# THE IMPORTANCE OF FEEDING RATES IN ROTORVANE MANUFACTURE

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Everyone engaged in the manufacture of black tea by the orthodox rolling process is familiar with the concept of optimum withered and rolled leaf charges for conventional rollers of different sizes. In this paper a similar concept is introduced for rotorvane manufacture. The optimum charges for Rotorvanes operated under varying conditions, however, have yet to be determined. An important factor governing the characteristics of rotorvaned teas is the quantity of leaf held within the Rotorvane barrel, once equilibrium conditions are reached between the leaf being fed and that which is being discharged from the machine. This quantity depends on the type of end plate, the combination of vanes, the rate of feed and the speed of the rotor shaft.

The effect of two vane combinations at three rotor shaft speeds using the Iris end plate in the maximum and minimum pressure positions, together with their interactions, are discussed. The results indicate that the influence of pressure exerted by the Iris end plate is more predominant than that of the two vane combinations investigated. In general, rotor shaft speed has no influence on characteristics of rotorvaned teas, provided that the intake of the Rotorvane is directly related to the rotor shaft speed.

## Introduction

Trials were conducted using an A-series model of an 8" Rotorvane to determine the influence of rotor shaft speeds on Rotorvane rolling as far back as in 1963. There was little to choose between one speed and the other (Keegel 1964). In the past, some estate Superintendents have claimed that under certain operating conditions, the Rotorvane gives superior results than under other conditions adopted elsewhere. The results obtained at a rotor shaft speed of 25 rpm are said to be superior to those obtained at a speed of 35 rpm at Kirkoswald Estate, Bogawantalawa, (Anley 1964). At Aislaby Estate, Bandarawela, rotor shaft speeds of about 35 rpm have been found to be the most suitable (Lushington 1965). Different views have also been expressed on the effect of the Iris end plate. Anley (1964) claims that it is efficient whereas Lushington (1965) has completely rejected it. There has also been some difference of opinion about the stage at which the Rotorvane could best be introduced into a mixed Orthodox-Rotorvane programme. It is now, however, a generally accepted principle, that the Rotorvane should be introduced in the initial stages of the rolling process (Anley 1964; de Silva & Sanderson 1964; Lushington 1965).

The present investigation was initiated in order to determine the influence of the Iris end plate, the rotor shaft speed and the vane combination, on the dhool and grade outturns; as well as on the made tea characteristics as evaluated by a panel of tasters in Colombo. The results obtained from this trial generally, follow a regular pattern. A possible explanation is offered, for the few variations in the regular pattern. The same explanation could be applied to interpret the inconsistencies obtained earlier (Keegel 1964).

## Experimental Design

The machine used for the trial was an 8" series-B model Rotorvane, the rotor shaft of which was capable of accommodating 9 vanes. It was incorporated with an Iris end plate. Plates 1 and 2 illustrate the rotor shaft incorporated with a vane combination having one reverse-pitched vane, and the interior view of the Rotorvane respectively. A split split-plot experimental design was used in the investigation.

The influence of two combinations of vanes on rotorvane rolling and made tea characteristics were studied. One combination had all forward-pitched vanes, whilst the other had eight forward-pitched vanes and one reverse-pitched vane, the latter being placed centrally. Each of these two principal treatments were divided into three sub-treatments consisting of three rotor shaft speeds of 16, 25.5 and 36 rpm. Each of these six treatments in turn were further divided into two groups corresponding to the maximum (fully closed) and minimum (fully open) pressure positions of the Iris end plate. Fully closed and fully open positions of the Iris end plate corresponded to the covering of the Rotorvane discharge end by 88% and 61% of the total area respectively. These positions are illustrated in Plate 3. A total of twelve Rotorvane treatment-combinations were studied in the trial. The main effects studied were those resulting from combinations of vanes, rotor shaft speeds and pressures exerted by the Iris end plate. In addition, the interactions of these main effects with each other were also studied. The twelve Rotorvane treatment-combinations are outlined in Figure 1.

