BOILING HOUSE PERFORMANCE

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Introduction

For a long time there has existed a desire amongst sugar technologists to gauge the quality of work in the boiling house by one simple expression. In 1950 Gundu Rao[1] criticized the existing yardsticks and made some suggestions. In 1953 Douwes Dekker[2] gave a summing-up of the different views and came to the conclusion that the target purity (a purity based on the exhaustibility of the final molasses) should be the basis of the calculations of crystallisable sucrose in mixed juice. Earlier, this same principle led to the introduction of the Boiling House Performance in Natal (unique in the world) and the exhaustibility of the molasses was arbitrarily presumed to be a function of the mixed juice purity.

In Table I of the Laboratory Manual for South African Sugar Factories, the factor "f" is given for different juice purities. Now, the factor "f" represents the fraction

$$\frac{p}{100 - p}$$

Here, "p" represents the purity of the final molasses and if "r" stands for the purity of mixed juice, Table I can be drawn up.

From the accompanying graph it is evident that the curve (A), representing the assumed relationship between "p" and "r", is very nearly a straight line (B).

Factors Affecting the Boiling House Performance

From many sides, strong criticism has been delivered on the value of Boiling House Recovery. As this figure is a direct function of S, J and M, nobody doubts the influence of the non-sucrose content of sugar, molasses and the mixed juice.

Hitherto, it has been assumed that the use of Boiling House Performance would avoid this disadvantage and the outcome of our calculations would show a "quality figure" which was only dependent on:

(a) The Effectiveness of the Clarification.

(b) The Quantity of the Undetermined Sucrose Loss.

(c) The Purity of Undetermined Sucrose Loss.

(d) The Purity of the Final Molasses.

(a) *The Effectiveness of the Clarification:*

Boiling House Performance is based on the effectiveness of the clarification in two ways, i.e. the loss of sucrose in cake and the rise in purity of the juice. As more water is used at the filter station, the pol of the cake will be lower. However, as a result of using excessive amounts of water, a part of the precipitated non-sugars may go into solution again and then the extra recovery of sucrose will be partly undone. Also, a fair amount of sucrose is added to the filters in the bagacillo, but this quantity is normally disregarded.

It seems feasible, however, to see the clarification effect as one single process, and for the purpose of this paper we assume:

1. Sucrose lost in cake % sucrose in mixed juice = c
2. Purity increase from mixed juice to clar. juice = d

If purity of the mixed juice is "r", we can evolve the following equations:

Sucrose in the clar. juice % sucrose in mixed juice

$$= 100 - c \qquad \ldots\ldots (1)$$

Brix in clar. juice % sucrose in mixed juice

$$= \frac{100 - c}{r + d} \times 100 \qquad \ldots\ldots (2)$$

Equation (2) minus equation (1) equals

Non sucrose in clar. juice % sucrose in mixed juice =

$$\frac{(100 - c)}{(r + d)} \times 100 - (100 - c)$$

$$= (100 - c)\frac{(100 - r - d)}{(r + d)} \qquad \ldots\ldots (3)$$

(b) *The Quantity of the Undetermined Loss:*

There is little to say about this: obviously, what is lost is not recoverable. We will call the percentage of sucrose in mixed juice lost in undetermined "u".

(c) *The Purity of the Undetermined Loss:*

This is a very important factor. If sucrose is lost at a purity of 100, the loss of recoverable crystal will be identical to the sucrose loss. But if sucrose is lost at the purity of final molasses, the loss of crystal will be zero. If the nature of the loss is chemical, it will show up in the purity rise of the clarified juice, which will be lower as a result of the inversion. We will call the purity of the undetermined loss "z". (For calculation of "z", see Appendix 1.)

Again a number of equations can be evolved:

Sucrose in sugar and molasses % sucrose in mixed juice = $(100 - c - u) \qquad \ldots\ldots (4)$

If "u" parts of sucrose are lost at a purity of "z", $\frac{100u}{z}$ parts of brix will be lost. Hence, by subtracting this term from formula (2), we get:

Brix in sugar and molasses % sucrose in mixed juice

$$= \frac{(100 - c)}{(r + d)} \times 100 - \frac{100u}{z} \quad \ldots\ldots(5)$$

Now the loss of non-sucrose is the difference between equations (5) and (4) and therefore:

Non-sucrose in sugar and molasses % sucrose in mixed juice =

$$\frac{100\,(100 - c)}{(r + d)} - \frac{100u}{z} - (100 - c - u)$$

$$= \frac{100\,(100 - c)}{(r + d)} - (100 - c) - \frac{100u}{z} + u$$

$$= \frac{(100 - c)\,(100 - r - d)}{(r + d)} - \frac{u(100 - z)}{z} \quad \ldots\ldots(6)$$

(d) *The Purity of the Produced Final Molasses:*

If the purity of the final molasses is P, then one part of non-sucrose will prevent the crystallisation of $\frac{P}{100 - P}$ parts of sucrose.

