SOME NOTES ON THE SETTING AND OPERATION OF MILLS

By A. VAN HENGEL and K. DOUWES DEKKER

A cane sugar mill can rend maximum performance only when both feed and discharge openings have been set correctly. The problem of finding the correct settings cannot be solved completely by mathematics; it is an art rather than science—according to Hugot—but calculations can help us considerably in obtaining satisfactory, although maybe not ideal, results.

In his book *La Sucrerie de Cannes* Hugot gives a formula showing the relationship between the various variables affecting the extraction of juice from cane (bagasse) which passes a set of parallel cylindrical rollers. This formula is based on the relationship between pressure and compression of bagasse as found by Noel Deerr, which for pressures higher than 50 kg/cm² (712 lbs./sq. in.) is reflected in a simplified formula also given by Hugot, t.w.

$$p=\frac{70}{(10\ c)^6}$$

Unfortunately the latter formula shows the static relationship between pressure and compression, whilst in a cane mill conditions are dynamic. This difference reduces the applicability of Hugot's formula, but since a better founded one is not yet available and moreover since it gives a useful picture of the nature of the link between the important variables, we shall discuss this formula first.

Hugot's formula: According to Hugot the relationship between the variables involved in the functioning of a set of rollers is:

$$K^{5\cdot5}=38\frac{L\sqrt{D}}{P}\left(\frac{q}{10F}\right)^6 \quad \dots \quad \dots (1)$$

or, after conversion into British units:

$$K^{5\cdot5}=28{,}570\frac{L\sqrt{D}}{P}\left(\frac{q}{10F}\right)^6 \dots \quad \dots (2)$$

where:

K=the radial opening between the rollers concerned, in in.

L and D=length and diameter of rollers, in in.

P =total pressure by top roller on bagasse, in lbs.

q =lbs. fibre/sq. ft. escribed roller surface area

F =the fractional fibre content of the discharged bagasse

Formula (2) is applicable to any squeezing of bagasse (cane) by parallel rollers and can be used to calculate from known values for L, D, P, q and F the corresponding value for K, the radial opening between the rollers. In normal practice formula (2) will only be used to calculate discharge openings, feed openings are usually found by multiplying the width of the discharge opening by an empirical factor.

When using formula (2) to calculate K,

q is found from

$$q=\frac{4{,}800\ Q}{n\pi DL} \quad \dots \quad \dots \quad \dots (3)$$

in which:

Q =tons of fibre passing the mill per hour

n =number of revolutions per minute of top roller

Q is normally found from Q=Cf in which:[1]

C =tons of cane passing the tandem per hour

f =the fractional fibre content of the cane

Hence:

$$q=\frac{4{,}800\ Cf}{n\pi DL} \quad \dots \quad \dots \quad (3a)$$

By substituting (3a) in (2):

$$K^{5\cdot5}=\frac{28{,}570\times480^6\times L\sqrt{D}}{(\pi DL)^6\ P}\left(\frac{Cf}{nF}\right)^6 \quad (4)$$

For a given mill $\frac{28{,}570\times480^6\times L\sqrt{D}}{(\pi DL)^6}$ =constant, and may be called the mill constant M.

In this way the formula (4) is reduced to:

$$K^{5\cdot5}=\frac{M}{P}\left(\frac{Cf}{nF}\right)^6 \quad \dots \quad \dots \quad \dots (5)$$

Formula (5) states that if cane passes a mill whose mill constant=M and rotates at a speed of n revolutions per minute, at a rate of Cf tons of fibre per hour, and exerts a total pressure of P lbs., the discharge opening must be K in. in order to deliver a bagasse containing 100F per cent fibre.

1. It is clear that the applicability of (5) is restricted. F cannot be increased to its maximum value, t.w. 0.77 just by reducing the setting of the discharge opening. There is a practical limit to F for each mill depending on the nature of the material to be crushed and the place of the unit concerned in the tandem. n and P are also restricted by practical limits.

2. Strictly P is the pressure exerted by the top roller on the bagasse between the top and discharge rollers. This pressure is not equal to the total pressure of the top roller, for fractions of the total pressure are absorbed by the feed roller and the bagasse turner plate. However, since the latter fractions are relatively small, and since the effect of variations

[1] Cf equals tons of fibre passing the mill opening per hour.

of P on K is also comparatively small, no significant error is made by assuming that P is the total pressure exerted by the top roller.

3. Formula (5) shows the relationship between K, C, f, n, P and F at any moment of the crushing operation in which under normal conditions the various variables are likely to vary all the time. We aim, however, at a constant F in spite of the normal variations in fibre throughput and formula (5) shows how this can be achieved. In the first place we must keep P constant, which is done (assuming the mill is provided with hydraulics or toggles) by not allowing the top roller to occupy either the highest or the lowest possible position, i.e. the top roller must float. More precisely for reasons to be explained under 7, we must aim at keeping the top roller continuously at a pre-determined position somewhere in between the extremes. In the third place we must aim at keeping the fibre throughput as given by Cf constant. This, however, is not very well possible and hence fluctuations will occur. They will show as variations in the lift of the top roller but then they can adequately be compensated for by regulating n. Formula (5) shows clearly that by regulating the rev's of the rollers, it is theoretically feasible to compensate for not too big variations in Cf in such a way that K and F remain constant, assuming the mill is provided with normal hydraulics which keep P constant.

4. If we have a mill of mill constant M, expected to crush consistently at a fibre rate of Cf tons per hour and to discharge bagasse containing 100F per cent fibre; if in addition the mill engineer has decided to apply pressure P on the top roller and to rotate the top roller on the average at n revolutions per minute, formula (5) shows what the radial opening K between the top and discharge rollers will be under these conditions. This radial opening, usually called the work opening, is not equal to the set opening because as we have said above we try to keep the top roller at a pre-determined position between the extremes which are possible, and the set opening is the radial opening when the top roller is at its lowest position.