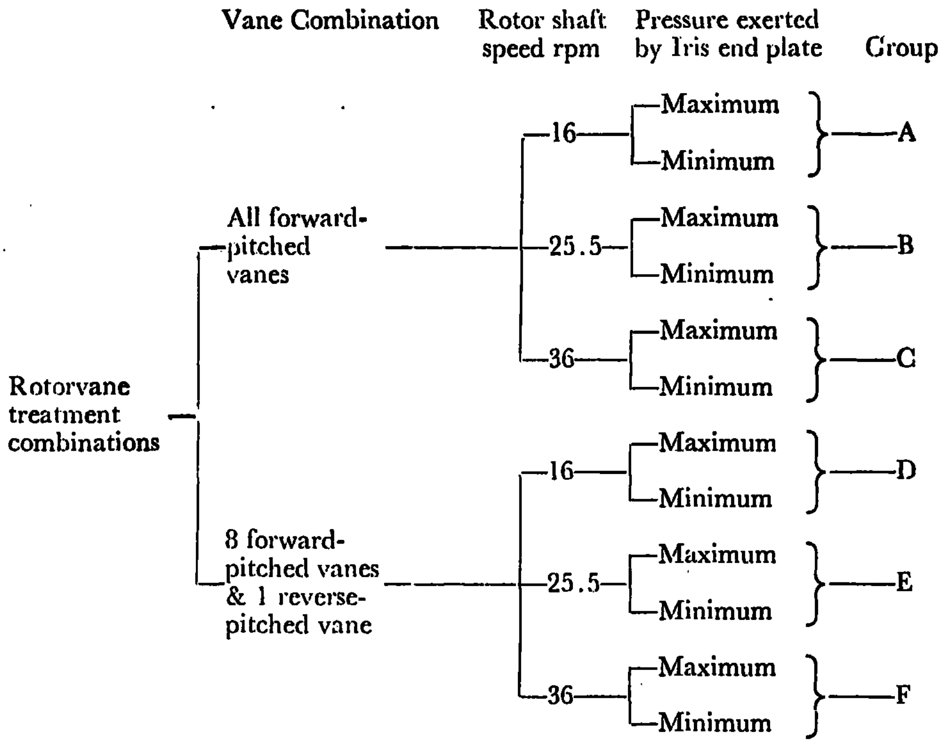


FIGURE 1—*The twelve Rotorvane treatment-combinations*

## Procedure

The trial was conducted during 1964, covering both the off-quality and quality seasons. Because of practical difficulties it was not possible to carry out more than two of the Rotorvane treatment-combinations on any one day of the trial. These two treatment-combinations corresponded to any one group outlined in Figure 1, the groups being taken in random order. Each replicate of the trial was, therefore, spread over a period of two weeks. In all, 6 replications of the trial were carried out.

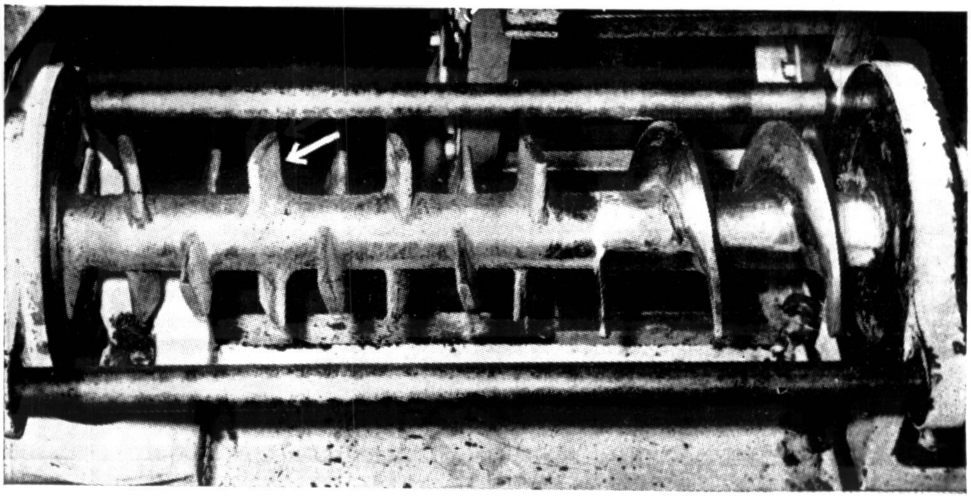

PLATE 1—*Rotor shaft showing the worm and the vanes — Note the reverse-pitched vane*

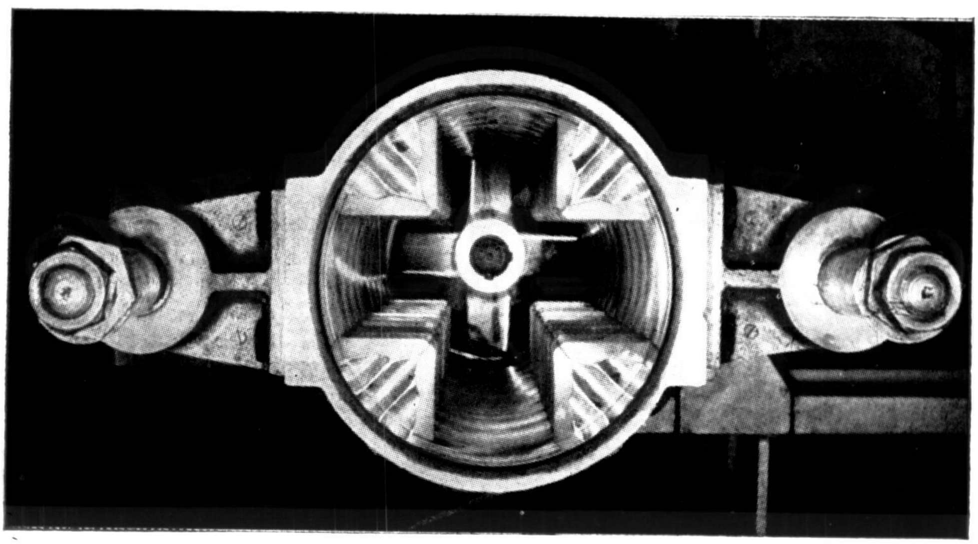

PLATE 2—*An interior view of the Rotorvane cylinder, showing the resistors and vanes*

