KEY NOTE ADDRESS

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1. "YEAR OF ADOPTION OF TRI RECOMMENDATIONS"

2015 - Soil Fertility Management Practices

Adoption of Good Agricultural Practices is essential to increase productivity and also to sustain the environment. In order to identify the level of adoption of TRI recommendations on agricultural practices, a diagnostic survey was conducted by TRI. The results of the diagnostic survey were discussed at the Consultative Committee on Estate and Advisory, Tea Research Board and the necessity to promote agricultural practices with poor adoption rates was highlighted.

1.1 Finding of the Diagnostic Survey (2008-2009)

The diagnostic survey carried out by the TRI in the RPC sector to find out the level of adoption of major cultural practices recommended by the TRI revealed that adoption levels of practices related to nursery, plucking and shade are fairly good (Figure 1).

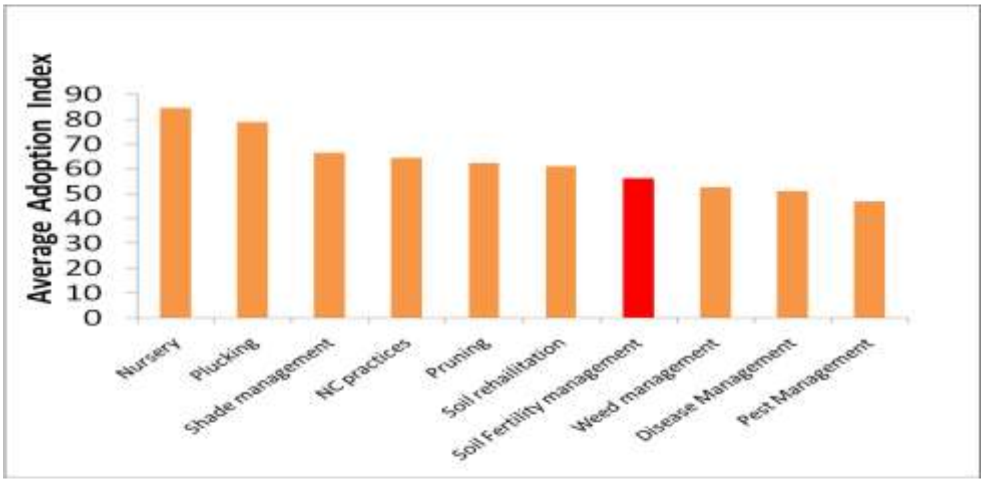


Figure 1 Adoption Level of Major Cultural Practices

Source: Diagnostic Survey in RPC tea Plantations, 2008-2009, TRI

However agricultural practices related to pest, disease and weed management, soil fertility management need improvements. Therefore to promote these practices among the growers TRI has identified Soil Fertility Management as the theme for the year 2015 under year of adoption of TRI recommended practices.

In the diagnostic survey, soil fertility management practices were divided into three sectors and the details are given in Table 1.

Table 1 Soil Fertility Management Practices

Soil Conservation	Fertilizer Use	Soil Improvement
Condition of Drains	Mature Tea	Green Manure Crops
Condition of Terraces	Foliar Fertilizer Mixtures	Burying of Prunings
SALT	Dolomite Use	
	Compost Use	

Average Adoption Index of soil conservation, fertilizer use and soil improvement are given in Figure 2.

Adoption rates showed that soil improvement measures such as burying of prunings, green manure crops and soil conservation measures such as condition of drains/terraces and SALT need special attention by the growers.

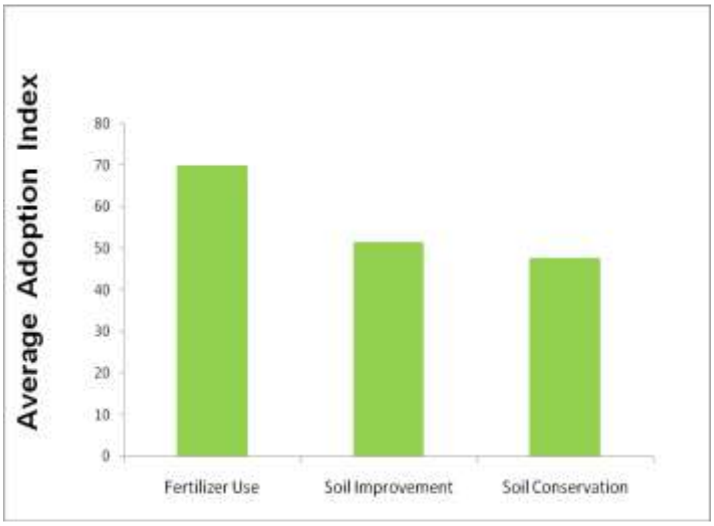


Figure 2 Adoption rates of soil fertility management practices

(Source: Diagnostic Survey in RPC tea Plantations; 2008-2009, TRI)

In the year 2015, special attention will be given to extension activities related to the "Year of Adoption of TRI Recommendations" which includes a sample survey in the RPC sector and Small

Holder sector to identify the current status of the adoption of soil fertility management practices in RPC estates and small holder sector and also training needs of both sectors.

2. TEA PRODUCTION & WEATHER

2.1 Tea Production

The comparison of world tea production in year 2012 and 2013 is given in Table 2. China recorded the highest production in 2013 followed by India, Kenya and Sri Lanka. Kenya recorded the highest increase in production (17%) in 2013 when compared with year 2012. Sri Lanka achieved 3.6% increase during the same period. Vietnam, Indonesia, Japan and Tanzania recorded negative growth in 2013 when compared with 2012.

Table 2 Tea Production in 2012 and 2013 (Mn Kg)

Country	2012	2013	Change	% Change
China	1789.75	1850	60.25	3.37
India	1126.33	1200.04	73.71	6.54
Kenya	**369.56**	**432.453**	**62.89**	**17.02**
Sri Lanka	**328.40**	**340.229**	**11.83**	**3.60**
Vietnam	174.03	170.325	-3.70	(2.13)
Turkey	147.00	149	2.00	1.36
Indonesia	137.25	134	-3.25	(2.36)
Argentina	84.00	84.7	0.70	0.83
Japan	85.90	84.7	-1.20	(1.40)
Bangladesh	62.16	63.159	1.00	1.62
Malawi	42.49	46.463	3.97	9.35
Uganda	57.94	58.295	0.36	0.61
Tanzania	32.28	32.123	-0.16	(0.49)
Others	171.23	173.6	2.37	1.38
Total	4608.31	4819.087	210.77	4.57

Scenario of the Sri Lankan tea production in the first six months of the year is given in Table 3. High grown tea production has increased by 2.17% in year 2014 whereas Mid and Low elevations recorded reduction in tea production by 1.49% and 0.68% respectively.

Table 3 Sri Lanka Tea Production (January-June)

Elevation	2014 Qty (Mn kg)	2013 Qty (Mn kg)	Difference (%)
High	41.5	40.62	2.17
Medium	28.4	28.83	(1.49)
Low	102.1	102.8	(0.68)
Total	172	172.8	(0.46)

A comparison of tea production in first six months of 2013 and 2014 at different elevations is given in Figures 3a, 3b and 3c. There was a significant decrease in tea production during February, March and April in all elevations in year 2014. However tea production was increased in May and June when compared with 2013.