Hence, from equation (6) it follows that the non-crystallised sucrose in molasses % sucrose in mixed juice will be:

$$\frac{P}{(100 - P)} \left[\frac{(100 - c)\,(100 - r - d)}{(r + d)} - \frac{u(100 - z)}{z} \right] \quad \ldots\ldots(7)$$

The Equation for the Boiling House Performance

After suffering the losses in cake and undetermined, the sucrose available for crystallisation per 100 sucrose in mixed juice is

$$(100 - c - u) \quad \ldots\ldots(4)$$

The crystallised sucrose % sucrose in mixed juice is, therefore, the difference between equations (4) and (7):

$$(100 - c - u) - \frac{P}{(100 - P)} \left[(100 - c)\,\frac{(100 - r - d)}{(r + d)} - \frac{u(100 - z)}{z} \right]$$

$$= (100 - c - u) + \frac{uP(100 - z)}{(100 - P)z} - \frac{P(100 - c)\,(100 - r - d)}{(100 - P)\,(r + d)}$$

$$= (100 - c) - u \left[1 - \frac{P(100 - z)}{z(100 - P)} \right] - \frac{P(100 - c)\,(100 - r - d)}{(100 - P)\,(r + d)} \quad \ldots\ldots(8)$$

The percentage of crystallisable sucrose in mixed juice is by definition

$$100 - \frac{100p(100 - r)}{r(100 - p)} \quad \ldots\ldots(9)$$

and, hence, the Boiling House Performance is:

$$\text{B.H.P.} = 100 \times \frac{100 - c - u \left[1 - \frac{P(100 - z)}{z(100 - P)} \right] - \frac{P(100 - c)(100 - r - d)}{(100 - P)\,(r + d)}}{100 - \frac{100p(100 - r)}{r(100 - p)}} \quad \ldots\ldots(10)$$

(See Appendix 2.)

Conclusion from the Formula for Boiling House Performance

Equation (10) can be rewritten as follows:

$$\text{B.H.P.} = 100 \times \frac{B - D}{A - C} \text{ if}$$

$$A = 100$$

$$B = 100 - c - u \left[1 - \frac{P(100 - z)}{z(100 - P)} \right]$$

$$C = \frac{100p(100 - r)}{r(100 - p)}$$

$$D = \frac{P(100 - c)\,(100 - r - d)}{(100 - P)\,(r + d)}$$

(A) The term A = 100 is simply stating that we start with 100 parts of sucrose in mixed juice.

(B) The term

$$B = (100 - c) - u \left[1 - \frac{P(100 - z)}{z(100 - P)} \right]$$

will normally be very near to 100. In South Africa, the average loss of sucrose in cake % sucrose in mixed juice is 0.6, the average undetermined loss 1.5 and the purity at which the loss takes place approximately 50. For a molasses purity of 40, the value of the term becomes 98.90. Moreover, if this figure becomes significantly lower than 98.90 this will be due to factors which can be influenced, such as by reducing the loss in filtercake and preventing undetermined loss of high purity material. In fact, it states the percentage of the sucrose in mixed juice still available for crystallization after clarification and pan-boiling, but disregarding the loss in molasses.

(C) The term

$$C = \frac{100p(100 - r)}{r(100 - p)}$$

states the "unavoidable" loss of sucrose in final molasses. It is obvious that

$$\frac{100p}{100 - p}$$

indicates the sucrose as a percentage of non-sucrose that will not crystallize under the condition that the final molasses reached the "target" purity "p". The term

$$\frac{100 - r}{r}$$

refers to the quantity of molasses to be expected from mixed juice with a purity r. Therefore A - C states the amount of sucrose that will crystallize if no losses other than the "normal" losses in molasses will occur.

(D) This term states the percentage sucrose lost in molasses at the *actual* purity of the final molasses, produced in a quantity as may be expected from clarified juice with a purity (r + d). The amount available for crystallization is then not 100 as under (C) but 100 - c.

Under normal circumstances the term B will be very nearly A and for our further considerations we concentrate on the terms C and D.

In South Africa, under normal conditions

$$\frac{P(100 - c)}{(100 - P)} > \frac{100p}{(100 - p)}$$

Every factory which is not able to reduce P to the pre-determined level of "p" is at a disadvantage. But, if the standard "p" is set fairly, the penalty can be reduced by better work or even turned into a bonus.

However, considering the two terms

$$\frac{(100 - r - d)}{(r + d)} \text{ and } \frac{(100 - r)}{r}$$

we can say that these are very definitely *not* under human control. We all know that "d" will be larger for a carbonatation factory than for a defecation factory or a sulphitation factory. But, if we speak only for defecation and sulphitation factories now, the variance of "d" will be between 0.5 and 1.5 and if we assume 0.5 it will certainly be conservative.

Under South African conditions

$$\frac{(100 - r)}{r}$$

$$\text{may vary between } \frac{18}{82} = 0.220 \text{ and } \frac{12}{88} = 0.136$$

$$\text{and } \frac{(100 - r - d)}{(r + d)} \text{ between } \frac{17.5}{82.5} = 0.212$$

$$\text{and } \frac{11.5}{88.5} = 0.130$$

(the extremes of the purities of mixed juice are assumed at 82 and 88 purity).