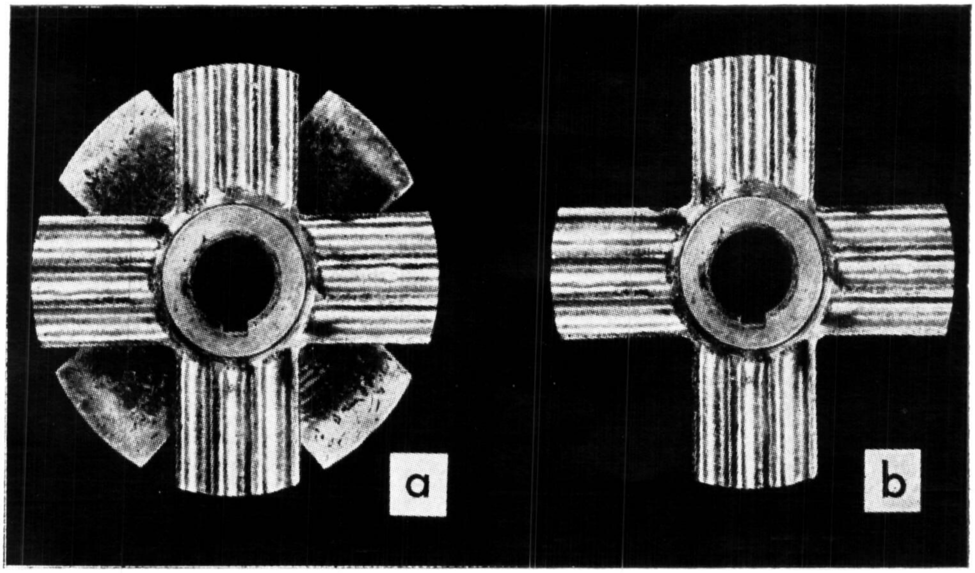


PLATE 3—*Iris end plate in (a) maximum and (b) minimum pressure positions*

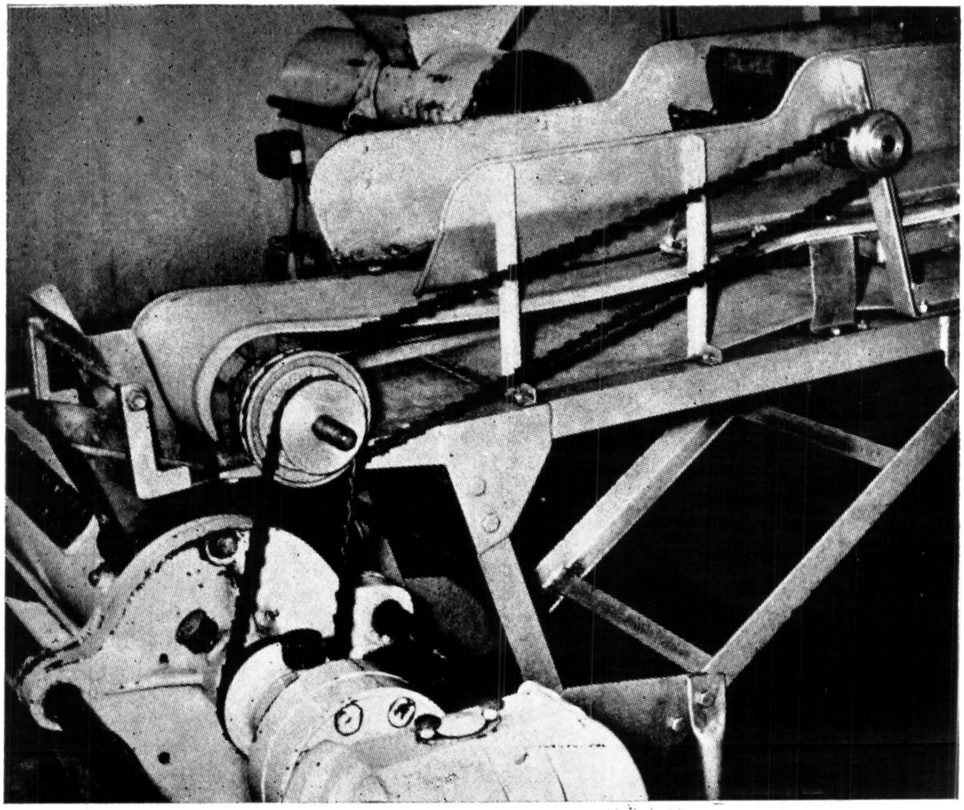

PLATE 4—*Conveyor belt system showing coupling of the conveyor to the rotor shaft*

Because of the inability to complete a single replicate of the trial on any one day, variations caused by diurnal weather fluctuations, type of leaf used *etc* were inevitable. The difficulty was largely overcome by having a control orthodox manufacture, corresponding to every Rotorvane treatment-combination, carried out on an experimental scale. Pre-rolling influences like the type of leaf, degree of wither and period of wither were identical for the control and the corresponding Rotorvane-treatment-combinations. The period of wither differed by 2 hours for the two Rotorvane treatment-combinations carried out on any one day. The other pre-rolling influences were identical for the two treatments. Variations in the characteristics of made tea caused by diurnal weather fluctuations, type of leaf, degree and period of wither and even errors in tasting were, therefore, minimized to a great extent if not eliminated completely, by analysing the differences between evaluations obtained for Rotorvane treatment-combinations and corresponding controls.

Medium withers were taken throughout the trial. For each of the Rotorvane treatment-combinations 340 lb withered leaf were charged into a 45" single action roller fitted with a Keegel table (Keegel 1962) and a Keegel cone. This leaf was pre-conditioned for 10 minutes under very light pressure. 30 lb of pre-conditioned leaf were given 1 x 20 minute, followed by 3 x 30 minute orthodox rolls with 8 on 2 off method of pressure application using two experimental rollers (control). The balance 310 lb of pre-conditioned leaf were passed through the Rotorvane with a particular set of treatment-combinations (*eg* all forward-pitched vanes, rotor shaft speed of 36 rpm and minimum pressure position of the Iris end plate).

The number of passes through the Rotorvane was dependent entirely on the dhool outturns, the aim being to reduce the big bulk outturn to about 10%. In the case of all Rotorvane treatment-combinations having the Iris end plate in the open position (minimum pressure), three passes were necessary to achieve this objective. In the case of the other Rotorvane treatment-combinations only two passes were necessary. The rotorvaned leaf was passed through an Aerator, and roll breaking was carried out using a machine having a combination of Nos 5 and 6 meshes. Throughout the trial, feeding of leaf into the Rotorvane was carried out, by using a conveyor belt system coupled to the rotor shaft. This is illustrated in Plate 4. The spreader blades were kept at a height of 2¾ cm above the conveyor belt. The intention was to have the thickness of spread of leaf on the conveyor belt more or less constant.