Usually the pre-determined position of the top roller is that where its lift is 30 per cent of the total possible lift. This position is selected because—

(*a*) it allows a considerable further lift if a foreign object passes the mill

(*b*) it allows sufficient play in the position of the top roller when the regulation of the speed of the rollers does not compensate completely for all the variations in Cf which consistently occur.

5. To explain how, after we have calculated with the aid of formula (5) the work opening K commensurate with the average conditions under which our mill will operate, K can be reduced to S, i.e. the corresponding set opening, we will assume in the first instance that the rollers are smooth cylinders. In this case the set opening S is found from K by applying the formula:

$$S = K - 0.8\,L \qquad \ldots \qquad \ldots \qquad \ldots (6)$$

where L is 30 per cent of the total possible lift of the top roller.

(N.B.—Appendix I shows how formula (6) has been developed.)

6. Normally roller surfaces are grooved and the volume of the grooves have to be taken into account when the mills are set. In Appendix II it is explained how the smallest diameter of rollers (i.e. measured in the grooves) is corrected into a hypothetical diameter corresponding to hypothetical surfaces between which the hypothetical distance should be equal to S. Appendix II also briefly describes a convenient method of using the center-to-center distance of the rollers as the basis of the actual setting operation.

7. Under 3 it was said that the reasons why we should aim at keeping the top roller as much as possible at a pre-determined position was to be explained later on. We will do this now. The maxijum lift of the top roller in a modern mill is $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. and hence the lift when the mill operates "normally" is, say, 0.3×1 in.$=0.3$ in. This means that the calculated K has to be reduced by $0.8 \times 0.3 = 0.24$ in. to find S, the set opening. For example, if—

$C = 50$ tons of cane/hr.	$D = 32$ in.
$f = 0.15$	$L = 60$ in. and
$F = 0.50$	$P = 450{,}000$ lbs.
$n = 3$ r.p.m.	

we find $K = 0.64$in., using formula (5).

Thus, $S = 0.64 - 0.24 = 0.4$ in.

As said in the beginning of this paper, the feed opening of a mill is found by multiplying the discharge opening with an empirical factor, i.e. a factor which has shown to yield optimum results if maintained throughout the crushing operation, for example 1.9.

This means that the feed opening must be $1.9\times$ the discharge opening when the lift of the top roller is 30 per cent of the maximum lift but it means also that at any other lift the ratio is not longer 1.9, i.e. the mill is not working under optimum conditions.

Fig. I shows how the ratio between feed and discharge openings changes when the lift increases from 0 to 100 per cent of its maximum value, being 1.9 at 30 per cent lift. This change is considerable and can definitely affect the milling result, hence should be restricted to a minimum. Another reason for endeavouring to keep the top roller at its predetermined position is that the trash plate has been

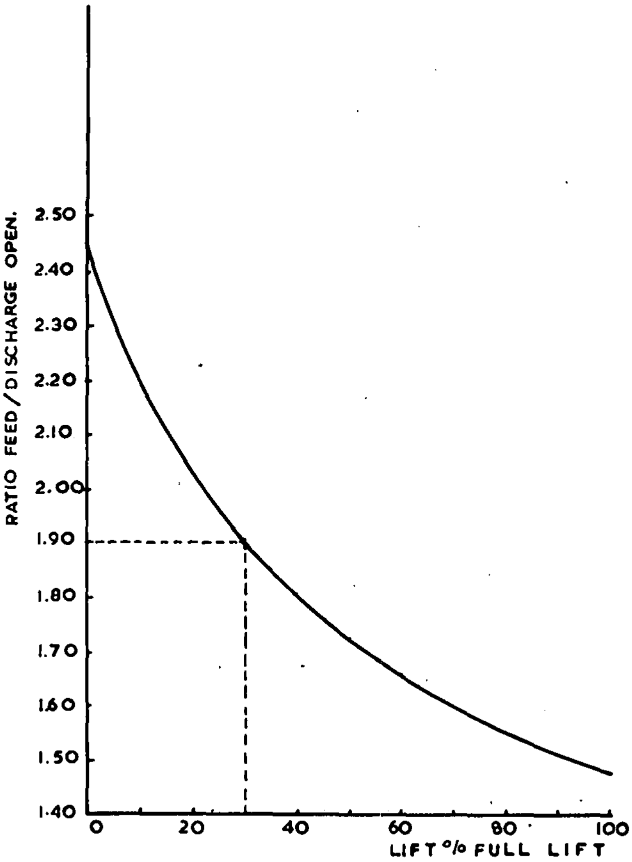

Fig. I

set according to the "normal" position of the top roller and cannot follow the latter's movements. At any other position of the top roller the position of the trash plate is no longer correct and for this reason fluctuations in the lift of the top roller should be avoided.

8. Under 4 it was said that the mill engineer decides at what average speed the rollers will rotate. This statement might occasion the question: does the actual value of n have any effect on the performance of the mill and what are the reasons for selecting a certain value of n? The answers to these questions are not straightforward; opinion in different countries may vary considerably and for this reason we will postpone a discussion on the subject till a later date.

Summarizing we have discussed:

(*a*) How Hugot's formula can be applied to calculate the work opening corresponding to the average conditions under which a mill has to operate,

(*b*) the desirability of keeping the top roller as much as possible in its pre-determined position. Not only that by doing so a constant pressure on the bagasse is ensured but the mill is also operating at the assumed optimum ratio between feed and discharge openings and thirdly the position of the trash plate is consistently correctly related to the position of the top roller.

N.B.—In respect of the basis of Hugot's formula, we have drawn attention to the fact that Noel Deerr's curve reflects static conditions, whilst milling is a dynamic process. For this reason some caution is recommended in accepting K as calculated from (5) as correct.

Alternative method

In 1923 Helmers, in Java, suggested basing the discharge opening of a mill on the factor lbs. of fibre per cu.ft. escribed volume and using for each mill in the tandem empirically found optimum data for the latter factor.