If any factory is able to satisfy the condition that:

$$\frac{P}{100 - P} = \frac{p}{100 - p}$$

or, in other words, that the final molasses purity is equal to the "target" purity, then the value of the terms

$$\frac{(100 - r)}{r} \text{ and } \frac{(100 - r - d)}{(r + d)}$$

is of no consequence. But if, e.g., P becomes larger than p, which it nearly always is by a considerable margin in South Africa, then the value of the terms

$$\frac{(100 - r)}{r} \text{ and } \frac{(100 - r - d)}{(r + d)}$$

becomes of extreme importance. Hence, as soon as a factory is not able to produce final molasses with a purity identical to the target purity, then this factory is at a disadvantage not only for the higher purity, but also for the quantity at which this final molasses is made, which, in turn, is dependent on the mixed juice purity.

Numerical Example of the Influence of the Mixed Juice Purity on the Boiling House Recovery

Let the mixed juice purity for two factories A and B be 82 and 88 respectively. This means that according to our table the "target purity" of factory A must be 31.5 and 34.0 for factory B. In the event that both factories exceed these "targets" by 6 points, the factory A will produce molasses with 37.5 purity and factory B molasses with 40.0 purity. If in both factories the loss in cake is 0.6% on sucrose in mixed juice, the undetermined loss is 1.5% on sucrose in mixed juice and if both factories suffer their undetermined loss at 50 purity, then factory A will record a B.H.P. of 95.86 and factory B a B.H.P. of 96.54.

Factory A, achieving a B.H.P. of 95.86, *is doing the same quality of work as factory B,* which is making a B.H.P. of 96.54. This is 0.68 higher and a considerable margin if compared with the accepted maximum realistically achievable of 100 − 95.86 = 4.14.

But is it realistic to assume that a factory working with 82 purity would make 37.5 purity molasses and a factory, equally well run, 40 purity molasses out of mixed juice of 88 purity?

Assuming for one moment that the exhaustibility of molasses resulting from mixed juice of low purity is better than of molasses made of high purity mixed juice (a fact which is difficult to prove) then still this would not be the only factor influencing the final molasses purity. Graham[3] states that:

> "Under normal factory operating conditions it is found that as the purity of molasses decreases its viscosity increases."

As curing time and viscosity are proportional, and available curing time depending on the quantity of massecuite to be treated by available machinery, it is therefore certain that the mixed juice purity will influence the final molasses purity inversely as low purities will lead to large quantities of molasses and large quantities of molasses to short curing times, in turn necessitating lower viscosities with, as a result, higher purities.

It is, therefore, reasonable to assume that the two influences off-set each other and that both factories in one example do well, according to South African standards, if they produce molasses with 37.5 purity. In that case, the B.H.P. for factory A would remain 95.86 and would become 97.90 for factory B. This is a tremendous difference, too much to be allowed to depend on a factor which is not under one's control. And, in fact, the B.H.P. suffers from exactly the same disadvantage as the Boiling House Recovery, be it to a lesser degree.

Suggestion for a Revised Boiling House Performance

As previously said, there is little reason to assume that low mixed juice purities will lead to low molasses purities in practice and for this reason we need not allow for a variation in the "target purity". If a constant factor "f" of 0.5 is assumed, then the target purity will be 33.33, still a highly ambitious one.

Further, it is suggested to fix the value of "r" (the mixed juice purity) at a standard 85.0, which is a reasonably average figure for Natal.

It appears now that in equation (10) the only variables are:

1. the loss of sucrose in cake,
2. the loss of sucrose in undetermined,
3. the purity rise in mixed juice,
4. the purity of the undetermined loss,
5. the actual purity of the final molasses.

In other words, the formula states the percentage of crystallisable sucrose that would have crystallised after suffering the normal losses in cake, undetermined, etc., but with the loss in molasses corrected for the quantity which would have been made if the purity of the mixed juice had been 85.0.

So, the Revised Boiling House Performance is:

$$\text{R.B.H.P.} = 100 \times \frac{100 - c - u\left[1 - \dfrac{P(100 - z)}{z(100 - P)}\right] - \dfrac{P(100 - c)\,(15 - d)}{(100 - P)\,(85 + d)}}{91.176} \quad \ldots\ldots (11)$$

This equation is too cumbersome for practical use and some simplification should be made. The term

$$\frac{P}{100 - P}$$

can be substituted by "f". In Table II the values of f for purities ranging from 30 to 45 are given. The term

$$\frac{100 - z}{z}$$

can be replaced by F (see Table III). The term

$$\frac{15 - d}{85 + d}$$

is accurately replaced by $D = 0.1765 - 0.0135d$ and the value of D is found in Table IV.