The range of fermentation of rotorvaned leaf and orthodox-manufactured leaf was kept the same at 2¼—3¼ hours, throughout the trial. To obtain better control of the period of fermentation representative samples, each of 13½ lb of rotorvaned leaf and orthodox-rolled leaf, taken proportional to their respective dhool and big bulk outturns, were fired in an experimental drier. The experimental drier was operated at a firing temperature of 195°F and at an exhaust temperature of about 125°F. The firing operations carried out in this drier, have been assumed (see Keegel 1962) to be identical to that of a commercial drier. Grading was carried out using hand sieves. The BOP's extracted were sent to a panel of tasters in Colombo for evaluation, to be made on the basis recommended by Keegel (1959).

## Results

1—*Intakes*—The average intakes recorded corresponding to the three rotor shaft speeds, together with the 95% confidence limits are presented in Table 1. In the case of the 1st and 2nd passes, the averages were worked out from 24 independent observations whilst the averages in the case of the 3rd pass were worked out from only 12 observations.

TABLE 1—*Average intake in lb per hour at 95% confidence limits*

| Rotor shaft speed (rpm) | 1st pass | 2nd pass | 3rd pass |
|---|---|---|---|
| 16 | 515±52 | 1118±112 | 1062±144 |
| 25.5 | 719±61 | 1673±127 | 1449±229 |
| 36 | 1079±128 | 1943±188 | 2086±350 |

In this trial the intention was to keep the thickness of spread of leaf on the conveyor belt constant for all Rotorvane treatment-combinations. The ratio of the intakes in lb per hour to the corresponding rotor shaft speeds in revolutions per hour should have resulted in more or less the same values, for all Rotorvane treatment-combinations, because the conveyor belt was coupled to the rotor shaft. This ratio, denoted by $\theta$ could be defined as the intake of the Rotorvane in lb per revolution of the rotor shaft. The actual values of $\theta$, derived from those in Table 1, are given in Table 2.

TABLE 2—*Mean $\theta$ values in lb per revolution of the rotor shaft*

| Rotor shaft speed (rpm) | 1st pass | 2nd pass | 3rd pass |
|---|---|---|---|
| 16 | 0.536±0.054 | 1.165±0.117 | 1.106±0.150 |
| 25.5 | 0.470±0.040 | 1.093±0.083 | 0.947±0.150 |
| 36 | 0.500±0.059 | 0.900±0.087 | 0.966±0.162 |

It is seen from Table 2, that although there should have been no variation in the $\theta$ value for any single pass through the Rotorvane, in practice there was some variation. The value of $\theta$ is greatest for the rotor shaft speed of 16 rpm and lowest for 25.5 rpm for the first pass. This could be attributed to the sagging of the conveyor belt, which was to some extent inevitable, because the conveyor belt was made of canvas. This variation in the $\theta$ values has an important bearing on the interpretation of the results.

2—*Dhool outturns*—Analysis of variance was carried out on the data obtained for the percentage dhool outturns in the 1st pass. It revealed that the variation caused by combination of vanes, rotor shaft speeds, and pressures exerted by the end plate, were all significant ($P<0.05$). Interaction of combinations of vanes X pressures exerted by the end plate, was also significant ($P<0.05$) whilst the variation due to replicates, and the interactions of rotor shaft speeds with combinations of vanes and pressures exerted by the end plate were all, not significant.

Mean percentage dhool outturns recorded for vane combinations, rotor shaft speeds and for pressures exerted by the end plate, together with their significant differences are given in Table 3.

TABLE 3—*Effect of vane combinations, rotor shaft speeds and pressures exerted by Iris end plate on the mean percentage dhool outturns in the first pass through the Rotorvane*

| | TREATMENT | | | Significant differences | |
|---|---|---|---|---|---|
| | All forward-pitched vanes | 8 forward-pitched +1 reverse-pitched vanes | | P=0.05 | P=0.01 |
| Effect of vane combination | 51.6 | 58.0 | | 5.0 | 7.9 |
| | 16 rpm | 25.5 rpm | 36 rpm | | |
| Effect of Rotor shaft speed | 58.5 | 54.0 | 51.7 | 3.5 | 4.8 |
| | Maximum Pressure | Minimum Pressure | | | |
| Effect of pressure exerted by Iris end plate | 62.0 | 47.6 | | 1.9 | 2.6 |

From Table 3 it is seen that the incorporation of 1 reverse-pitched vane centrally, has significantly increased the production of dhool, when compared to the production of dhool by a Rotorvane having all forward-pitched vanes. It is also seen that the mean percentage dhool produced at a rotor shaft speed of 16 rpm is significantly ($P<0.01$) higher than that produced at rotor shaft speeds of 25.5 and 36 rpm. The amounts produced at the latter rotor shaft speeds are not significantly different. But these differences observed must not be viewed without reference to the corresponding $\theta$ values (see discussion). Maximum pressure exerted by the Iris end plate gives a dhool outturn significantly (at $P<<0.001$) higher than that produced when minimum pressure is employed.

The interaction of combinations of vanes and pressures exerted by the Iris end plate can be understood by reference to Table 4. In the analysis of variance this interaction was found to be significant ($P<0.05$).

TABLE 4—*Interaction of vane combination and pressure exerted by the Iris end plate on the mean percentage dhool outturn in the 1st pass through the Rotorvane*

| | | All forward-pitched vanes | 8 forward-pitched +1 reverse-pitched vanes | Effect of 1 reverse-pitched vane placed centrally |
|---|---|---|---|---|
| Pressure exerted by Iris end plate | Maximum pressure | 59.9 | 64.0 | 4.1 |
| | Minimum pressure | 43.3 | 51.9 | 8.6 |
| | Effect of maximum over minimum pressure | 16.6 | 12.1 | |

Interaction =4.5—significant at $P<0.05$

The interaction of combination of vanes and pressures exerted by the Iris end plate being significant means that the influence of presssure exerted by the end plate is not independent of, but is governed by the combination of vanes and *vice versa.* This interaction is graphically represented in Figure 2.