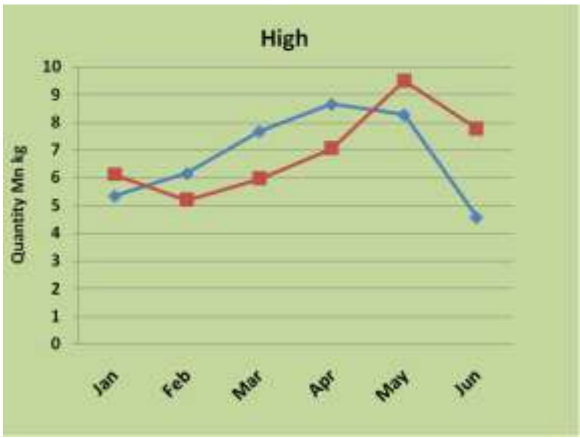


Figure 3a

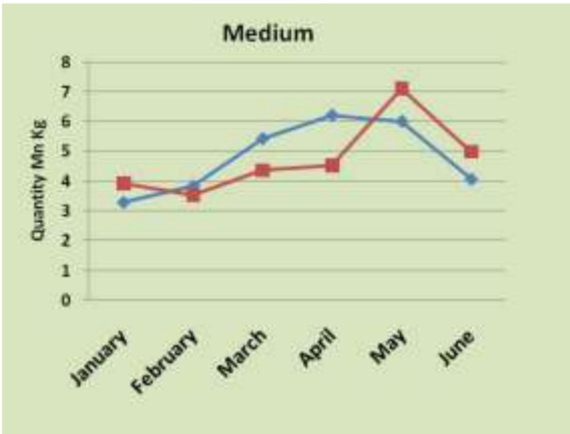


Figure 3b

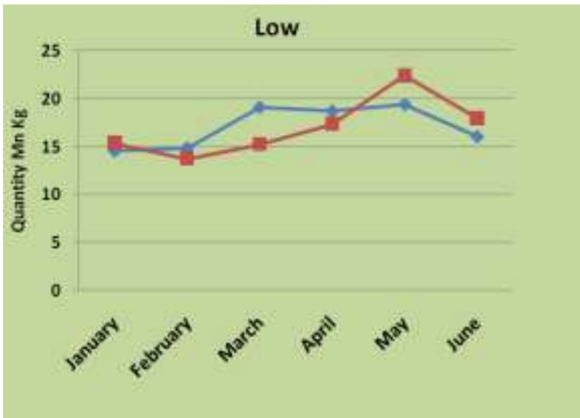
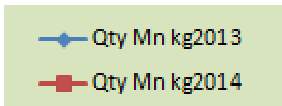


Figure 3c



The variation of total tea production in first six months is given in Figure 3d.

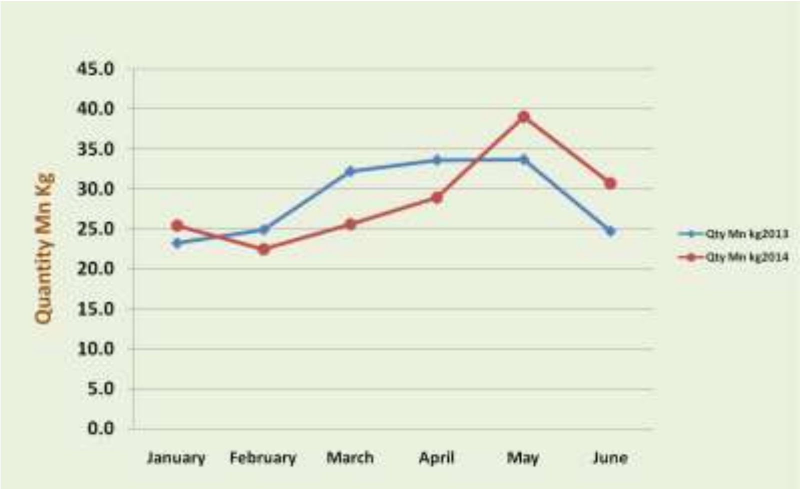


Figure 3d

Tea production of agro climatic regions in the first six months of the year is given in Table 4. Tea production in four agro climatic regions namely Nuwara Eliya, Mediums, Uda Pusallawa and Low growns was decreased in 2014 when compared with 2013.

Table 4 Sri Lanka Tea Production January-June in 2014

Agro Climatic Regions	Qty (Mn kg) 2014	Qty (Mn kg) 2013	Change %
Nuwara Eliya	2.22	2.32	(4.39)
Westerns	28.67	28.23	1.57
Mediums	22.97	23.67	(2.97)
Uda Pussallawa	4.43	4.64	(4.58)
Uvas	16.71	16.03	4.22
Low Growns	96.52	99.17	(2.68)

2.2 Rainfall

Analysis of rainfall data in the first six months of the year revealed that there was a significant reduction of rainfall in January-June period in 2014 compared to 2013 (Figure 4).

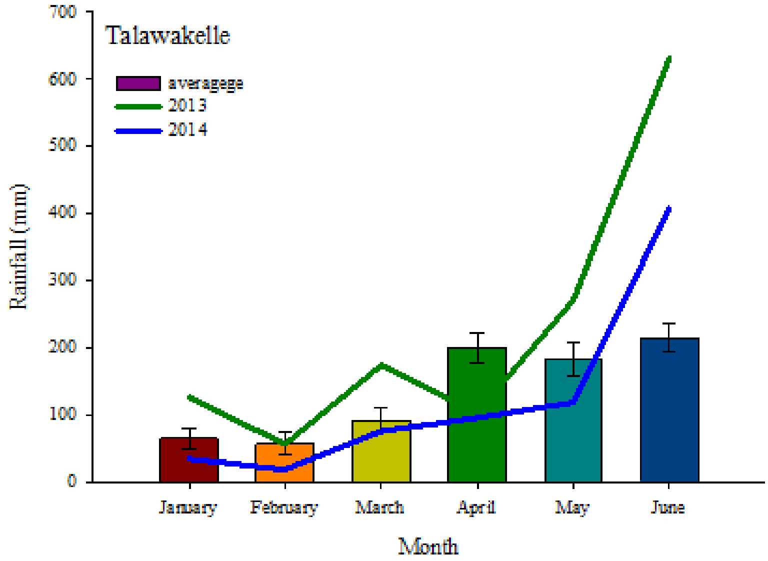


Figure 4 Rainfall in Talawakelle during January – June

Analysis of rainfall data in the first six months of the year in Galle region revealed that there was a significant reduction of rainfall in January, February and March in 2014 compared to 2013 (Figure 5).

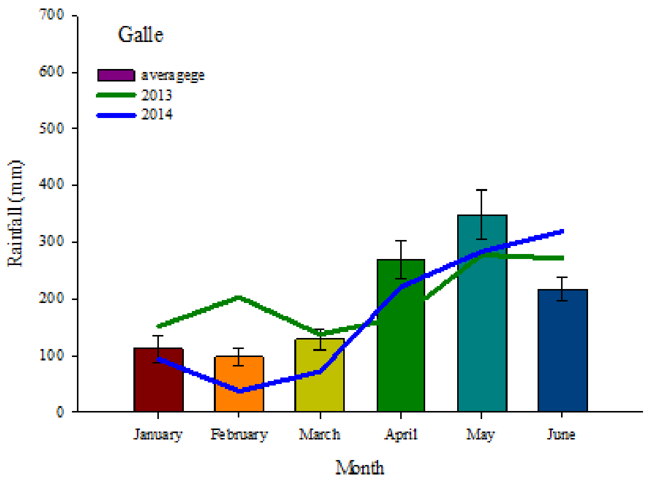


Figure 5 Rainfall in Galle during January – June

Analysis of rainfall data in the first six months of the year in Kandy region revealed that there was a significant reduction of rainfall in January, February and March in 2014 compared to 2013 (Figure 6).