If we indicate lbs. fibre/cu.ft. e.v. by V, we have

$$V=\frac{C\times f\times 2{,}000\times 1{,}728}{60\pi n\ DLK}=\frac{57{,}600\ Cf}{n\pi\ DLK} \quad \ldots \quad \ldots \ (7)$$

or

$$K=\frac{57{,}600\ Cf}{n\pi\ DLV} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7a)$$

As the number of the unit in the tandem becomes higher, V will be larger, i.e. the weight of fibre per cu. ft. escribed volume will increase.

For a mill with characteristics equal to those we have used in the example demonstrating the application of Hugot's formula, we now find

$$K=\frac{57{,}600\times 50\times 0.15}{3\times 3.24\times 32\times 60\times V}=\frac{23.9}{V}$$

The correct values for V for each mill of a tandem can only be found empirically by long experience but if we assume that no Re-absorption occurs V can be computed after we have accepted practical values for the fibre content F of the bagasse to be discharged by each individual mill.

Assuming that the fibre of the bagasse is associated with 30 per cent Brix-free water and that the volume of natural fibre is equal to the sum of the volume of the dry fibre and the (Brix-free) water contained in it, the volume I (in cu.ft.) of 1 lb. of bagasse is:

$$I=\frac{F}{1.53\times 62.4}+\frac{0.3F}{1.0\times 62.4}+\frac{1-1.3F}{\text{density juice}\times 62.4}\ \text{cu.ft.}$$

Since we may also assume that the discharge opening is completely filled with bagasse and since according to definition

V = lbs. fibre/cu.ft. bagasse

F = lbs. fibre/lb. bagasse

I = cu. ft. bagasse/lb. bagasse

it follows that

$$V=\frac{F}{I}=\frac{F}{\dfrac{F}{1.53\times 62.4}+\dfrac{0.3F}{1.0\times 62.4}+\dfrac{1-1.3F}{\text{density juice}\times 62.4}}$$

or

$$\frac{V}{F}=\frac{100}{1.53F+\left(\frac{1.6-2.08F}{\text{density juice}}\right)} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

In this equation (8)

$$\frac{V}{F}=\frac{\text{lbs. fibre/cu. ft. bagasse}}{\text{lbs. fibre/lb. bagasse}}=\frac{1}{I}=\text{the specific}$$

weight of the bagasse in the discharge opening.

If it is now assumed that the target fibre contents to be achieved in the first to the fifth mill are F=0.30; 0.40; 0.45; 0.48 and 0.50 respectively, Table I can be calculated:

TABLE I

Mill Number	*Brix juice in bagasse*	*Density juice*	*Attainable F*	$\frac{V}{F}$	V (lbs./ *cu. ft.*)
1	20	1.08	0.30	73.4	22
2	12	1.05	0.40	74.5	30
3	8	1.03	0.45	74.9	34
4	5	1.02	0.48	75.5	36
5	3	1.01	0.50	75.8	38

Using the data of Table I to calculate K for the mill discussed in connection with Hugot's formula, we find

$$K=\frac{23.9}{V}=\frac{23.9}{38}=0.63 \text{ in.}$$

This result is in excellent agreement with the result obtained with Hugot's formula, i.e. 0.64 in. In the latter example a pressure P of 450,000 lbs. was assumed, but if a higher pressure had been assumed, for example 540,000 lbs., a pressure which according to Royston is more in agreement with milling conditions in Natal, the application of Hugot's formula would have resulted in K=0.62 in., still in good agreement with the K calculated by the second method.

The effect of P on K is obviously small.

Unfortunately it would be overhasty to conclude that the fact that both methods for calculating K have yielded practically identical figures proves that the calculated K values will yield the expected results when applied in a mill. We must remember that both methods are based on an assumption known to be incorrect. Hugot, in deriving his formula, has assumed that the pressure/compression relationship in a mill follows Noel Deerr's formula which was found under static conditions and in the second method of calculating K it was assumed that no Re-adsorption would occur. Actually, both incorrect assumptions amount to the same thing, and for this reason it is not surprising that nearly identical K values were obtained. The agreement between the results of the two methods of calculation can, however, not be used as an indication of the correctness of these methods.

In the beginning of our discussion of the alternate method it was said that the V-values to be used in formula (7a) should be found empirically instead of theoretically and the question now is, are enough statistical data available to conclude from what practical experience has shown to be satisfactory values for V.

The only data on milling performance available to us are those published before the war by the Java Sugar Experiment Station and they refer to first and last mills only.

Fig. 3 in "Communication from the S.M.R.I." No. 40 (1958) shows that in Java No. 1 mills V varied between 20 to over 50 lbs./cu. ft. escribed volume, and a further study revealed that in last mills V varied between roughly 40 and 75 lbs./cu.ft. escribed volume.

Apparently there was little uniformity in the degree of filling of pre-war Java mills and for this reason some caution has to be exercised in selecting an "average" value for V which can reasonably be expected to be satisfactory when used as a basis for the setting of other mills.

If the available data are examined closer, it appears in respect of first mills that at the lower values of V the fibre content of the first mill bagasse tends on the average to be lower than when V is 33 to 37 lbs./cu. ft. escribed volume. It would also appear that there is a tendency for F to drop rather than to increase when V is increased to over 40 lbs. of fibre/cu. ft. escribed volume. This means that Java No. 1 mills on the average gave their best performance when fed at a rate of round about 35 lbs./cu. ft. escribed volume.

For last mills the situation is similar in respect of low values of V (say under 50 lbs. fibre/cu. ft. escribed volume), where the fibre content of the final bagasse is also low. However, when V is increased to over 55 lbs. of fibre/cu. ft. e.v. the fibre percentage of the bagasse tends to become constant at on the average 53 per cent. Hence although from a point of view of extraction there would be little objection to raising V to over 55 lbs./cu. ft., there is no doubt that in doing this more power will be required. On the whole there does not seem to be any advantage for the degree of filling of last mills to be raised to much over 55 lbs. of fibre/cu. ft. e.v. These figures are considerably higher than those found in Table I where the optimum filling of a first mill is given as 22 lbs. of fibre/cu. ft. e.v. and of last mill as 38 lbs. of fibre/cu. ft. e.v. The situation is illustrated by Fig. II.