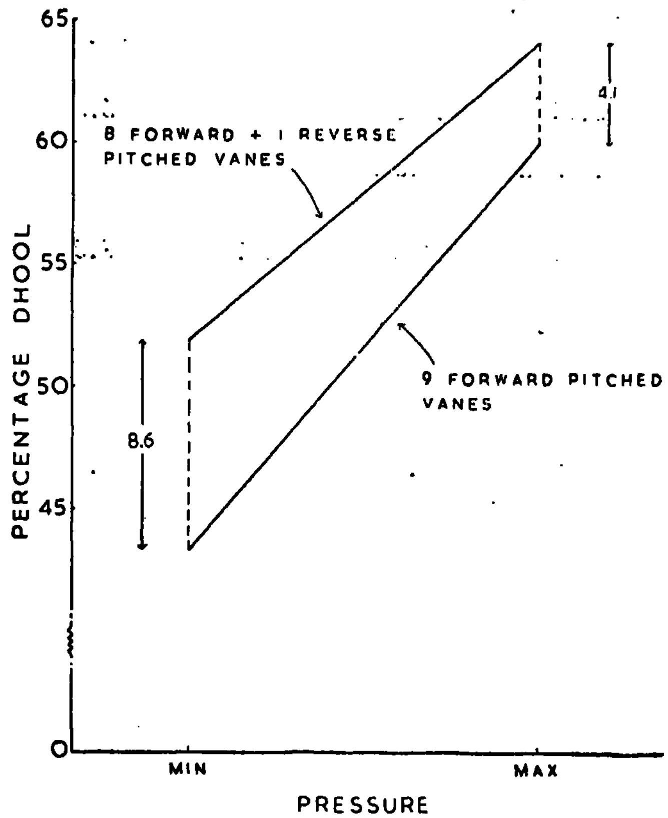


FIGURE 2 — *Variation of the percentage dhool outturn in the 1st pass with pressure exerted by the Iris end plate Minimum pressure corresponds to closure of discharge end by 61% — Maximum pressure corresponds to closure of discharge end by 88%*

3—*Grade outturns*—Analysis of variance was carried out on the data obtained for the three main grades. This revealed that the variation caused by the pressures exerted by the end plate, in the two positions were significant ($P<0.05$), for the main grades. Dust No 1 too should be considered as one of the main grades. This grade although classed as a dust, being grainy and blackish, is in fact much superior to common dusts. This grade differed from the BOPF grade only in that its particle size, was slightly smaller. For these main grades variation due to combination of vanes, rotor shaft speeds, interactions of both rotor shaft speeds with combinations of vanes, as well as with pressures exerted by the end plate, were all, not significant. The interaction of vane combinations X pressures exerted by the end plate, was significant for the BOPF grade ($P<0.05$), and not significant for the other two grades. Table 5 gives the mean percentage main grades and the significant differences obtained for the two pressures investigated. Table 6 shows the interaction of combination of vanes and pressures exerted by the end plate in the case of the BOPF grade. This is further illustrated graphically in Figure 3.

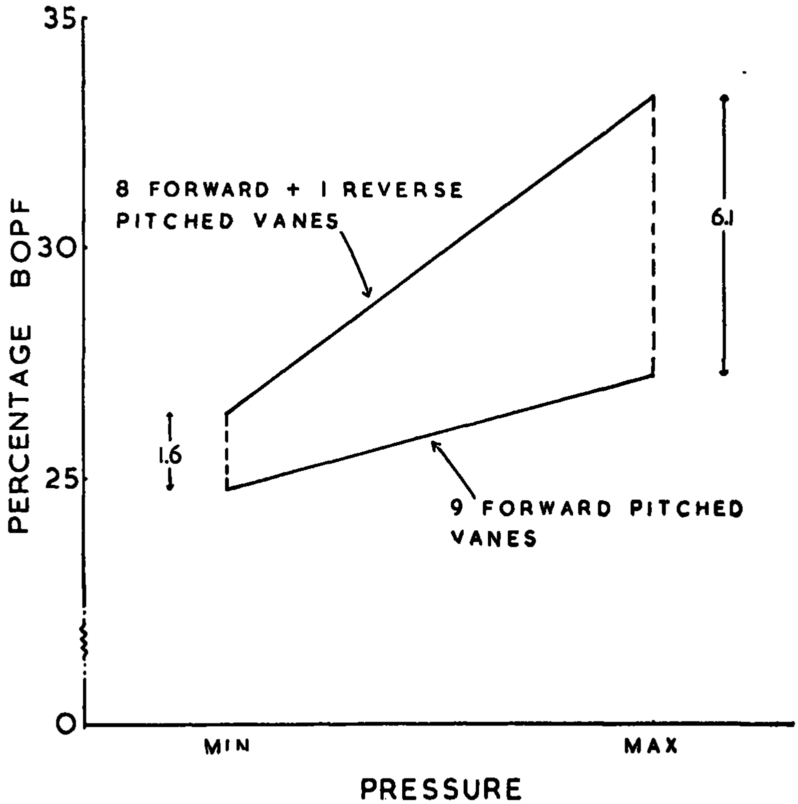


FIGURE 3 — *Variation of mean percentage BOPF with pressure exerted by Iris end plate — Minimum pressure corresponds to closure of discharged end by 61% — Maximum pressure corresponds to closure of discharge end by 88%*