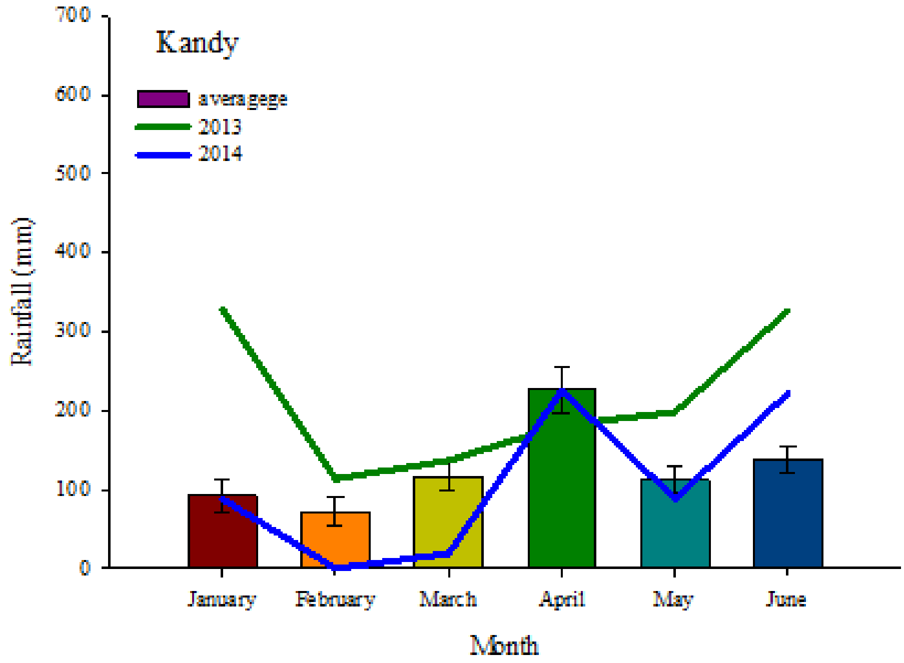


Figure 6 Rainfall in Kandy during January – June

3. UPDATE ON MRL ISSUE

3.1 Tea MRLs for TRI Recommended pesticides

MRL of tea set by tea importing countries for TRI recommended pesticide are given in Table 4.

Table 4 MRLs of Tea (ppm)

Chemical	EU	Japan	USA	China	Canada	Australia
Bitertanol	0.10	0.10				
Copper Hydroxide	40	Exempted				
Copper oxide	40	Exempted				
Copper Oxychloride	40	Exempted				
Hexaconazole	0.05	0.05				
Propiconazole	0.10	0.10			4	
Tebuconazole	0.05	50				
2,4-D	0.10	0.01				
Diuron	0.10	1.0				
Glufosinate Ammonium	0.10	0.30		0.5		20(T)
Glyphosate	2	1.0	1.0	1.0		2
MCPA	0.10	-				
Oxyfluorfen	0.05	0.01				
Paraquat	0.05	0.30				0.5(T)
Carbofuran	0.05	0.20				
Chlorfluazuron	0.01	10				
Diazinon	0.02	0.10				
Dazomet	0.02	0.10				
Imidachloprid	0.05	10		0.5		
Fipronil	0.005	0.002				
Metam Sodium	0.02	0.10				
Sulphur	Exempted	Exempted				

3.2 FAO/IGG Working Group on MRL

FAO/IGG Working Group on MRL was established in 2005 and the committee comprised members from China, India, Sri Lanka, Kenya, Japan, Bangladesh, Argentina, USA, Canada and EU. In 2005 the committee identified 24 chemicals for residue data generation. In 2012 the pesticides identified for data generation was increased up to 62. The objective of this exercise was to prepare a priority list in order to remove anomalies, duplication of residue generation work and also to submit data to CODEX with a view to achieve global harmonization of MRL for tea.

Currently sufficient data are available for following compounds used in tea.

1. Hexaconazole: 11 trials data available [Scope for submission by Sri Lanka & India]
2. Propiconazole: 11 trials data available[Scope for submission by Sri Lanka & India]
3. Chlorfluazuron: 10 trials data available [Scope for submission by Sri Lanka & Japan]
4. Fipronil : 8 trials data available [Scope for submission by Sri Lanka]
5. Imidacloprid: 12 trials data available [Scope for submission by India, Japan, & Sri Lanka]
6. Aetamiprid: 8 trials data available [Scope for submission by Japan, India & China]
7. Flufenoxuron: 8 trials data [Evaluation 2014]
8. Ethion: 12 trials data [Scope for submission by India]
9. Indoxacarb [8-trial data submitted by China for 2013 JMPR Evaluation]
10. Tolfenpyrad [Registrant/Japan submitted 4-trial data for 2013 JMPR Evaluation [Scope for submission of 8-trial data by China]

3.3 FAO/IGG Working Group on MRLs in Tea Brew - "Brew Factor"

Tea is traded as tea leaves and therefor at present MRLs for tea is set for tea leaves. However tea is consumed as a brew/liquor and therefor residue levels in tea brew or both in brew and tea in leaves should be considered when setting MRLs. The concept of Brew Factor which can be defined as (BF) = Residues in tea brew ÷ Residues in dry leaves was discussed at FAO/IGG working group and a concept paper was developed and it was presented to the 44th CCPR in 2012. The committee supported the concept and encouraged member countries to submit data/information on brewing factors. At the Inter sessional meeting of FAO/IGG in 2012, it was decided to prepare a detail methodology and policy document on brew factor to be presented at the main FAO/IGG meeting.

The Approach:

- Generation of data on residues in made tea and tea brew
- Determination of Brew Factor
- Risk Assessment based on brew factor (As risk assessment on the basis of solid tea is gross overestimation of risk)
- Propose MRL after risk assessment based on brew factor
- Data submission to regulators for MRL fixation in tea

This approach will ensure food safety, provide realistic MRLs and prevent elimination of useful chemicals.

The computation of MRLs for Propiconazole in tea brew is given in Table 5.

Table 5 Computation of MRL for Propiconzole in tea (For an adult of 60g weight - (ADI 0.07mg/kg bw)

Pesticide	Maximum Residues (HR) ppm	Food Consumption (g)	TMDI Base on HR mg/day	TMDI Base on proposed MRL (5ppm)	ADI mg/kg/day	ADI per person (mg/day)	% of ADI per person based on HR	% of ADI per person based on proposed MRL	Proposed MRL (ppm)
Propiconazole	1.66	10	0.0166	0.05	0.07	4.2	0.40	1.19	5.0
	1.66	10	0.0166x BF= 0.002	0.05xBF =0.0065	0.07	4.2	0.05	0.16	5.0

The Tea Research Institute of Sri Lanka

229th MEETING OF THE EXPERIMENTS AND EXTENSION FORUM

25 July 2014

MODIFICATIONS TOWARDS FLUID BED DRYING TO SUIT THE PRESENT DAY ORTHODOX-ROTORVANE TEA PROCESSING

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ABSTRACT

Manufacturing process of Orthodox-rotorvane tea has been changed since late nineties to produce tea grades according to current market demands. This resulted in production of high percentage of tea particles within 1 mm in size. At present, many factories are experiencing difficulties in drying such small particles in conventional fluid bed drier (FBD) and tea often get under-fired or over-fired and fine tea particles are carried over by the exiting fluid stream leading to increased blowout. Drying of tea was studied using three different Grit plates in a pilot-scale FBD in the present study. One Grit plate consists of 36 mm long and 0.5 mm wide perforations with 4% opening area was found to be suitable for drying tea at conventional loading of 25 kg/m^2. Another Grit plate consists of 36 mm long and 0.6 mm wide perforations with 5% opening area was found to be suitable for drying tea at a range of loading of 29 -33 kg/m^2 with comparatively lower fluidizing velocities. The drying time of tea was extended only by 2 to 3 minutes at higher loadings using this Grit plate. When monitored, it was found that difference between tea-bed temperature and exhaust air temperature was about 3 ^{0}C. This indicated intensive interaction between tea particles and the drying air. The differential static pressure across the tea-bed and that across Grit plate reduced with time without fluctuation indicated fluidizing of tea without any stagnation and channeling during drying. An empirical model was tested for predicting differential static pressure across the tea-bed & Grit plate with tea-bed temperature. Non-linear regression analysis was used to estimate the empirical constants of the model and closer values were obtained for the empirical constants for the tested loadings using the Grit plates. The correlation coefficient was found to be above 0.955 and values for root mean square error and chi-square were found to be low for all the tested loadings using the Grit plates. The model was found to be valid and accommodate variations in fluidizing velocity due to uncontrollable factors such as initial moisture content, particle size distribution and bulk density of tea.