Then our final equation becomes:

$$\text{R.B.H.P.} = 100 \times \frac{(100 - c) - u(1 - fF) - fD(100 - c)}{91.176}$$

$$= \frac{(100 - c)\,(1 - fD) - u(1 - fF)}{0.91176} \quad \ldots\ldots (12)$$

Example: A factory is losing 0.5% of its sucrose *in mixed juice* in cake and 1.2% in "undetermined". The undetermined loss is suffered at 65 purity. The purity-rise from mixed juice to clarified juice is 0.95 and the molasses purity 39.0. The Boiling House Performance under these circumstances will be:

$$\text{R.B.H.P.} = \frac{(100 - 0.5)\,(1 - 0.639 \times 0.1634) - 1.2(1 - 0.639 \times 0.538)}{0.91176}$$

$$= \frac{99.5 \times 0.8956 - 1.2 \times 0.6562}{0.91176}$$

$$= 96.87$$

On the other hand, one can ask the question: "Which purity of final molasses will a normal factory have to make to obtain a R.B.H.P. of 100?" (All losses the same as in our previous example.)

$$100 = \frac{(100 - 0.5)\,(1 - f \times 0.1634) - 1.2(1 - f \times 0.538)}{0.91176}$$

OR $f = 0.456$ and hence
$P = 31.3$

Conclusion

The suggested Revised Boiling House Performance is independent of the purity of the mixed juice and only on the losses in cake, undetermined and molasses. Correction is made for the purity of the undetermined loss. It is fully realised that the Revised Boiling House Performance is one, but not necessarily the best, solution. It is hoped that enough interest has been raised in the subject to have the Boiling House Performance in its present form re-examined critically by a committee, preferably within the Council of our own S.A. Sugar Technologists' Association.

References

1. Gundu Rao, S. N.: Boiling House Efficiency Indicators, Proceedings I.S.S.C.T. 1950, page 665.
2. Douwes Dekker, K.: Judging Boiling House Work, Proceedings I.S.S.C.T. 1953, page 671.
3. Graham, W. S.: Some Notes on Natal C Massecuites and C Molasses S.M.R.I. Bulletin No. 30.

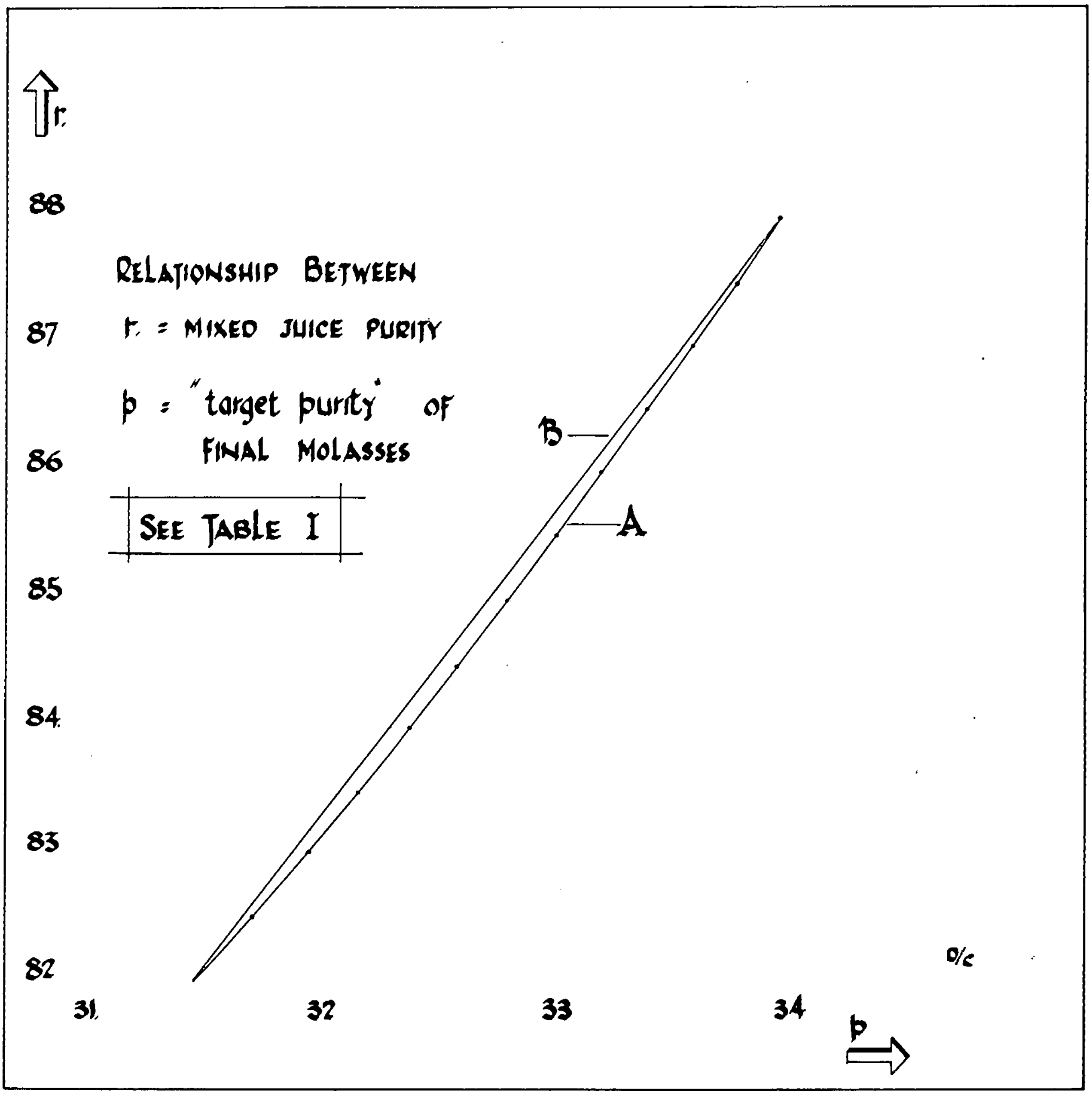
r
88
87
86
85
84
83
82
31
32
33
34
%
p
RELATIONSHIP BETWEEN
r = MIXED JUICE PURITY
p = "target purity" OF
FINAL MOLASSES
SEE TABLE I
B
A