TABLE 5—*Effect of pressure exerted by the Iris end plate on the mean percentage main grades*

| Grade | Pressure exerted by Iris end plate: Maximum Pressure | Minimum Pressure | Significant differences: P=0.05 | P=0.01 |
|---|---|---|---|---|
| BOP | 43.5 | 50.0 | 1.8 | 2.2 |
| BOPF | 30.4 | 25.6 | 1.5 | 1.8 |
| Dust No 1 | 15.2 | 13.2 | 2.0 | 2.4 |
| Total main grades | 89.1 | 88.8 | — | — |

Values given in Table 5 show that the employment of maximum pressure results in a significantly ($P<<0.001$) lower BOP percentage outturn when compared to BOP percentage obtained with minimum pressure. At the same time, the percentage of fines increase with increase of pressure; the loss in BOP percentage (about 7%) is compensated for by a significant increase in the percentage of fines. An increase of about 5% BOPF (Significant at $P<<0.001$) and about 2% dust No 1 (significant at $P<0.05$), is observed with increase of pressure.

TABLE 6—*Interaction of vane combination X pressures exerted by the Iris end plate on the mean percentage BOPF grade*

| | | VANE COMBINATION | | |
|---|---|---|---|---|
| | | All forward-pitched vanes | 8 forward-pitched + 1 reverse-pitched vanes | Effect of 1 reverse-pitched vane |
| Pressure exerted by Iris end plate | Maximum Pressure | 27.2 | 33.3 | 6.1 |
| | Minimum Pressure | 24.8 | 26.4 | 1.6 |
| | Effect of maximum over minimum pressure | 2.4 | 6.9 | |

Interaction = 4.5—significant at $P<0.01$

As in the case of dhool outturns, the significant interaction between the combinations of vanes X pressures exerted by the Iris end plate indicates that the production of BOPF is influenced by the pressure exerted by the end plate, and that this influence is governed to a great extent by the vane combination. This influence is more predominant, for the vane combination having one reverse-pitched vane than for the other combination investigated.

4—*Made tea characteristics*

(*a*) *Colour of infusion*—The frequencies of the colour of the infused leaf being reported as greenish or coppery for rotorvane-treated teas, and the controls, are given in Table 7. Analysis of this data to determine whether the rotorvane-treated teas are associated with coppery infusions, revealed a positive correlation in general with rotorvaned teas, and in particular with teas rotorvaned using the Iris end plate in the maximum pressure position. The Chi-square test was used for this purpose. Calculated values of $Chi^2$ after applying Yates correction for continuity are also given in Table 7.

(*b*) *Effect of vane combinations on brightness of infusion, colour, strength, quality, flavour of liquors and valuations*—Analysis of variance of data revealed that the variation caused by vane combinations, was significant ($P<0.05$) with respect to colour of liquors, while variations for the other characteristics, were not significant. Differences observed for vane combinations are given in Table 8.

TABLE 8—*Effect of vane combinations on the colour of the liquors—Mean* differences *in evaluations for colour of liquors between rotorvaned teas and controls, made simultaneously*

| | Mean Evaluations | | Significant Differences | |
|---|---|---|---|---|
| Vane combination | All forward-pitched vanes | 8 forward- + 1 reverse-pitched vanes | $P=0.05$ | $P=0.01$ |
| Colour of liquor | 0.535 | 0.924 | 0.364 | 0.570 |

TABLE 7—*Frequencies of colour of infused leaf being reported as greenish or coppery in rotorvaned and orthodox (control) teas made simultaneously*

| Vane Combination | All forward-pitched vanes | | | | | | | | | | | | 8 forward-pitched and 1 reverse-pitched vanes | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rotor shaft speed (rpm) | 16 | | | | 25.5 | | | | 36 | | | | 16 | | | | 25.5 | | | | 36 | | | | Rotorvane in general | |
| Pressure exerted by end plate | Max | | Min | | Max | | Min | | Max | | Min | | Max | | Min | | Max | | Min | | Max | | Min | | | |
| Colour of infused leaf | G | C | G | C | G | C | G | C | G | C | G | C | G | C | G | C | G | C | G | C | G | C | G | C | G | C |
| Frequencies of rotor-vaned teas | 9 | 15 | 14 | 10 | 9 | 15 | 11 | 13 | 3 | 21 | 8 | 16 | 10 | 14 | 10 | 14 | 7 | 17 | 12 | 12 | 8 | 16 | 9 | 15 | 110 | 178 |
| Frequencies of orthodox teas (controls) | 15 | 9 | 19 | 5 | 17 | 7 | 14 | 10 | 14 | 10 | 12 | 12 | 19 | 5 | 17 | 7 | 16 | 8 | 16 | 8 | 16 | 8 | 15 | 9 | 190 | 98 |
| Chi squared | 2.083 | | 1.552 | | 4.112* | | 0.334 | | 9.108** | | 0.771 | | 5.575* | | 3.048 | | 5.343* | | 0.771 | | 4.083* | | 2.083 | | 43.416*** | |

G = Greenish
C = Coppery
* = Significant at $P < 0.05$
** = Significant at $P < 0.01$
*** = Significant at $P < 0.001$

It is seen from the results given in Table 8 that the vane combination having one reverse-pitched vane tends to produce more coloury liquors than those produced using the other vane combination. The interactions of vane combinations with pressures exerted by the end plate and rotor shaft speeds were not significant with respect to all the characteristics. See also section 4(*e*).

(*c*) *Effect of rotor shaft speeds on brightness of infusion, colour, strength, quality, flavour of liquors and valuations*—Analysis of data revealed that variations caused by rotor shaft speeds were significant ($P<0.05$) with respect to quality and flavour of the liquors and, therefore, the valuations of the teas. These variations are given in Table 9.