KEYWORDS: Orthodox-rotorvane type tea, TRI-CCC FBD, Grit plate, tea-bed, fluidizing velocity, differential static pressure

1. INTRODUCTION

Orthodox-rotorvane tea with distinct characteristics is the preferred option for consumption in western countries and Japan. It is produced in large quantities in 180 tea factories in Sri Lanka. Drying is important in tea manufacturing for partly obtaining tea character and also to retain the tea character already achieved through early stages of the manufacturing process. Industrial and continuous type fluid bed drier (FBD) called "TRI-CCC FBD" that was introduced to tea factories in early seventies (Kirtisinghe, 1974) is found to contribute effectively in this context. Notable changes to tea manufacturing process was taken place in late nineties with the increased demand for BOPF grade that resulted in production of significantly high percentage of small particles (Raveendran et al., 2012). Consequently effectiveness of already available FBDs became questionable. At present, many factories are experiencing difficulties in drying such small particles in conventional fluid bed drier and teas often get under-fired or over-fired and fine tea particles are carried over by the exiting fluid stream leading to blowout of considerable amount of tea.

In FBDs, weir-end temperature is maintained at 200 – 210 °F (93 – 99 °C) in order to ensure tea is dried to a moisture content of about 2.5% (w/w, wet basis). Feeding rate of tea is varied as required in this regard. The grit plate of the drier has limited opening area percentage of 3.4% and whenever the feeding rate is changed blowout or channeling and stagnation occur. Therefore, suitable grit plate should be selected and fluidized bed drying parameters should be tested in order to maintain tea-bed without stagnation areas or entrainment for different loading rates throughout the drying section.

2. MATERIAL AND METHODS

Green leaf with 65% good leaf was selected and manufactured carefully in a tea factory and fermented tea with a moisture content of about 53 % (w/w, wet basis) was collected. A pilot-scale batch type fluid bed drying unit coupled with a temperature data logger and a controller system for maintaining drying air temperature was used to dry the fermented tea. An inverter was coupled to the motor of the fan through a potentio meter to adjust the speed according to airflow requirement for fluidization of tea. Grit plates made of aluminium sheet of 0.85 mm thickness with perforations of 36 mm long and 0.5 or 0.6 mm wide having an opening area percentage of 4 or 5 were used for the test. Pattern of the perforations on the Grit plates is given in Figure 1.

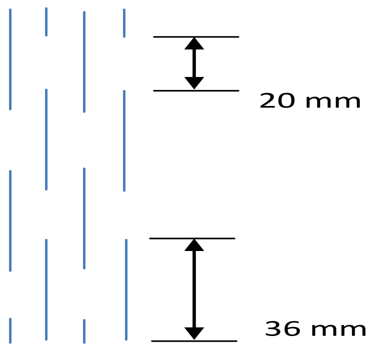

Figure 1 Perforation pattern of Grit plates

Details of the Grit plates are given in Table 1.

Table 1 Details of Grit plates

Grit plate Number	**Opening area (%)**	**Perforation**			
		Length (mm)	**Width (mm)**	**Numbers (/sq.m)**	**Space ("d", Fig. 2.1, mm)**
1	4	36	0.5	2,177	8.2
2	5	36	0.5	2,748	6.5
3	5	36	0.6	2,266	7.9

Tea samples were dried in the pilot-scale fluid bed drying unit maintaining the drying air temperature at 124°C. The data logger was set to measure and record inlet drying air temperature, tea-bed temperature and exhaust temperature. The fan was started and the heater and control system was switched on to obtain drying air with the set inlet temperature. Required amount of fermented tea sample was weighed for the experiment. The amount varied between 4.8 to 6 kg (25 – 33 kg/m^2.). The tea sample was loaded into the fluidizing section of the unit within 15-20 seconds. Airflow was adjusted to obtain fluidization without stagnation and entrainment from the beginning to end of drying. Differential static pressure across tea-bed and bedplate was monitored using a micromanometer. Air velocity was monitored using an anemometer. Readings of both the meters were recorded every 15 seconds. It was found that tea dries to acceptable moisture content of 2.5 – 3.0% (w/w, wet basis) when tea-bed temperature was reached around 106^0C. Therefore, the tea-bed temperature was continuously monitored in the data logger and when this temperature was reached, air heater was stopped immediately and air by-pass door was opened to prevent further drying.

Fluidizing section was removed and the tea was unloaded on a table as quickly as possible in order to cool down the tea.

Initial and final moisture content of tea samples was determined. Wet tea samples of 25g each and dried tea samples of 10g each were measured using an electronic balance with an accuracy of ± 0.01 g. The tea samples were kept in a standard oven at 103 ± 2°C for 6 hours. Samples were removed from the oven after drying and its final weight was measured. Moisture content of tea samples was determined by obtaining difference in weight as a percentage of its initial dry weight.

3. RESULTS AND DISCUSSION

A graph of inlet drying air temperature, tea-bed temperature and exhaust air temperature versus time was drawn for drying tea at 29 kg/m^2 using bedplate No.3 and is given in Figure 2. The temperature of inlet drying air was maintained within ±1^{0}C. The difference between tea-bed temperature and exhaust air temperature was found to be about 3^0 C. Similar graph was obtained for drying tea at various loadings at the Grit plates tested in this study. This indicates intensive interaction between tea particles and the drying air.

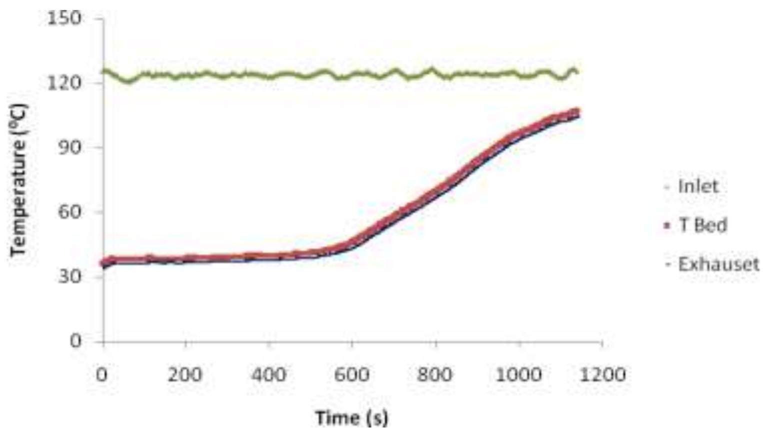

Figure 2 Variation of temperatures during drying tea at 29 kg/m^2 using Grit plate No. 3

Results of variation of the fluidizing velocities with time is given in Figure3.