TABLE I

r	p	f	r	p	f	r	p	f
82.0	31.51	0.460	84.1	32.48	0.481	86.1	33.27	0.499
82.1	31.57	0.461	84.2	32.52	0.482	86.2	33.31	0.500
82.2	31.61	0.462	84.3	32.56	0.483	86.3	33.35	0.501
82.3	31.65	0.463	84.4	32.60	0.484	86.4	33.39	0.502
82.4	31.70	0.464	84.5	32.64	0.485	86.5	33.43	0.502
82.5	31.75	0.465	84.6	32.68	0.486	86.6	33.47	0.503
82.6	31.79	0.466	84.7	32.72	0.487	86.7	33.51	0.504
82.7	31.84	0.467	84.8	32.76	0.488	86.8	33.55	0.505
82.8	31.88	0.468	84.9	32.80	0.489	86.9	33.59	0.506
82.9	31.93	0.469	85.0	32.84	0.489	87.0	33.63	0.507
83.0	31.97	0.470	85.1	32.89	0.490	87.1	33.66	0.508
83.1	32.03	0.471	85.2	32.93	0.491	87.2	33.70	0.509
83.2	32.07	0.472	85.3	32.97	0.492	87.3	33.74	0.509
83.3	32.13	0.473	85.4	33.01	0.493	87.4	33.78	0.510
83.7	32.16	0.474	85.5	33.05	0.493	87.5	33.82	0.511
83.5	32.20	0.475	85.6	33.08	0.494	87.6	33.85	0.512
83.6	32.26	0.476	85.7	33.12	0.495	87.7	33.89	0.513
83.7	32.31	0.477	85.8	33.16	0.496	87.8	33.93	0.513
83.8	32.35	0.478	85.9	33.20	0.497	87.9	33.97	0.514
83.9	32.39	0.479	86.0	33.23	0.498	88.0	34.00	0.515
84.0	32.43	0.480						

TABLE II

The value of $\frac{P}{100-P}$ for purities from 30 to 45

Purity	.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
30	0.429	0.431	0.433	0.535	0.437	0.439	0.441	0.442	0.445	0.447
31	0.449	0.451	0.453	0.456	0.458	0.460	0.462	0.464	0.466	0.468
32	0.471	0.473	0.475	0.477	0.479	0.481	0.484	0.486	0.488	0.490
33	0.493	0.495	0.497	0.499	0.502	0.504	0.506	0.508	0.511	0.513
34	0.515	0.517	0.520	0.522	0.524	0.527	0.529	0.531	0.534	0.536
35	0.538	0.541	0.543	0.546	0.548	0.550	0.553	0.555	0.558	0.560
36	0.563	0.565	0.567	0.570	0.572	0.575	0.577	0.580	0.582	0.585
37	0.587	0.590	0.592	0.595	0.597	0.600	0.603	0.605	0.608	0.610
38	0.613	0.616	0.618	0.621	0.623	0.626	0.629	0.631	0.634	0.637
39	0.639	0.642	0.645	0.647	0.650	0.653	0.656	0.658	0.661	0.664
40	0.667	0.669	0.672	0.675	0.678	0.681	0.684	0.686	0.689	0.692
41	0.695	0.698	0.701	0.704	0.706	0.709	0.712	0.705	0.718	0.721
42	0.724	0.727	0.730	0.733	0.736	0.739	0.742	0.745	0.748	0.751
43	0.754	0.757	0.761	0.764	0.767	0.770	0.773	0.776	0.779	0.783
44	0.786	0.789	0.792	0.795	0.799	0.802	0.805	0.808	0.812	0.815
45	0.818	0.821	0.825	0.828	0.832	0.835	0.838	0.842	0.845	0.848

TABLE III

The value of $F=\frac{100-z}{z}$ for values of 30 to 100

	0	1	2	3	4	5	6	7	8	9
30	2.333	2.226	2.125	2.030	1.941	1.857	1.778	1.703	1.632	1.564
40	1.500	1.439	1.381	1.326	1.272	1.222	1.174	1.128	1.082	1.041
50	1.000	0.962	0.924	0.887	0.852	0.818	0.786	0.755	0.724	0.695
60	0.667	0.639	0.614	0.588	0.563	0.538	0.516	0.493	0.471	0.449
70	0.429	0.408	0.389	0.370	0.352	0.333	0.316	0.295	0.282	0.266
80	0.250	0.235	0.220	0.205	0.191	0.176	0.163	0.149	0.136	0.124
90	0.111	0.099	0.087	0.075	0.064	0.053	0.042	0.031	0.020	0.010
100	0.000									