Fig. II is an illustration of the performance of crushing by consecutive mills. On the abscis V is recorded, i.e. lbs. fibre/cu. ft. e.v., on the ordinate 100 F., i.e. the fibre content of the discharged bagasse. The theoretical relationship between V and F is given by curve AB, whilst curve AC indicates the natural fibre content of the bagasse. Hence the area left of AC represents juice, the hatched area between AC and AB represents Brix-free Water and the area right of AC represents fibre.

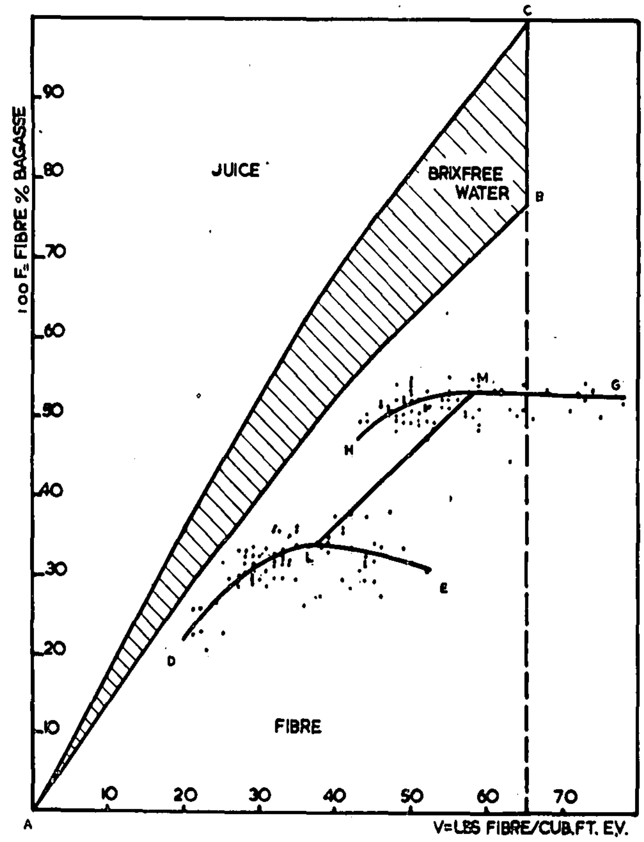

Fig. II

The actual relationship between V and F as found in 1940 for the first and respective last units of Java tandems is shown by two groups of dots of which the lower one represents No. 1 mills and the top one the last mills.

The curves DE and HG are representative of the average behaviour of the No. 1 and last mills respectively. The deviation of the empirical curves DE and HG from the theoretical curve AB is due to Re-absorption. It will, however, also be noticed that a few last mills show higher values for V than is theoretically possible. This must be explained by assuming that not only the juice but also the fibre particles in these last mills travelled faster than the peripheral speed of the top roller. In other words: a positive slip.[2]

As said above the curves DE and HG indicate that a higher F was not obtained when V was raised to over 35 lbs. fibre/cu. ft. e.v. in the case of No. 1 mills and to over 55 lbs. fibre/cu. ft. e.v. in the case of the last mills. We might call these values the optimum values of V for No. 1 and last mills. As such they can be used for the calculation of K using formula (7a).

[2] The possibility of the fibre travelling faster than the peripheral speed of the top roller has already been demonstrated in the Technical Report No. 41 of the Sugar Research Institute, Mackay.

Unfortunately similar data are not available for the intermediate mills but it is not far fetched to assume that the optimum values for V for intermediate mills must lie on the straight line connecting the corresponding points for the No. 1 and last mill respectively, i.e. on the line LM.

This line satisfies the condition $\frac{V}{F}=110$ lbs. bagasse/cu. ft. (9) and by substituting this value in formula (7a) we get:

$$K=\frac{523.6\,Cf}{n\pi DLF}=\frac{167\,Cf}{n\,DLF} \quad \cdots \quad (10)$$

Formula (10) correlates the work opening K with F, i.e. the fibre percentage of the bagasse we think is reasonable to expect for the various mills in a tandem.

For a 15 roller and a 18 roller tandem, we suggest the following target values of F (Table II) be used for calculating K.

TABLE II

Unit No.	15-*roller* tandem	18-*roller tandem*
1	0.32	0.30
2	0.40	0.39
3	0.45	0.43
4	0.48	0.46
5	0.50	0.48
6		0.50

It has to be appreciated that work openings calculated with formula (10) and using the target F values of Table II are based on the performance of Java mills, crushing Java cane. The performance of a mill depends to a large extent on the Re-absorption phenomenon which in its turn should depend a.o. on the nature of the fibre of the cane crushed. We have no means of comparing the nature of the fibre of Java cane with, let us say, Natal cane, and we must admit that for this reason a difference in Re-absorption between Java and corresponding Natal mills is a distinct possibility. The work openings calculated with formula (10) and Table II should therefore be regarded merely as an initial guidance when the object is to establish as correctly as possible the work openings of, say, a Natal tandem. They should be adhered to as long as an adequate milling control has not shown that modified settings yield a superior result.