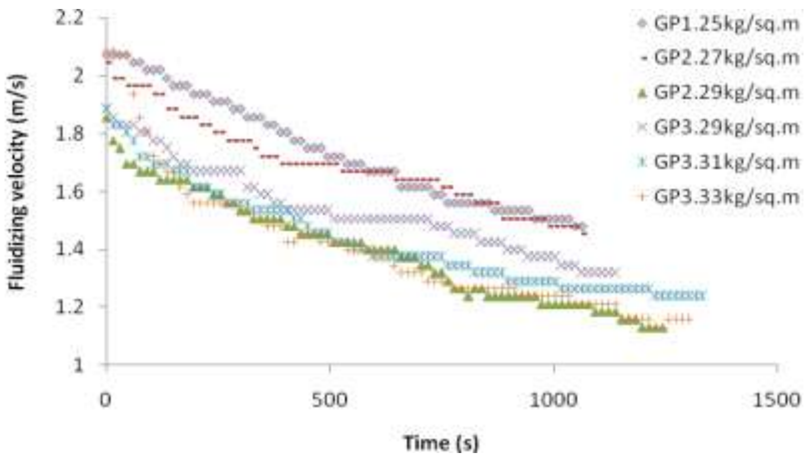

Figure 3 Variation of fluidizing velocity with time

Grit plate No.1

Airflow had to be increased to fluidize the tea at higher fluidizing velocities on Grit plate No. 1 at loading of 25 kg/m^2. This Grit plate could be used if the industrial type drier (TRI-CCC FBD) is to be operated at the conventional loading of 25 kg/m^2.

Grit plate No.2

Drying tea at higher loadings was found to be possible using Grit plate No.2. However, when tea was dried at 27 kg/m^2, a tendency of escaping of air through channels leading to entrainment was observed. This resulted in increased fluidizing velocities. Airflow requirement was found to be low when tea was dried at 29 kg/m^2 using Grit plate No. 2. The higher loading would have prevented by-passing of air and occurring of channeling in the tea-bed. Further, airflow was adjusted frequently to prevent throwing and entrainment of tea. Also, it was observed that fluidizing of tea was very sensitive to even small change in the drying air flow. The lower fluidizing velocities maintained during drying tea at 29 kg/m^2 reduced mixing effect to tea and resulted in extended drying time. Sometime, it led to casehardening of large size tea particles where the out layer was dried and some moisture was trapped inside the tea particles. Properly dried tea particles are black in colour and cannot be easily broken using hand. But, casehardened tea particles from this experiment could be broken and the broken pieces gave brownish appearance which is an undesired character and reduces the price of tea at the auction. Therefore, using this Grit plate for drying tea in TRI-CCC FBD is not attractive.

Grit plate No.3

Drying tea at higher loadings as high as 33 kg/m^2 was found to be possible using Grit plate No.3. Drying time of tea at 29 kg/m^2 was reduced with higher fluidizing velocities maintained at Grit plate No.3 compared to Grit plate No.2. This indicates that Grit plate No.3 performed comparatively better than Grit plate No.2 in drying of teas at 29 kg/m^2 with satisfactory mixing effect. Also, it was found that fluidizing velocity was reduced when the loading was increased to 31 & 33 kg/m^2 in Grit plate No.3. The drying time was extended by 2 to 3minutes at these loadings. It is preferable to test this Grit plate in the industrial type drier (TRI-CCC FBD) as fluidizing of tea is possible at a range of loading of 29 – 33 kg/m^2 without any adverse effect of blowout and entrainment.

Variation of total differential pressure, differential pressure across tea-bed and differential pressure across Grit plate with time is given in Figure 4 for drying tea at 31 kg/m^2 using Grit plate No.3. Total differential pressure reduced with time without any fluctuation and similarly differential pressure across the tea-bed and Grit plate reduced with time without any fluctuation. This indicates fluidization is achieved from the beginning to end without any stagnation and channeling. Similar graph was obtained for other loadings on the different Grit plates tested.

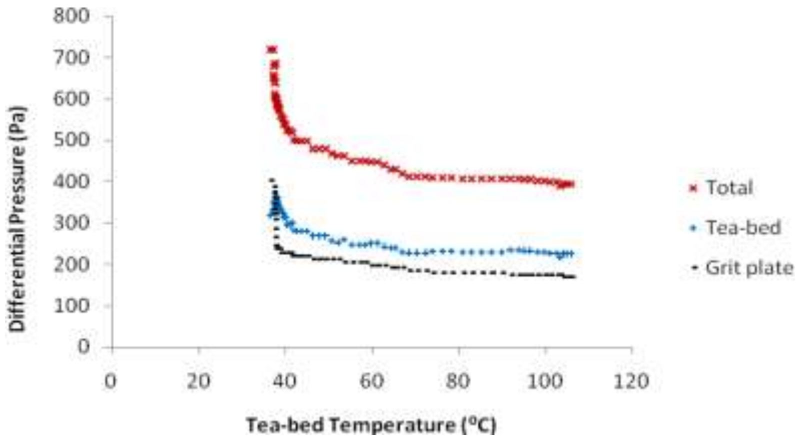

Figure 4 Variation of differential pressure during drying

In the industrial continuous type drier (TRI-CCC FBD), drying section is divided into 3 or 4 or 5 and volume of drying air is adjusted in each section for fluidization of tea using individual air control dampers. By adjusting airflow, average fluidizing velocity is maintained for drying tea in each section. Figure 3 showed that fluidizing velocity changed frequently with time during drying. Therefore, a model is needed to control and improve drying process in the drier. However, measuring airflow and adjusting it accordingly is difficult as drying air enters through rectangular chambers with a cross-sectional area of 120cm x 110cm in each drying section. Therefore, a measurable parameter is needed to be selected for the control. The drying airflow is directly related to total differential pressure across tea-bed and Grit plate. The total differential pressure in the drier could be measured using a micromanometer. Also, temperature of tea-bed could be monitored during drying of tea in the drier. Therefore, an attempt was made to obtain a model for describing variation of total differential static pressure with tea-bed temperature with a view to use the model to measure and adjust the total differential static pressure in each drying section according to average tea-bed temperature in that section. Variation of total differential static pressure with tea-bed temperature for drying tea at 25 kg/m^2 using Grit plate No.1 is given in Figure 5.

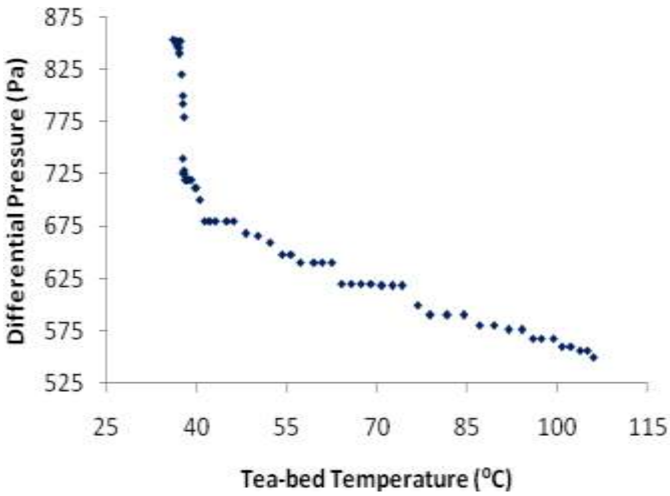

Figure 5 Differential static pressure with tea-bed temperature for tea at 25 kg/m^2. on Grit plate 1