TABLE IV

The value of $D=\frac{15-d}{85+d}$ (or $D=0.1763-0.0135d$) for values of d from 0 to 2.0

	0	0.02	0.04	0.06	0.08
.0	0.1763	0.1760	0.1758	0.1755	0.1752
.1	0.1750	0.1747	0.1744	0.1741	0.1739
.2	0.1736	0.1733	0.1731	0.1728	0.1725
.3	0.1723	0.1720	0.1717	0.1714	0.1712
.4	0.1709	0.1706	0.1704	0.1701	0.1698
.5	0.1696	0.1693	0.1690	0.1687	0.1685
.6	0.1682	0.1679	0.1677	0.1674	0.1671
.7	0.1669	0.1666	0.1663	0.1660	0.1658
.8	0.1655	0.1652	0.1650	0.1647	0.1644
.9	0.1642	0.1639	0.1636	0.1633	0.1631
1.0	0.1628	0.1625	0.1623	0.1620	0.1617
1.1	0.1615	0.1612	0.1609	0.1606	0.1604
1.2	0.1601	0.1598	0.1596	0.1593	0.1590
1.3	0.1588	0.1585	0.1582	0.1579	0.1577
1.4	0.1574	0.1571	0.1569	0.1566	0.1563
1.5	0.1561	0.1558	0.1555	0.1552	0.1550
1.6	0.1547	0.1544	0.1542	0.1539	0.1536
1.7	0.1534	0.1531	0.1528	0.1525	0.1523
1.8	0.1520	0.1517	0.1515	0.1512	0.1509
1.9	0.1507	0.1504	0.1501	0.1498	0.1496
2.0	0.1493				

APPENDIX 1

Calculations of the Purity of the Undetermined Loss

This calculation is best shown in a calculation scheme:

Tons of sucrose in mixed juice ... ...
Tons of sucrose in cake ... ...
——— −
Tons of sucrose in clarified juice ... .
Purity of clarified juice/100 ... ...
——— ÷
Tons of brix in clarified juice ... ...
Tons of brix in sugar made ....
Tons of brix in molasses ... .
——— +
Tons of brix recovered ... ...
——— −
Tons of brix lost ... ...
Tons of sucrose lost (except bagasse) ... .
——— −
Tons N.S. lost ... ...

It is obvious that

$$\frac{\text{tons sucrose lost}}{\text{tons brix lost}} \times 100 = \text{Purity of Loss}$$

APPENDIX 2

Test of Derived Formula (10) with Actual Figures

The following example was taken from the 41st Weekly Report Sheet of Amatikulu (all figures to Date: 28/1/1967).

Sucrose loss in cake % sucrose in cane = 0.54
Sucrose loss in undetermined % sucrose in cane = 0.89
Extraction = 94.40
Purity Clarified Juice = 86.54
Purity Mixed Juice = 84.93
Gravity Purity Final Molasses (refractometer) = 40.43
Purity of Undetermined Loss = 31.10
Boiling House Performance = 98.05

$$\text{Hence: } c = \frac{0.54 \times 100}{94.40} = 0.572$$

$$u = \frac{0.89 \times 100}{94.40} = 0.943$$

$$r = 84.93$$
$$d = 86.54 - 84.93 = 1.61$$
$$P = 40.43$$
$$z = 31.1$$

When these figures are substituted in formula (10) the result is that B.H.P. = 98.08. The slight difference with 98.05 should be explained by the fact that the undetermined loss etc., are only known in two decimals.

These figures were chosen purposely because r = 84.93 is very near the assumed standard purity of 85.0. Also, p for r = 84.93 is 32.81 (see Table I), which is very near the assumed "standard target" of 33.33. So if the figures are used in formula 12, the R.B.H.P. should in this case be *very near* the B.H.P. In fact the result is 98.13.

Discussion

Dr. Douwes Dekker: When, in 1950, the Chemical Control Committee discussed the introduction of a figure which would indicate the performance of a factory better than Boiling House Recovery does, the merits of the old Winter Rendement based on the formula Crystallizable Sucrose=S - 0.4(B-S) were considered. It was rejected, in the first place because the factor 0.4 was deemed too small for Natal conditions and secondly because the formula does not reflect a possibly better exhaustibility of final molasses produced from lower purity mixed juice. At that time it was already known that a higher reducing sugar content and a lower ash content of the nonsugars in final molasses corresponded to a better exhaustibility than a lower reducing sugar content and a higher ash content.

It was also known that low purity mixed juice, in particular if extracted from unripe cane, contains more reducing sugars than high purity juice. The continued evidences prompted the Committee to carry out a simple statistical investigation which showed that taken over several years and taking all factories into account, a slightly lower purity final molasses was produced from lower rather than from higher purity mixed juice. It was subsequently decided—and this decision should not be called "arbitrary"—to use the new knowledge in the formula to be used in future as an indicator of the performance of the factory by replacing the fixed factor 0.4 of the Winter formula by a factor 'f' which increased from 0.460 for 82 to 0.530 for 90 purity mixed juice. The new criterion which was called Boiling House Performance has been used for the past sixteen years and one can agree with Mr. van Hengel when he suggests that the time has come to examine again the basis of its method of calculation.

