately the tumbler is stopped. However, it is quite possible that in an industrial environment the diffusion time is extended due to the operator being occupied on other duties. An additional problem that has emerged over the years has been leaks caused by poor sealing of the plastic jars containing the cane/water mixture. When new, the jars are robust and seal well but this changes with time and leaks occur, giving rise to experimental errors.

As a result of these problems, the SMRI redesigned the PI equipment.

Design of the New Equipment

A prototype Preparation Index apparatus, is shown in Figure 1. The apparatus was based on the design of equipment used in a number of projects at the SMRI[3] to investigate the extraction of impurities from cane.

The new equipment differs in operation from the tumbler in that the cane/water mixture is stirred in a stationary container instead of being tumbled. In addition, the equipment is fully automated and the only operator involvement is the weighing of cane and activation of a switch.

The new equipment is built on a steel frame and is transportable. It consists of a 0,75 kW motor running at 1 460 rpm which drives 2 stirrers via a gearbox and chain drive. The speed of the stirrers is 100 rpm. The cane/water mixture is stirred in a stainless steel pot (6 litres) which can tilt on a hinge for easy cleaning. Two pots and stirrers allow the analysis to be done in duplicate.

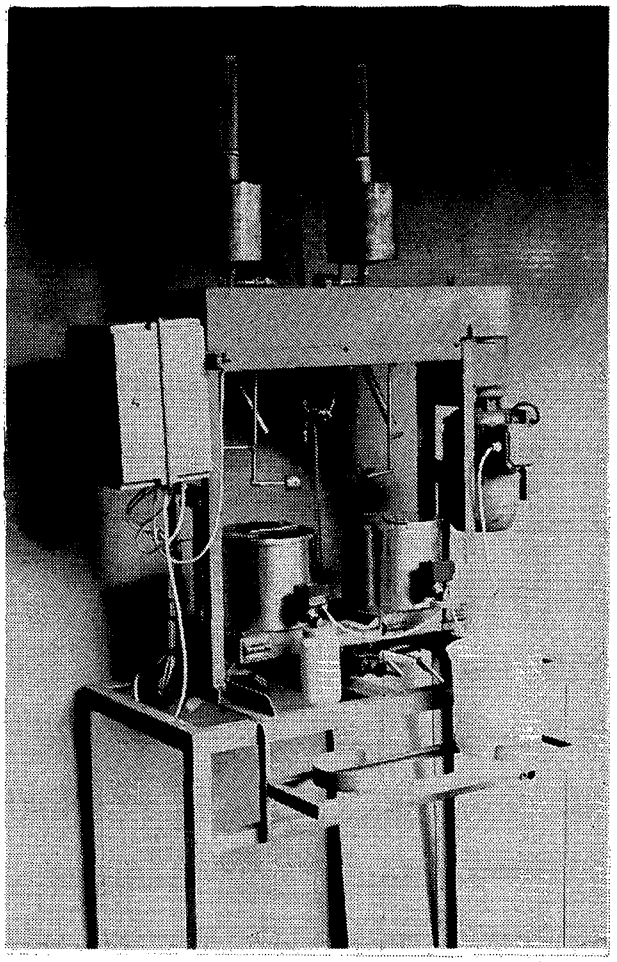

FIGURE 1 The new PI apparatus.

Water is added to the pots via automatic batch dispensers fitted with level sensors to control the volume.

The water dispensers are connected to a water line for automatic filling of water. After the set time has elapsed a sample of cane extract is automatically allowed to flow into a receptacle.

The cost of materials for the new equipment, including the electronics, is around R3 000 while the cost of the tumbler is around R1 300. It must be remembered, however, that replacement of plastic jars for the tumbler is becoming difficult.

The electronics for this equipment consist of a controller which was built around a commercially available microcomputer board using the 8052 processor. This chip is programmable in BASIC and the programme is stored on board in an EPROM. The computer has 8 input lines which respond to a contact closure and 8 output lines which provide outputs of 220 V. The inputs are driven by the start, stop and rinse push buttons and the two water level sensors. The 220 V outputs control all the solenoid valves and indicator lights and operate the stirrer motor. Figure 2 shows a block diagram of the controller.