TABLE 9—*Effect of Rotor shaft speeds on the quality, flavour and valuation of teas—Mean* differences *in evaluations for quality and flavour of liquors between rotorvaned teas and controls, made simultaneously*

| Rotor shaft speed (rpm) | Mean Evaluations | | | Significant Differences | |
|---|---|---|---|---|---|
| | 16 | 25.5 | 36 | P=0.05 | P=0.01 |
| Quality | 0.094 | -0.302 | 0.062 | 0.321 | 0.438 |
| Flavour | -0.021 | -0.229 | -0.010 | 0.174 | 0.236 |
| Valuation (cts) | 5.427 | -2.727 | 5.573 | 7.286 | 9.937 |

It is seen from Table 9 that the teas produced at a rotor shaft speed of 25.5 rpm are significantly inferior ($P<0.05$) to those produced at the other two rotor shaft speeds with respect to quality, flavour of the liquors and valuation of the teas. This result too should be considered in relation to the actual $\emptyset$ values recorded for rotor shaft speed of 25.5 rpm. As was pointed out earlier, the intention of the trial was to have more or less the same $\emptyset$ value for all Rotorvane treatment-combinations. But in practice the value of $\emptyset$ recorded for rotor shaft speed of 25.5 rpm was the lowest for the first pass. This will be dealt with further in the discussion that is to follow.

(*d*) *Effect of pressure exerted by the Iris end plate on brightness of infusion, colour, strength, quality, flavour of liquors and valuations*—The most interesting results obtained are those resulting from the effect of pressure. The degree of pressure exerted by the Iris end plate, as governed by the opening or closure of the end plate, plays an important role in rotorvane rolling. The effect of pressure on dhool outturns, grade outturns and on the colour of the infused leaf, have already been dealt with. The degree of pressure also governs the brightness of the infused leaf, and the quality and flavour of the liquors. There are also indications ($P<0.10$) that if minimum pressure is employed in rotorvaning leaf, a better valuation is to be expected. These findings are given in Table 10. The effect of pressure on quality, flavour and valuation, is not significantly influenced by the effect of rotor shaft speed or vane combinations, because the interactions of pressures exerted by the Iris end plate with rotor shaft speeds, as well as with vane combinations were not significant, for these characteristics.

TABLE 10—*Effect of pressures exerted by Iris end plate on the brightness of infusion, quality, flavour of liquors and valuations — Mean* differences *in evaluations for brightness of infusions, quality and flavour of liquors, and valuations between rotorvaned teas and controls made simultaneously*

| Character | Pressure exerted by Iris end plate | | Significant differences | |
|---|---|---|---|---|
| | Maximum | Minimum | P=0.05 | P=0.01 |
| Brightness of infusion | 0.979 | 0.681 | 0.227 | 0.306 |
| Quality | -0.194 | 0.097 | 0.250 | 0.337 |
| Flavour | -0.181 | 0.007 | 0.174 | 0.234 |
| Valuation (cts) | 0.778 | 4.736 | n.s. | n.s. |

n.s. = not significant

(*e*) *Interactions of combination of vanes, rotor shaft speeds and pressures exerted by the Iris end plate*—Interactions of both rotor shaft speeds with combinations of vanes as well as with pressures exerted by the Iris end plate were not significant with respect to brightness of infusion, colour, strength, quality and flavour of liquors and valuations of BOPs. The interactions of vane combinations X pressures exerted by the end plate were not significant for all made tea characteristics and valuations; but there are strong indications ($P<0.10$) to show that this interaction influences to some extent the brightness of the infusions. This could be seen from the values given in Table 11.

TABLE 11—*Interaction of vane combinations and pressures exerted by Iris the end plate—Mean* differences *in evaluations for brightness of infusions between rotorvaned teas and controls made simultaneously*

| | | Vane combination | | |
|---|---|---|---|---|
| | | All forward-pitched vanes | 8 forward-and 1 reverse-pitched vanes | Effect of 1 reverse-pitched vane |
| Pressure exerted by Iris end plate | Max | 1.04 | 0.92 | -0.12 |
| | Min | 0.53 | 0.83 | -0.30 |
| Effect of maximum over minimum pressure | | 0.51 | 0.09 | |

Interaction = 0.42 (not significant at P=0.05 but significant at P=0.10)

## Discussion

The results obtained from this trial show what occurs inside a Rotorvane cylinder during rotorvaning. It could be concluded that the most important factor governing the dhool outturns, grade outturns, and the characteristics of made tea, is the quantity of leaf held within the Rotorvane barrel, once equilibrium conditions are reached. This quantity is dependent on the type of end plate used, combination of vanes, rotor shaft speed, and the rate of feed of leaf into the Rotorvane. An even, continuous feed which results in uniformity of pressure within the cylinder is a prerequisite in rotorvane rolling, without which inconsistent results, contrary to expectations cannot be avoided. This was realized earlier by Keegel (1964) and Anley (1964).

The results indicate that for the same quantity of leaf held within the Rotorvane cylinder under equilibrium conditions, the dhool outturns, grade outturns, and made tea characteristics will be more or less the same. If the $\emptyset$ values had been the same for the three rotor shaft speeds, (as was intended) it *can be* shown mathematically (de Silva 1965) that the quantity of leaf held within the Rotorvane cylinder would have been independent of the rotor shaft speed. This leads us to assume that the dhool outturns, grade outturns and made tea characteristics would have been independent of rotor shaft speeds provided the $\emptyset$ values had been the same. Also, it can be shown mathematically that as $\emptyset$ increases, the amount of leaf held within the Rotorvane barrel also increases. The degree of pressure developed inside a Rotorvane barrel could be associated with the value of $\emptyset$, for the same vane combination and end plate used. The higher the value of $\emptyset$, the greater will be the degree of pressure.