In the first place I have tried to answer the question whether the B.H.P. as calculated annually by the S.M.R.I. is a function of mixed juice purity or not. I divided all data available from 18 factories over a period of thirteen years in groups of 20. The first group of 20 comprised all mixed juice purities between 81.09—83.52, the second group all purities between 83.57 and 84.20, etc. For each group I calculated the average purity of the final molasses produced by these twenty factories, and their average B.H.P. The following data were found:

Mixed Juice Purity	Mean Purity Final Molasses	Boiling House Performance
81.09—83.52	39.35	96.42
83.57—84.20	39.40	96.95
84.20—84.80	38.70	97.27
84.81—85.14	39.44	97.46
85.15—85.40	40.31	96.96
85.41—85.80	39.34	97.10
85.80—86.10	40.02	97.48
86.10—86.40	39.32	97.41
86.40—86.86	40.17	96.78
86.88—87.57	39.50	96.91
87.67—88.55	39.88	96.33

If the above molasses purity data are divided in two groups and the average purity is calculated for each group, the average figure for the lower mixed juice purity group is lower than the average figure for the higher mixed juice purity group, whether the dividing line between the groups is drawn at mixed juice purity 85.14, 85.40 or 85.80. The differences between the average molasses purities are small but their existence seems to indicate that there has been a definite trend for lower purity mixed juice to yield a final molasses of a somewhat lower purity. This conclusion obviously refers to exhaustion as achieved and not to theoretical exhaustibility. Since the data are industrial averages the applicability of the conclusion to a single factory and the inference to be drawn from such application are matters which need further study.

As to the B.H.P. data shown above, they do not seem to indicate that a higher mixed juice purity has led to a higher B.H.P. or vice versa. The lowest B.H.P. data are found for the groups of extremely low and extremely high mixed juice purities, and when the means are calculated for a high and a low purity mixed juice group, they do not differ more than a few units in the second decimal, whether the dividing line is taken at 85.14, 85.40 or 85.80 mixed juice purity.

Altogether I do not think that the present B.H.P. figure can be accused of tending to prejudice factories working mixed juice of low purity. Within its obvious limitations it seems to have worked fairly well. This however does not mean that a better criterion cannot be arrived at, and I think that it is the task of the Chemical Control Committee, of which both Mr. van Hengel and myself are members, to examine the use we can make of Mr. van Hengel's new criterion.

There is one point which is worrying me, and that is the use of the purity rise by Mr. van Hengel. In this connection I refer to the latest Annual Summary by Mr. Perk in which he quotes Mr. Clayton as having written: "As for the clarification process what efforts have been wasted in the careful measurement of purity rise." Obviously I am aware of the fact that the inaccuracy in our measurement of mixed juice purity also affects the B.H.P. calculation in its present form.

Mr. van Hengel: I withdraw the word "arbitrarily", but stand by the word "presumed". As Dr. Douwes Dekker states, a simple statistical investigation was carried out but such an investigation could easily lead to wrong conclusions. It is incorrect to try to prove the dependence of such a complex figure as the B.H.P. on one factor only, especially if it be such an imperfectly proved one as the influence of reducing sugars in low purity juices. From the statistics produced by Dr. Douwes Dekker, the following questions arise:

1. Are molasses from high purity mixed juices more difficult to exhaust with available machinery than those of low purity juices with the **same** machinery?
2. Does not the comparative ease with which a reasonable B.H.P. or B.H.R. is obtainable, or even sucrose lost in molasses % sucrose in cane, possibly allow a certain amount of carelessness on the part of the process manager?
3. Is not the absence of a formula like the revised B.H.P. which makes it harder to obtain a good B.H.P. when the purity of mixed juice is high, the reason why it was never found that equally low or lower purities could be produced when ample boiling time and centrifugal capacity were available (all for standard installations).

I once more refer to Graham's statement—quoted on page 3—"Under normal factory operating conditions . . ." etc. and the ensuing paragraph.

Coming to a practical comparison in my calculated examples, the factory producing 37.5 purity final molasses can still not match the same B.H.P. as the factory with 40.0 purity final molasses, the values being 95.86 and 96.54 respectively. If 2.5 points difference cannot compensate the mixed juice purity advantage, how can the maximum one point as shown by Dr. Douwes Dekker's "simple statistics"? Obviously other influences, such as undetermined losses, etc., play a role.

Dr. Douwes Dekker is worried by my use of the purity rise from mixed juice to clarified juice. The B.H.P. is based on the mixed juice purity and I can assure you that if one takes the trouble of substituting actual factory data in my formula, the identical answer is obtained as the one derived in the normal way. The term 'd' simply has to be there to represent the purity increase which is recorded, whether the difference is apparent or not.

I feel that my formula (10) states clearly what is actually happening in a sugar factory. The accuracy of the formula should be either disproved or accepted, but not vagely discredited on account of "simple statistics".