Theoretical drying model for describing variation of differential static pressure with tea-bed temperature was difficult to be developed as airflow was reduced with time during drying process. Further, there is wide variation in size of tea particles dried in the drier. Therefore, it was decided to test an empirical model given in equation 1 in this regard.

$$\Delta P = aT^b \quad \text{........ (1)}$$

Where,

ΔP - Total differential pressure

T - tea-bed temperature and

a, b - empirical constants

Fitting the model was found to be difficult for the whole drying process due to removal of surface moisture taking place in tea for several minutes (4 -5 minutes) at the beginning. Therefore, the empirical model was tested with data collected after a tea-bed temperature of 41^{0}C at which most of the surface moisture is expected to be removed. Non-linear regression analysis was used to estimate the empirical constants starting with a set of initial values estimated from the corresponding linearised form. The criteria used for adequacy of fit such as correlation coefficient (R^2), root mean square error (RMSE) and reduced chi-square (χ^2) were obtained and the results are presented in Table 2. The correlation coefficient was found to be above 0.955 and values for RMSE and chi-square were found to be low for all the tested loadings using the Grit plates. Further, closer values were obtained for empirical constants for all the tested loadings using the Grit plates except for 25kg/m^2 at Grit plate No.1.

Table 4 Results of statistical analysis verifying empirical model

Bedplate	**Load (kg/sq.m)**	**Constants**		**R^2**	**RMSE**	**χ^2**
No.2	25	a = 1592	b = -0.2434	0.9550	0.9592×10^1	0.9202×10^2
No.3	27	a = 1380	b = -0.2435	0.9828	0.4944×10^1	0.2444×10^2
	29	a = 1167	b = -0.2662	0.9703	0.5855×10^1	0.3428×10^2
No.6	29	a = 1308	b = -0.2609	0.9694	0.6424×10^1	0.4127×10^2
	31	a = 1084	b = -0.2359	0.9795	0.4519×10^1	0.2042×10^2
	33	a = 1146	b = -0.2634	0.9655	0.6146×10^1	0.3777×10^2

Trials were conducted with tea to verify the model. Results obtained are presented in figures 6, 7, 8, 9, 10 and 11. The model was modified to include another constant ‘c’ as given in equation 2. This is to accommodate variation of differential static pressure due to other influencing factors such as initial moisture content in tea, particle size distribution and bulk density of tea. Further, fluidizing velocity could be varied within a limited range without affecting fluidizing and drying of teas on the Grit plate. It was found that the measured differential static pressures across tea-bed and Grit plate were close to predicted values from the identified model at all the tested loadings in the Grit plates.

$$\Delta P = aT^b + c \quad \ldots\ldots\ldots\ldots (2)$$

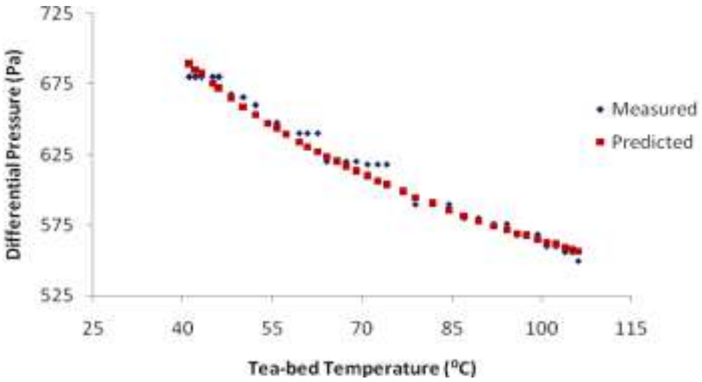

Figure 6 Measured and predicted Differential static pressure with tea-bed temperature for tea at 25 kg/m^2. on Grit plate 1. C = 45

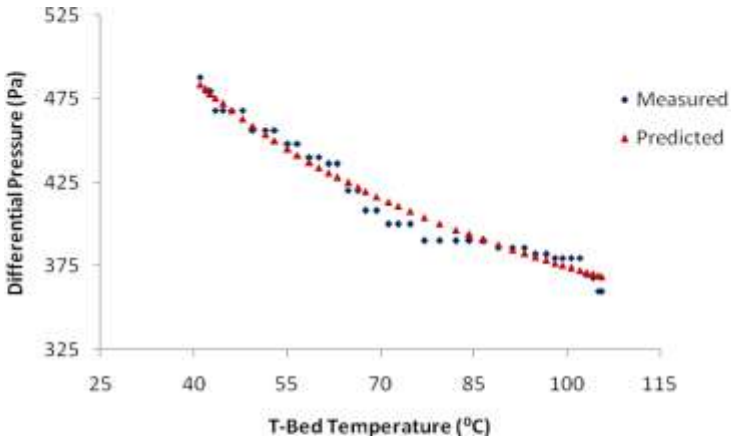

Figure 7 Measured and predicted Differential static pressure with tea-bed temperature for tea at 27 kg/m^2. on Grit plate 2. C = -75

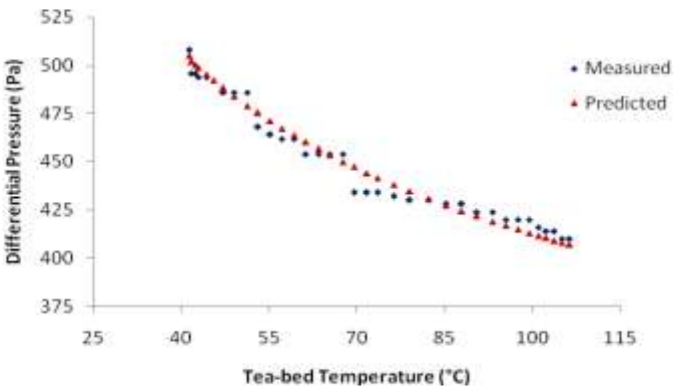

Figure 8 Measured and predicted Differential static pressure with tea-bed temperature for tea at 29 kg/m^2. on Grit plate 2. C = 70

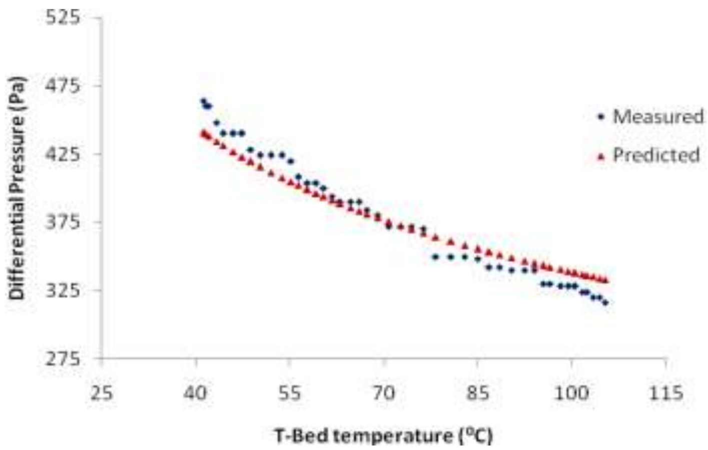

Figure 9 Measured and predicted Differential static pressure with tea-bed temperature for tea at 29 kg/m^2. on Grit plate 3. C = -55