It is, however, not always the setting of the discharge opening which is responsible for an inferior result. The overall performance of an individual mill depends also on the setting of the feed opening and on the position of the trash plate. Obtaining maximum results is for this reason a complicated problem in which the correct setting of the discharge opening is nevertheless the most important factor. The setting of the feed opening is usually derived from the discharge opening and the position of the trash plate from the feed opening. Most mill experts seem to agree that depending on the place of the unit in the tandem and on the presence or not of a 2-roller crusher, the feed opening can be found from the discharge opening by multiplication by a factor of which the magnitude is apparently based on experience only. Table III gives these factors—or mill ratio's—as recommended by various authors:

TABLE III

	2-*roller crusher*	1*st mill*	2*nd mill*	3*rd mill*	4*th mill*	5*th mill*
Hugot	With ...	2.0	2.0	2.0	2.0	2.0
	Without	2.5	2.0	2.0	2.0	2.0
Maxwell	With ...	2.2	1.9	1.9	1.9	
	Without	2.6	1.9	1.9	1.9	
Java 1940 (average)	With	2.5	1.9	1.8	1.9	1.9
	Without	2.5	1.9	1.8	1.7	1.6
Dr. Kerr		Between 1.75 and 1.5				

For the setting of trash plate Hugot and also Maxwell gives a method developed by Müller von Czernicky which is also generally used in Java. To explain this method we refer to Fig. III.

A drawing to scale is made of the rollers, the top roller being in its lowest position where the radial distance between them equals the set opening S. The toe of the trash plate is now found by drawing a line under an angle of 13° with the line connecting the centres of the top and feed roller, the former, however, being in its normal working position, i.e. lifted over 30 per cent of its maximum lift. The curve of the trash plate is a circle and to allow for a gradually increasing opening between top roller and trash plate, the centre of the circle is located in point A on Fig. III, i.e. at a distance D from the vertical through the centre of the top roller and on the horizontal line through this center when the top roller is in its working position.

D is found from formula $D=\frac{p}{100}(R+s)$, where

p = per cent drop over the length of the trash plate
R = radius of the top roller
s = setting of feed roller.

Normally p is 4 or 5, or D is $\frac{R+s}{25}$ or $\frac{R+s}{20}$

Had we based the position of the trash plate either on the top roller being in its lowest, set, position or

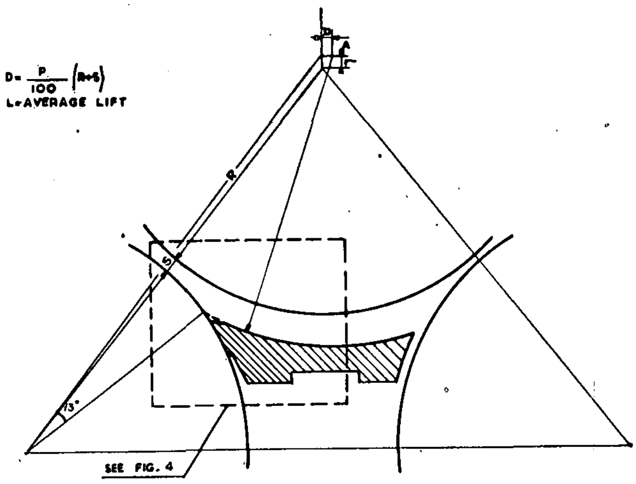

Fig. III

on the top roller being lifted over the maximum distance, we would have found a not inconsiderable difference. This is illustrated in Fig. IV which is an enlarged part of Fig. III. In this figure T gives the former position of the trash plate, T^1 the latter. The correct position based on 30 per cent lift is somewhere between T and T^1.[3]

It should be clear from the above considerations that the feed opening through the mill ratio depends on the discharge opening, further that the position of the trash plate depends on the feed opening, and the lift of the top roller. This narrow correlation between the various variables makes it the more important to do our utmost to get the best possible value of the discharge openings. The openings to start a tandem with can be found as already explained, but from then on the correctness of the openings should regularly be checked.

In our opinion the best way to provide the engineer in charge with adequate data on which he can base a decision regarding whether or not to alter his settings is to initiate a system of milling control which is somewhat more complete than the one at present in force at many Natal mills.

It entails preparing Weekly Data Sheets showing the required details of each unit. These sheets have to be filed and will in due time provide an invaluable wealth of information on the performance of such a unit when working under varying conditions.

More specifically they will show what is the best factor to be substituted for factor 167 in formula $K=\frac{167\ Cf}{nDLF}$, or in other words they will show what is the best practical ratio between V and F. Java experience accepts that for that country $\frac{V}{F}=110$ gave the best results but for Natal this may be different. If the above suggested system of milling control will

[3] Fig. IV is approximately 40 per cent of the true size.

be applied in this country, it should not take long before we are in the position to state which is the best figure for Natal conditions.

The extended system of milling control requires recording n, i.e. the number of revolutions of each unit. Revolution counters will have to be installed and read regularly. It will also be necessary to install lift indicators. They will have to be read regularly or should be of the recording type. Their indications are required to find the average work opening with which its unit was operating. F will also have to be determined regularly for all units. It is of course done already at all factories for the last mill but the data of the first and intermediate units are also required.

For the intermediate mills dry matter per cent. bagasse corrected for brix with a constant correction factor will yield a sufficiently reliable fibre percentage. For a first mill, the fibre content of the bagasse can suitably be found from the fibre content of the cane and the brix data of mixed juice, first, and secondary mill juice using the formula:

$$\frac{F_1}{100} = \frac{Fc}{100 - M\left(\frac{b_m - b_2}{b_1 - b_2}\right)}$$

in which M = mixed juice per cent cane

b_m = brix mixed juice

b_1 = brix primary juice

b_2 = brix secondary juice

F_c = fibre per cent cane

It is, however, not our intention to discuss here fully the implications of this intended method of milling control. The matter will shortly be taken up with the appropriate S.A.S.T.A. Committee and it is hoped that a large number of factories will agree to participate in it.

An example of the Data Sheets which we would like to see prepared weekly at every mill is given in Appendix III.