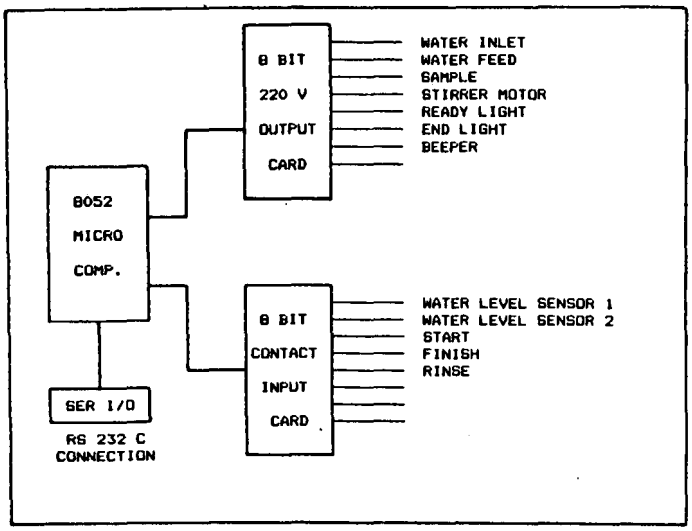

FIGURE 2 Block diagram of the controller.

Since this controller is essentially a BASIC computer it is very easy to change various parameters in the control programme or even rewrite the programme if desired.

Programming is done via an RS 232 communications port on the controller. A computer terminal or a personal computer may be used to write the programmes. A PC has the great advantage of having support software such as editors and communications programmes as well as disk storage which make programme development very simple.

Operation of the New Equipment

A sketch of the new apparatus is shown in Figure 3.

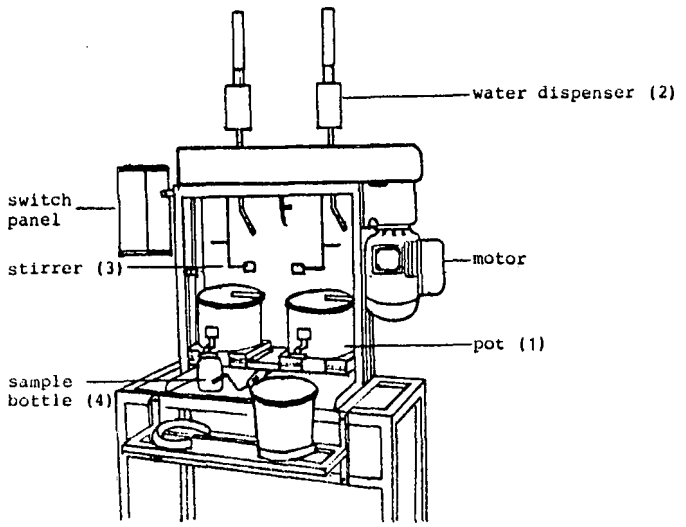

FIGURE 3 A sketch of the new apparatus.

A fixed mass of cane is weighed into the pot (1). The ratio of cane to water is the same as used for the tumbler method and described in the SASTA Laboratory Manual.[4] The "start" switch is then activated which starts a timer and automatically fills the water dispensers (2). The stirrers (3) are started the moment the water is dispensed to the pots. The cane/water mixture is continuously agitated for exactly 30 minutes, at the end of which time samples of extract are automatically collected into the sample bottles (4). The apparatus then switches off. The operator has to take the samples (which does not have to be done immediately the machine stops), clean the pots and be ready for the next analysis. Facilities are available for an emergency stop of the moving parts.

Results and Discussion

Tests were carried out to evaluate the new equipment against the tumbler. The comparisons were carried out at the SMRI and under industrial conditions at MS and SZ. It should be noted that under industrial conditions the new equipment was handled by the same person responsible for the tumbler.

Evaluation at the SMRI

Repeatability tests were done at the SMRI on one large sample of prepared cane. The results are shown in Table 1. All the cane was prepared in the Jeffco shredder.