The results obtained from this trial indicated that the effect of rotor shaft speed was significant with respect to dhool outturn in the first pass, quality and flavour of liquors, and the valuation of the BOP's. This is contrary to the assumption already made. But a glance at Table 2 which gives the mean values of $\emptyset$ recorded, indicate that though the intention was to keep $\emptyset$ constant, in practice, due to sagging of the conveyor belt, there had been a considerable variation in the value of $\emptyset$. The mean value of $\emptyset$ is greatest for a rotor shaft speed of 16 rpm and lowest for a rotor shaft speed of 25.5 rpm. A higher mean dhool outturn at a rotor shaft speed of 16 rpm is, therefore, to be expected. Further, it is most probable that this value of $\emptyset$ (0.536) is higher than the optimum value of $\emptyset$ with respect to the 1st pass for the development of made tea characteristics. Probably because of the higher value of $\emptyset$, there had been some extra shearing action, without any additional wringing of juices, which resulted in a significantly higher dhool outturn, without in any way affecting the made tea characteristics. Then again, the lower mean value of $\emptyset$ (0.470) recorded for rotor shaft speeds of 25.5 rpm probably resulted in the quality and flavour of teas rotorvaned at this rotor shaft speed not developing fully. The teas rotorvaned at this rotor shaft speed were valued at a discount. It is also probable that the optimum value of $\emptyset$ is higher than *this* value (0.470) of $\emptyset$. It appears, therefore, that the optimum value of $\emptyset$ lies between 0.470 and 0.536 probably very nearly equal to 0.5. The value of $\emptyset$ and, therefore, the amount of leaf held within the Rotorvane barrel under equilibrium conditions is very critical and probably the optimum amount of leaf held within the barrel is the same for all rotor shaft speeds; but different for different combinations of vanes and end plates.

Interactions of rotor shaft speeds with vane combinations and pressures exerted by the Iris end plate were not significant with respect to dhool outturns, grade outturns and made tea characteristics. This is in accordance with the assumption made earlier that the amount of leaf held in the barrel is independent of the rotor shaft speed under the conditions of these particular experiments.

TABLE 12—*Summary of the results—Effect of vane combinations, rotor shaft speeds, pressures exerted by the Iris end plate and their interactions on dhool outturns, grade outturns and made tea characteristics*

| Variable | Vane Combinations | Rotor shaft speeds | Pressures exerted by Iris end plate | Interaction of vane combinations and rotor shaft speeds | Interaction of vane combinations and pressures exerted by Iris end plate | Interaction of rotor shaft speeds and pressures exerted by Iris end plate |
|---|---|---|---|---|---|---|
| Dhool outturn in 1st pass | Significantly ($P<0.05$) higher for combination with 1 reverse-pitched vane | Significantly ($P<0.01$) higher for 16 rpm | Significantly ($P<<0.001$) higher for maximum pressure | n.s. | Significant ($P<0.05$) | n.s. |
| BOP percentage | n.s. | n.s. | Significantly ($P<<0.001$) higher for minimum pressure | n.s. | n.s. | n.s. |
| BOPF percentage | n.s. | n.s. | Significantly ($P<<0.001$) higher for maximum pressure | n.s. | Significant ($P<0.01$) | n.s. |
| Dust No 1 percentage | n.s. | n.s. | Significantly ($P<0.05$) higher for maximum pressure | n.s. | n.s. | n.s. |
| Brightness of Infusion | n.s. | n.s. | Singnificant ($P<0.05$) in favour of maximum pressure | n.s. | n.s. (at $P<0.05$) but significant (at $P<0.1$) | n.s. |
| Colour of Liquor | Significant ($P<0.05$) in favour of combination with 1 reverse-pitched vane | n.s. | n.s. | n.s. | n.s. | n.s. |
| Strength of Liquor | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| Quality of Liquor | n.s. | Significant ($P<0.05$) against 255 rpm | Significant ($P<0.05$) in favour of minimum pressure | n.s. | n.s. | n.s. |
| Flavour of Liquor | n.s. | Significant ($P<0.05$) against 25.5 rpm | Significant ($P<0.05$) in favour of minimum pressure | n.s. | n.s. | n.s. |
| Valuation of tea | n.s. | Significant ($P<0.05$) against 25.5 rpm | Indications ($P<0.10$) in favour of minimum pressure | n.s. | n.s. | n.s. |

n.s. = not significant

The results of this trial support the assumption that the most important factor in rotorvane rolling is the quantity of leaf held within the Rotorvane barrel, once equilibrium conditions are reached between the leaf fed and that which is being discharged from the machine. This quantity not only governs the dhool outturns but also the grade outturns and made tea characteristics. A knowledge of the factors which control the quantity of leaf held within the Rotorvane cylinder under equilibrium conditions, is of paramount importance, if the best results are to be achieved in Rotorvane manufacture. Feeding rate is one of these factors.


**Summary**

The effect of Rotorvane treatment-combinations on the dhool outturns, grade outturns, brightness of infused leaf, colour, strength, quality and flavour of liquors and valuation of BOP's are presented in Table 12, in a summary form. In addition to the results given in Table 12, it was found that a positive correlation exists between coppery infusions and rotorvaned teas in general and in particular with teas rotorvaned using the Iris end plate in the maximum pressure position.

The results presented in Table 12 must be considered with reference to the feeding rates recorded for rotor shaft speeds. The intention was to keep the intake of the Rotorvane in lb per revolution of the rotor shaft more or less the same for all rotor shaft speeds. In practice there was a considerable variation. It is assumed that the effect of rotor shaft speeds would not have been significant, for dhool outturns, grade outturns and all made tea characteristics, but for this variation.



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