Summary

Two theoretical methods have been discussed which can be used to calculate discharge openings

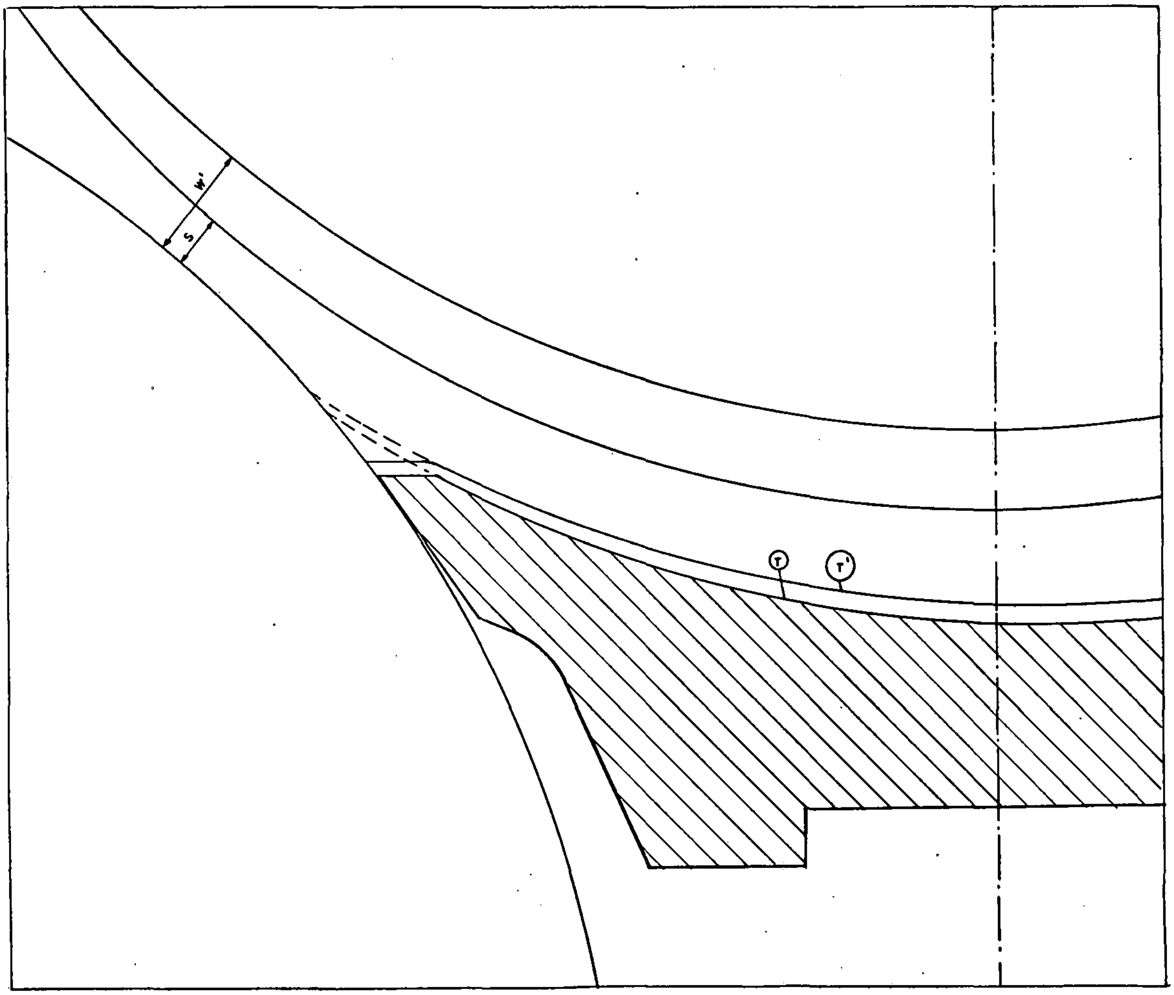

Fig. IV

of cane mills. The first one is based on a formula given by Hugot, the second one is based on a principle first mentioned in 1923 by Helders. It has been shown that both methods give nearly identical results. Since, however, the former method is based on a static pressure-compression ratio and the latter method fails to take into account the Re-absorption phenomenon, the calculated settings cannot be accepted as correct.

For this reason, it has been suggested to base the calculation of mill openings on empirical data and as such certain Java data have been proposed. They lead to the formula $K = \frac{167\ Cf}{n\ DLF}$

The factor 167 although being typical for Java conditions may, however, have to be modified for Natal cane. To find the correct factor for Natal, it has been suggested to initiate a system of milling control in Natal factories in which a.o. it will be necessary to determine regularly the roller speed and the average lift.

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Since β is a very small angle, we may assume that:

$$DP = DT$$

Thus

$$DF = FP + PD = FP + DT = DT + FT \cos a = R + R^1 + K$$

$$DT = \quad DT \quad R + R^1 + S$$

$$FT \cos a = K - S$$

If FT is the actual lift of the floating top roller, we can replace FT by L. Further, since, in most cases, the top angle of a mill is approximately 80°, the cosine of the half top angle is 0.8 Hence:

$$0.8\,L = K - S$$

$$S = K - 0.8\,L$$

APPENDIX II

See Fig. VI

A very small error is made if we assume that the hypothetical diameter of a grooved roller is just half-way between its largest (D_R) and smallest (D_G) diameters.

$$D = D_R - 2 \times \tfrac{1}{2}\,C = D_R - C, \text{ or}$$

$$D = D_G + 2 \times \tfrac{1}{2}\,C = D_G + C$$

The latter formula is easier to apply, because the tops of the ridges are often damaged by passing of foreign objects.