Table 1

Repeatability of PI using the tumbler and new apparatus

	Tumbler	New apparatus
Mean PI	89	89
Standard deviation	0,7	0,5
No. of samples	6	6

The results show that the PI values are the same with both sets of apparatus. However, it should be noted that great care had to be taken when using the tumbler and in fact numerous tests had to be aborted due to leaking seals on the plastic jars. The results therefore indicate that satisfactory results are obtained with either equipment provided the procedure for the tumbler is rigidly controlled. The results also indicate that with finely prepared cane, sub-sampling is not a problem. In addition to the above results a series of precision tests was also conducted at the SMRI in which duplicate samples were tested in the tumbler and the new machine. In these tests the PI ranged from 56 to 96. Once again, the cane was prepared in equipment at the SMRI. The results are shown in Table 2 where the differences in PI values between duplicate tests are used to determine the precision.

Table 2

Precision tests on duplicate samples

	Tumbler	New apparatus
Mean difference between duplicates	1,1	1,1
Standard deviation of duplicates	0,8	0,9
No. of duplicate samples	18	18

The results in Table 2 indicate that both machines are able to produce the same precision provided the necessary care is taken when using the tumbler.

Factory tests

Evaluation at MS

At MS, equipment that is similar in principle to the tumbler but slightly different in design is used to determine PI. The apparatus was described by Buchanan.[1] Therefore in the evaluation of the new machine, three different sets of apparatus were used.

The MS extraction plant consists of a diffuser and a milling tandem. The PI tests were done in duplicate on cane obtained from each of these. The results obtained at MS are shown in Table 3. These indicate that the precision of the new machine under industrial conditions is superior to the MS tumbler and the SMRI tumbler. However, the actual PI values appear to be slightly lower in the case of the new machine. This could be due to the late removal of samples from the tumbler.

Table 3

Precision tests based on difference between duplicates at MS

	Diffuser			Mill		
	MS tumbler	SMRI tumbler	New apparatus	MS tumbler	SMRI tumbler	New apparatus
Diff. between duplicates	1,4	1,2	1,0	1,4	0,8	0,8
Standard deviation of duplicate	1,4	1,3	0,6	1,1	1,1	0,8
No. of duplicates	16	16	16	19	19	19
Mean PI (of total samples)	92,3	91,5	90,4	91,2	89,3	87,6

Evaluation at SZ

A further evaluation of the new equipment was carried out at SZ. The results obtained at SZ are shown in Table 4.

In total 19 sets of duplicate cane samples were analysed. However, a slight leak was detected in one of the solenoid valves on the new machine which was rectified after the 9th sample. As a result the first 9 sets of duplicate results have been omitted from Table 4. The results again show that greater precision is obtained with the new equipment than with the tumbler. The PI obtained with the new machine was lower than with the tumbler.

Table 4

Precision tests based on difference between duplicates at SZ

	Tumbler	New apparatus
Mean difference between duplicates	2,4	0,7
Standard deviation of duplicates	1,5	0,8
No. of duplicate samples	10	10
Mean PI (of all samples)	91,1	89,0

Conclusions

The tests have shown clearly that duplicate samples done in the new machine showed less scatter than in the tumbler. The standard deviation between duplicate samples was very similar for the new machine in spite of the tests being performed under different conditions, while the standard deviation for the tumbler varied. This indicates that the analysis done on the new machine is equipment dependent while the analysis on the tumbler is place dependent. In addition, under strict experimental conditions, the PI values obtained on the new apparatus and the tumbler are equal, as shown in Table 1. The very good agreement between duplicate samples has highlighted the fact that sub-sampling of finely prepared cane is not a problem. Initial problems were experienced with the jack (used to move the pots into position) and solenoid valves which leaked due to fibre restricting the valve seal. These have been rectified. The advantages of the new apparatus over the tumbler are:

(i) verly little operator involvement is required
(ii) results are reproducible
(iii) sampling of juice is automatic so that contact time between water and cane is exact
(iv) plastic bottles that often leaked on the tumbler are no longer used
(v) operators prefer using this apparatus to the tumbler.

The disadvantages are:

(i) more expensive than the tumbler
(ii) bulky and difficult to move around
(iii) greater chances of a breakdown due to more moving parts.

Acknowledgements

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