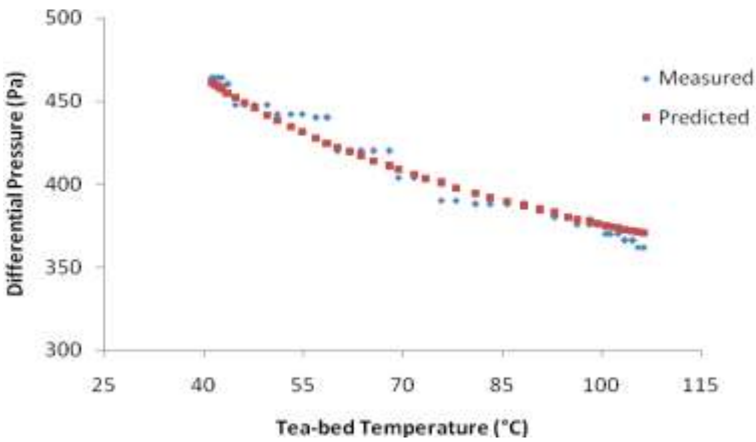

Figure 10 Measured and predicted Differential static pressure with tea-bed temperature for tea at 31 kg/m^2 on Grit plate 3. C = 10

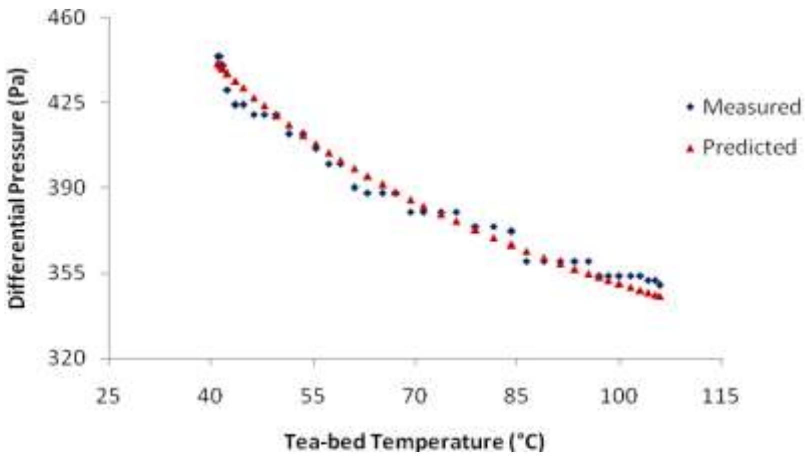

Figure 11 Measured and predicted Differential static pressure with tea-bed temperature for tea at 33 kg/m^2 on Grit plate 3. C = 10

4. CONCLUSIONS

Fluid bed drying of Orthodox-rotorvane tea could be improved using the Grit plate consists of 36 mm long and 0.5 mm wide perforations with 4% opening area at the conventional loading of 25 kg/m^2. Fluid bed drying of Orthodox-rotorvane tea could be improved using the Grit plate consists of 36 mm long and 0.6 mm wide perforations with 5% opening area at a range of loading of 29 – 33 kg/m^2. An empirical model was identified and validated for predicting total differential static pressure across tea-bed and Grit plate for varying tea-bed temperature during fluid bed drying. This model is applicable for varying tea-bed temperature above 41^0C.

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The Tea Research Institute of Sri Lanka

229th MEETING OF THE EXPERIMENTS AND EXTENSION FORUM

25 July 2014

SELF CLEANING SIFTER FOR GRADING LOW GROWN TEAS

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ABSTRACT

Michie Sifter fitted with different size meshes are used for sorting teas into long leaf & pekoe family grades maintaining size variation to a minimum in Low grown tea manufacture. Clogging of tea particles often occurs in the Sifter and is manually removed by using a piece of wood at regular interval. This is the main difficulty in making the sorting a continuous operation. Sorting of tea in this manner results in breaking and greying of tea particles and the tea grades fetch lower prices. Further, regular cleaning leads to sagging of meshes and results in inefficient sorting of teas. Therefore, an innovative mechanism was developed to remove clogging tea particles during sorting with a view to improve efficiency of sorting process, reducing damage to tea particles and making the process continuous and thereby increasing worker productivity.

A mesh tray arrangement with bouncing balls was designed, fabricated and incorporated into an existing Michie Sifter for grading long leaf family and pekoe leaf family teas. During sorting with this arrangement, bouncing balls hit the mesh and dislodge clogged tea particles. In this manner, clogged tea particles are removed continuously with less breakage to the tea particles. This self cleaning arrangement in michie sifter was tested successfully for sorting teas using mesh No 08.

The results shows that off grade percentage reduced and grade mix improved when michie sifter with self cleaning arrangement is used. Professional tea tasters' evaluation showed that the average selling price of teas increased by Rs.9.70. The increase in price contributed to NSA as well. The self cleaning mechanism could be incorporated in existing michie sifter at a cost of about Rs.200,000.00. Simple payback period for fabricating and using one such sifter in a factory producing 2000 kg made tea per day was found to be 2 months.

Key words – Michie sifter, sorting, Low grown tea, self cleaning mechanisms, valuation

1. INTRODUCTION

Tea is identified as a healthy beverage and is popular in the world. Black tea is derived solely and exclusively produced by acceptable processes, withering, rolling & roll breaking, aeration and drying, from the tender shoots of varieties of the species *Camellia sinensis* (L.) O. Kuntze, known to be suitable for making tea for consumption as a beverage. It is an important commodity in the international trade and Sri Lanka is the largest producer and exporter of orthodox leafy type tea in the world.

Tea growing areas are broadly grouped according to their elevations, with high grown ranging from 1200 m upwards, medium grown ranging between 600 m to 1200 m and low grown from sea level up to 600 m. The characteristics of made tea vary with the elevation.

There are about 710 tea factories in the country. Amongst, 450 tea factories follow Low Grown Orthodox Tea manufacture (Low Grown Manufacture). Main tea grades produced in this method could be categorized into three types depending on their particle size as given below.

01. Long Leaf Family Tea Grades
02. Pekoe Family Tea Grades
03. Small Leaf Family Tea Grades

Separation of Long Leaf Family and Pekoe Family Tea Grades in Low Grown Manufacture into different grades is a tedious process in tea manufacture and a great care should be taken not to break the teas during this process. Middleton Bubble Tray Stalk Extractor, Michie Sifter, Chota-Rotary Sifter, Winnower, Colour Separator and Tarry Nipper are the main sorting machinery used for the sorting of Low grown teas. Michie sifters incorporated with mesh nos. 04, 06, 08 and 10 are widely used to separate the above families of tea grades which are more than 60% of the total graded tea production in Low Grown Manufacture. Therefore, it plays a significant role.

In long leaf family, tea particles are long and wiry in shape. The second largest dimension of the tea particle should be smaller than the mesh aperture size for it to pass through. As the tea particles are not uniform in shape, in some places second largest dimension of a particle could be larger than the aperture size of the mesh. In such situation tea particle get clogged in the mesh. It is a common problem observed in Low grown tea manufacture. Therefore, workers are employed with each sorting machine to remove the tea particles clogging the mesh with a piece of wood at regular intervals. Hence, conveyorizing and automation of the existing Michie Sifters are impossible. Sorting tea in this manner results in breaking and greying of tea particles. Tea grades with broken and greyed tea particles lose their appearance and fetch lower prices compared to that with even size black tea particles. Further, regular cleaning leads to sagging of meshes and results in inefficient sorting of teas. There are more chances for contamination of wooden and metal particles to teas due to this. Cost of sorting is also high due to deployment of additional workers for cleaning of meshes in sifters. Therefore, the sorting machine needs to be improved with a mechanism to automatically remove the clogging tea particles during sorting with a view to improve efficiency of sorting and to avoid breaking and greying of tea particles.

1.1 Present Grading Method and use of Michie Sifters

Processed and dried-tea is first separated into Large, Medium and Small size fractions using Middleton Stalk Extractor. The Large and Medium size fractions are then separated into different Long Family & Pekoe Family tea grades such as OPA, OP, OP1 and BOP1. The separation is carried out using four Michie Sifters each with a standard mesh of Nos. 4, 6, 8 or 10 (Figure 1).