It is common practice to determine the set opening of a mill by measuring the distance A. It will be clear that in this way exact measuring can be done only if:

APPENDIX I

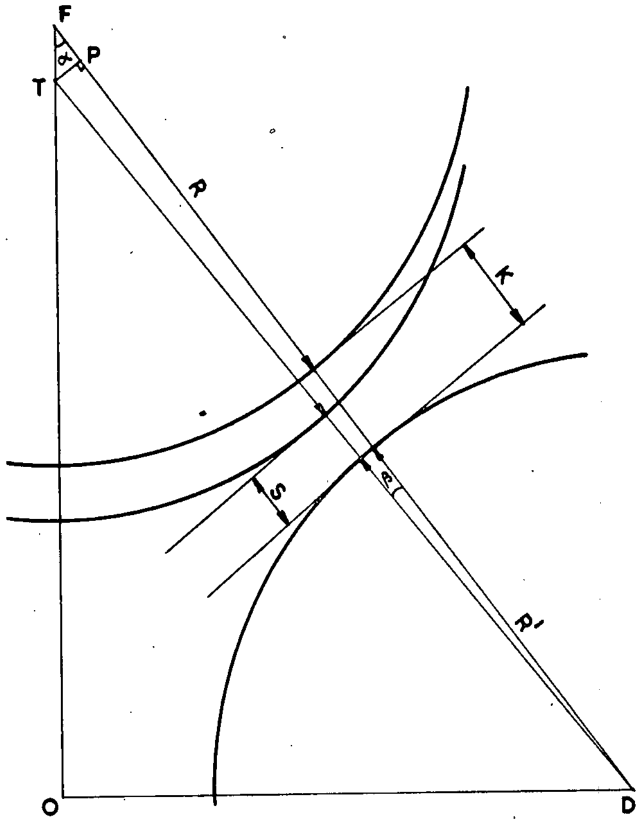

Fig. V

(a) the roller surfaces are not damaged; and

(b) the two rollers concerned are identically grooved.

To avoid errors due to damage of rollers, and different types of grooving, it is recommendable to base the setting of rollers on the centre-to-centre distance of the rollers according to:

$$H = \frac{D + Dm}{2} + S, \text{ or}$$

$$S = H - \frac{D + Dm}{2}$$

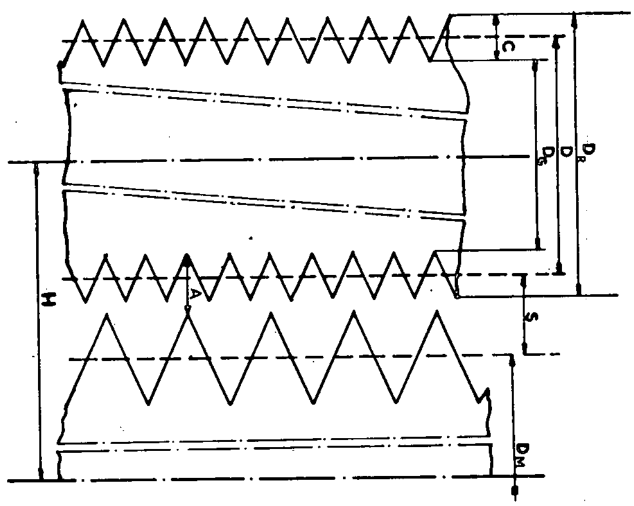

Fig. VI

APPENDIX III

An example of a control-sheet which enables the engineer to obtain an insight into his milling process follows hereunder (fifth mill):

FACTORY ....

Week ending.............................. Crusher (Mill No..........................

Rollers	Top	Feed	Discharge
Diameter of roller *in* groove ... ... (in.)	31.0	30.7	31.1
Depth of groove ... ... (in.)	1.0 +	1.0	1.0
WORKING DIAMETER OF ROLLERS (D) (in.)	32.0	31.7	32.1
LENGTH OF ROLLERS (L)... ... ... (in.)	60.0	60.0	60.0
Hydraulic load... ... ... (tons)	220		

Settings	Feed		Discharge	
Centre to centre ... ...(in.)		32.8		32.45
Top roller working diameters ... ...(in.)	32.0		32.0	
Feed/Discharge roller working diameters ... ...(in.)	31.7 + 63.7 2 :	31.85	32.1 + 64.2 2 :	32.05 −
SET OPENING (S) ... ...(in.)	−	0.95	−	0.40
Average % of lift/100 ...	0.28		0.28	
Total possible lift ... ...(in.)	1.0 ×		1.0 ×	
Average lift ... ...(in.)	0.28 0.8 ×	+0.22	0.28 0.8 ×	+0.22
Working openings (K) ...(in.)		1.17 0.62 :		0.62
Mill ratio		1.89		

Total number of revolutions of top roller...					24758
Hours actual crushing			139.5 60 ×		
Minutes actual crushing					8370 :
REVOLUTIONS OF TOP ROLLER PER MINUTE (n) ...					2.96
Moisture per cent Bagasse			49.27		
Sucrose per cent Bagasse		2.47			
Purity juice last mill/100		0.77 :			
Brix per cent Bagasse			3.21 +		100.00
Juice per cent Bagasse...					52.48 −
FIBRE PER CENT BAGASSE (100F.)					47.52
Alternative for intermediate mills...		100	e.g. Third mill		
Moisture per cent Bagasse		54.14 −			
Dry matter per cent Bagasse		45.86			
Brix per cent Bagasse (estimated)		7.00 −			
FIBRE PER CENT BAGASSE (100 F.)		38.86			
Alternative for first mills:					
Fibre per cent cane					16.12
Mixed juice per cent cane			106.7		
Brix mixed juice	15.12				
Brix secondary juice	11.63 −				
		3.49			
Brix primary juice	19.23				
Brix secondary juice	11.63 −				
		7.60 :		100.00	
			0.459 ×	48.90 −	
					51.10 :
FIBRE PER CENT BAGASSE/100 (F.)					0.316
Cane crushed (ton)	8783				
Average fibre per cent cane/100...	0.1612 ×				
Tons fibre crushed...	1415.82				
Hours actual crushing	139.5 :				
TONS FIBRE PER ACTUAL CRUSHING (Cf)	10.15				

$$\text{Milling factor} = \frac{nDLFK}{Cf} = \frac{2.96 \times 32.0 \times 60.0 \times 0.4752 \times 0.62}{10.15} = 165$$

Mr. Gunn said that regarding re-absorption, at Maidstone last year they endeavoured to calculate the bagasse volume in the first mill as compared with the escribed volume. He considered this a method of assessing the amount of re-absorption.