Mr. Alexander: (in the chair). Do you agree that the use of the refractometer could possibly allow the 'd' to be removed from your formula?

Mr. van Hengel: Yes, if the refractometer could also be used for mixed juice. As it is now, the refractometer is used for clarified juice and molasses purities and brix is recorded as 85 instead of 92. As the sucrose determination remains unaltered, this represents a sucrose loss of 7% in molasses, not compensated by the mixed juice purity.

Mr. Fourmond: Mr. van Hengel says that the B.H.P. in its present form does not correctly express the efficiency of a boiling house as it does not take into account losses in filter cake, undetermined losses, purity or the efficiency of clarification. He is incorrect as the S.A.S.T.A. Chemical Control Committee made a 'hidden' allowance for these losses and for efficiency of clarification by fixing the targets for factor 'f'. The fact that in 1957 Sezela and Illovo achieved a B.H.P. of 100.0 and 99.7% respectively is proof that such provisions were made.

He also assumes that the purity of mixed juice has no influence on the purity of final molasses. Again he is incorrect as many years ago Prinsen Geerligs proved that salts have more affinity for reducing sugars than for sucrose and it is common knowledge that juices of high purity have a lower reducing sugar ash ratio than juices of low purity. The Douwes Dekker formula for target purity is based on this and sugar technologists know that the purity of molasses varies directly with the purity of mixed juice. B.H.P. was formulated with this in mind, based on practical findings, in order to take care of the mixed juice purity.

In the paper it is also assumed that the purity of mixed juice influences B.H.P. and to prove the point a series of calculations are given, but these are misleading as they are based on assumptions.

Let us take two factories processing mixed juice of 82 and 88 purity respectively. If both suffer losses in cake of 0.50%, undetermined losses, at same purity levels, of 1.50% and both exhaust their molasses to target purity then both will achieve a B.H.P. of 97.8%. This is proof that purity of mixed juice has no effect on B.H.P. in its present form.

Mr. van Hengel is correct in saying that efficiency of clarification and the purity level of undetermined losses will influence B.H.P. One degree rise in clear juice corresponds to 0.3% rise in B.H.P. and a difference of purity level of 20 in undetermined losses for a loss of 1.5% corresponds to .2%.

Mr. du Toit: I am pleased that Dr. Douwes Dekker has pointed out that after seventeen years the B.H.P. figure is possibly due for revision.

I do not agree with Mr. van Hengel's comments on the figures presented by Dr. Douwes Dekker. He referred to the purities and the differences with target as irrelevant. I do not consider them irrelevant. If the figures were not affected by purity or final molasses the differences should have had a definite trend, which they did not have. The fact also that the difference in final molasses purity between mixed juice above and below 85 is small does not mean that the argument on which it is based is not sound, because the differences between the purities could also have been small. I think it is necessary that a proper statistical evaluation be made to determine if final molasses purity does, within the range that we experience, depend on the purity of mixed juice.

Dr. Douwes Dekker: Mr. van Hengel has asked why his calculations have not been criticised. The reason is that as such one can agree with them. I have merely been trying to find out if there is any good reason why we should reject the present B.H.P. figure and as far as I can see there is still no evidence that the B.H.P. figure provides an unrealistic criterion.

Mr. van Hengel: The fact that the figures are more or less the same through the years does not prove that the B.H.P. is a realistic criterion; in fact it proves the opposite. An accurate mass balance shows that every factory is losing progressively more crystal with lower mixed juice purities if the molasses purity is higher than the assumed "target" purity. So, factories producing an average B.H.P. from high purity mixed juice have a lower than average performance.

Mr. Fourmond: When the present formula for B.H.P. was derived provision was made for losses in filter cake and undetermined, but what was the standard determined?

Dr. Douwes Dekker: The evidence of past figures is usually used for setting standards.

One advantage of the old B.H.P. formula is the target figure of 100. If I understand the proposed new formula correctly we would have to set targets for all five variables.

Mr. van Hengel: I do not at all suggest the introduction of five standards. I take the losses in cake and undetermined as they are. We know what is normal or abnormal, but I correct for the purity of the loss, e.g. a defect at the mixed juice scale may cause a certain undetermined loss, and a defect at the molasses scale may cause an identical one. But in the first case, crystal is lost and the B.H.P. is affected, in the last case it is not. Does Dr. Douwes Dekker maintain that the present B.H.P. gives a fair comparison of the work done in our factories, so that a process manager obtaining 98 B.H.P. is really doing better than the man obtaining 97, and that it is not necessary to take into account other relevant factors?

Dr. Douwes Dekker: We are dealing with the past performance of our factories. From the figures I gave if factories were working mixed juice of a purity between 86.88 and 87.57 the average B.H.P. was 96.91. If the mixed juice purity was between 83.57 and 84.20 the B.H.P. was 96.95. So if you have mixed juice purities of 83 and 87 factories apparently should show the same B.H.P.

Mr. van Hengel: That is not a straight answer to my question. Different factories, different circumstances, different years are compared. My question was: Are the B.H.P. figures calculated at present a fair reflection of the quality of the performance?