Mr. van Hengel agreed that this was a useful method, in so far that it gives figures about re-absorption, but not about mill settings.

Mr. Rishworth wanted to know what effect the inclined headstock would have on the formula given in the paper.

Mr. van Hengel stated that in the case of an inclined type headstock, Figure No. 1 would not be applicable. He had no experience, however, of such a type of mill.

Mr. Royston said attempts had been made to simplify the calculation of mill settings. He had attempted to do this some years ago and hoped the S.A. Sugar Technologists' Association would take advantage of this paper.

Mr. van Hengel said it had not been the authors' endeavour to simplify the formula, but investigations reached a point that made simplification possible.

Formula $K = \frac{167\ Cf}{n\,DLF}$ could be accepted as K was proportional to the tons of cane crushed per hour and its fibre content.

Dr. Douwes Dekker said one object of the paper was to provide a starting point for further work and secondly, if the methods outlined on page 65 were adopted, more information or data could be obtained about Natal milling conditions. Some mills have already agreed to take part in this milling control system and he hoped others would shortly follow. A point to be stressed was that mills should be provided with revolution counters and a lift indicator.

Mr. Rault asked Mr. van Hengel how he arrived at the figure in Table II, and asked what the position was in Java as there the final bagasse moisture was much lower than in Natal. He asked if this meant that we had to process too much fibre per hour, or in other words, our mills were working over normal capacity.

Mr. van Hengel stated that in Java a normal moisture for final bagasse was between 44 and 43. After the war it was between 47 and 48 per cent. Owing to war conditions the mills could not be kept in the same condition as before the war. After the war some very good Java canes were out of production, for instance POJ. 2878, and another cane had to be used. In any case it showed decreased performance as far as moisture content was concerned. Cane grown under very different conditions would have a very different bearing on the results obtainable when compared with Java conditions. He thought that some mills in this country were overloaded. It was, therefore, very difficult to make a straight comparison between these varying conditions. A lot of investigation, which had been done in Java, would require to be done here, to find out the sizes of grooves, for example. It might be that after a good milling control had been established, figures shown in Table II would have to be altered because of an improved milling performance.

Mr. Dick referred to Page 4 of the paper and drew attention to the reference that with a "V" figure of over 55 lbs./cu. ft. more power would have to be developed by the engines to cope with this condition. He mentioned that while in another sugar-growing country he had carried out experiments by taking engine indicator diagrams for varying hydraulic loads on the mills, which proved that beyond an optimum hydraulic pressure there is no increase in mill extraction, but a decidedly rising horse power demand from the engines. He expressed a view that in South Africa there appeared to be little information on the horse power requirements of milling plant to suit local conditions, and therefore recommended that, in addition to the data on page 51 of the paper, further data should be collected as to the horse power delivered by steam engines, turbines or electric motors.

Dr. Douwes Dekker said that in Java it was usual to have indicator diagrams taken for each mill frequently and he would like to see that system applied regularly in Natal, where possible.

Mr. Walsh said Mr. van Hengel quoted 40 per cent moisture in bagasse and asked what was the roller speed.

Mr. van Hengel said that the normal speed of a Java mill was 1.8 to 2.2 revs. per minute, i.e. about 18 ft. per minute.

Mr. Walsh said that 18 ft. per minute was quoted in a recent S.M.R.I. report and did that not have some considerable bearing on bagasse moistures?

Mr. Gunn said that Dr. Kerr, last year, had introduced us to the "Woolly" top rollers. Some mills tried it and got no benefit from it whatsoever. He asked Mr. van Hengel if this was because the figure of 55 lbs./cu.ft. escribed volume was too high.

Mr. van Hengel said he had seen mills where there was too much compression leading to excessive re-absorption. He thought this might occur in Natal as well. He also thought that the running of a top roller "woolly" when not taking the decreased opening into account would lead to more re-absorption.

Dr. Douwes Dekker said that while it was stated in the paper that a throughput of 55 lbs./cu.ft.

escribed volume was advocated, Dr. Kerr had shown a much lower figure and the results he claimed when running with a "woolly" top roller may be due to the fact that he must reduce the escribed volume and therefore increase the lbs. per cu.ft. escribed volume.

Dr. Douwes Dekker said there was a particular concern in Java which ran mills with shallow grooving more or less comparable with "woolly" top rollers. The subject was a complicated one and he would not like to give any opinion at the moment. One thing was certain and that was that the surface of the roller should be rough.

Mr. van Hengel said that Dr. Kerr had mentioned a particular mill where the Chief Engineer used a 35° groove and they found it was necessary to allow the grooves to be filled up with bagasse to avoid squirting. This was similar to experience in Java and he therefore recommended 55° grooving.

Mr. Bentley, referring to the question asked by Mr. Walsh about the speed at which the mill should be run, wanted to know what Mr. van Hengel thought of running mills at 75 ft. per minute, as was done in several countries overseas. As far as plain top roller scraper plates were concerned, there were also mechanical advantages such as reduced roller wear and ease of manufacture of the scraper plate.

Dr. Douwes Dekker said that while in Java 18 ft. per minute was the roller speed but in the West Indies much higher speeds were used. He said he would not be prepared at the moment to give any opinion as to which was more desirable.

Mr. van Hengel said that higher revolutions involved lighter construction of mills and so far were of advantage.

Mr. Royston asked Mr. van Hengel his opinion of the distance of the heel of the trash plate to the discharge roller. He wanted to know what the normal practice was in Java.

Mr. van Hengel said that the normal practice in Java was to decrease the opening from $1\frac{1}{4}''$ to $\frac{1}{2}''$ in the consecutive mills.

Mr. Rault enquired how the quantity of fine bagacillo in Java compared with that in Natal.

Mr. van Hengel said there was quite a lot of trouble experienced in Java with fine bagasse falling down between the heel of the trash plate and discharge roller. In the old days strainers were used, but now chokeless pumps, and nobody worried any longer about the amount of cush cush coming through.