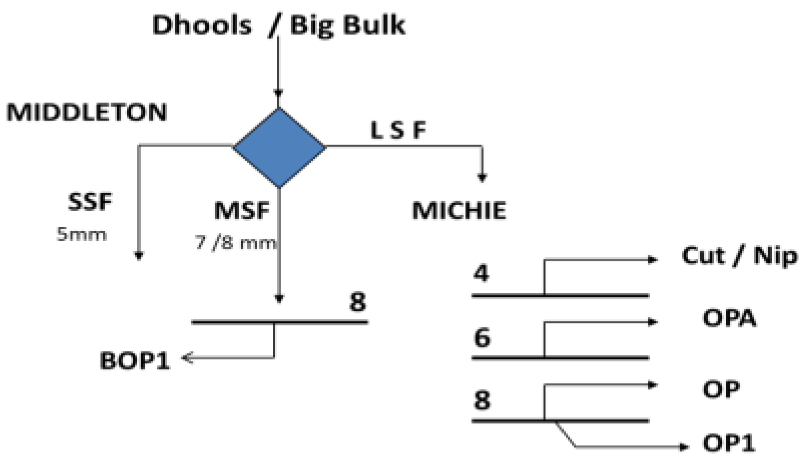

Figure 1 Long Leaf Family –Michie Sifter Involvement

The Michie Sifter is also suitable for removing near spherical particles from tea grades such as FBOP and FBOP1 to make them leafy in appearance (Figure 2 and 3).

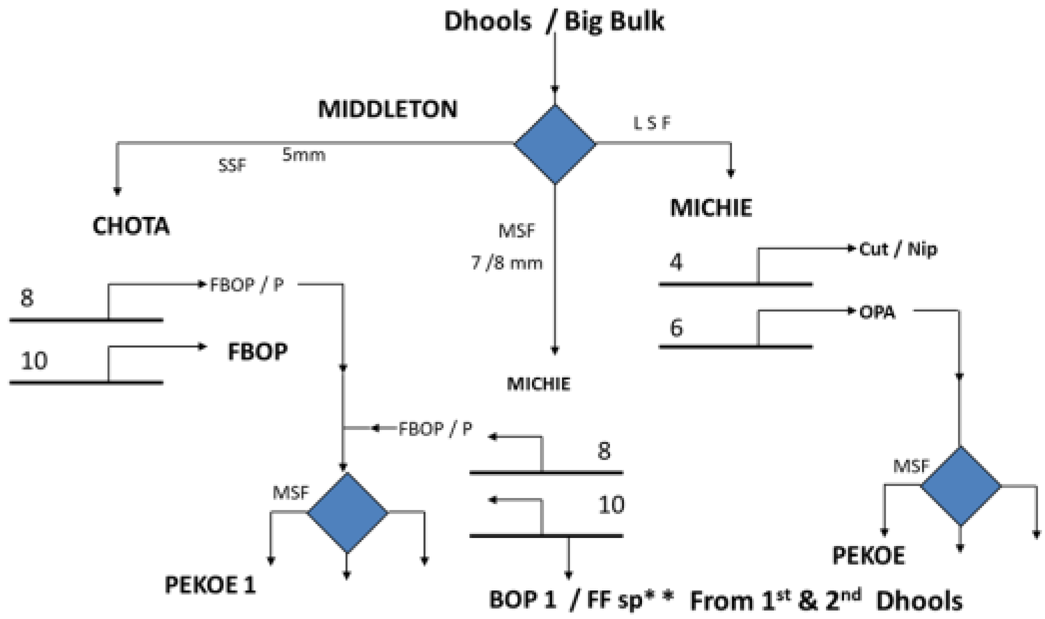

Figure 2 Pekoe Leaf Family –Michie Sifter Involvement

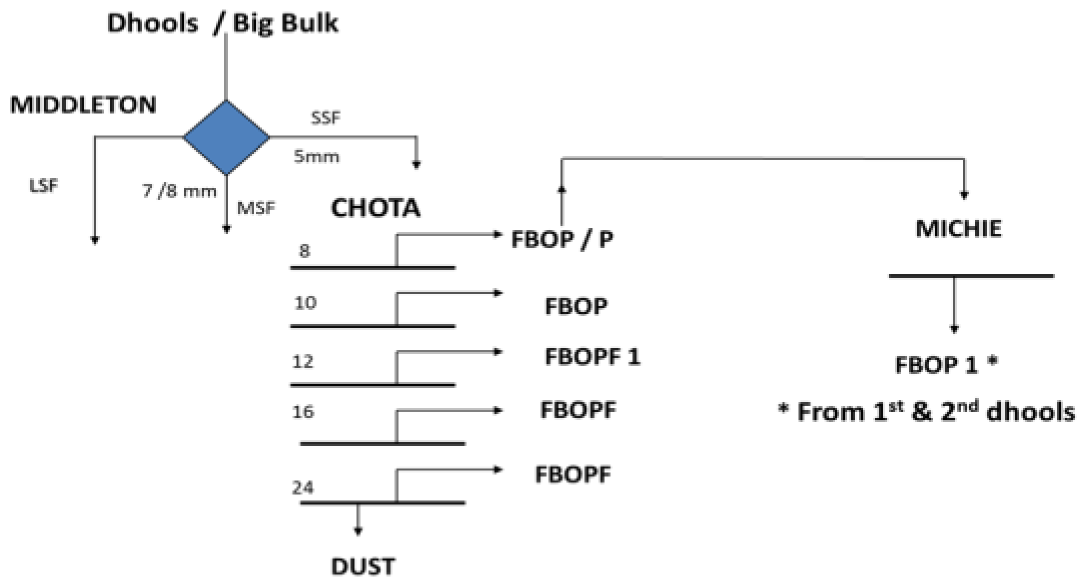

Figure 3 Small Leaf Family –Michie Sifter Involvement

Michie sifter presently used in tea factories consists of one mesh tray or two mesh trays with one on top of the other. The Michie Sifter is made to have 260 to 270 oscillations per minute and the speed of the machine has much influence on its output and uniformity of separation. The mesh tray/s is/are given an oscillatory motion in vertical plane to make tea particles jump forward from feeding end to the discharge end. Therefore, the Michie Sifter imparts a galloping motion on particles and long leafy & wiry type particles go through the mesh and bolder particles flow over the mesh. As certain amount of particles tends to get entangled to the wire mesh clogging it and tampering the sieving process, workers are employed to manually remove/ break them with a piece of wood at regular interval.

The problems encountered with the present Michie Sifter are;

1. High breakage of tea particles due to manual cleaning resulting in poor grade mix

2. Greying of tea particles due to too much of handling (scraping/abrasions)

3. Heavy Clogging of mesh with particles and thereby affecting the process output

4. Sagging of mesh caused by frequent manual cleaning of the meshes leading to inefficient sorting process

5. Less efficiency due to none continuous process and inability to automate the sorting process

Therefore, a self-cleaning sifter was developed with the following objectives.

1. To make grading process a continuous one

2. To minimize breakage of tea particles

3. To minimize labour use and handling of tea

4. To make Michie Sifter more worker friendly

5. To conveyorize/ automation of grading process

1.2 Self-Cleaning mechanism

The michie sifter was incorporated with a mesh tray (6ft x 3ft) made of wooden flanks and aluminium. The mesh (No. 8 size) was fixed to an iron frame and was fitted to the top of the tray. Six adjustable screws were fitted on either side (two long edges) of the mesh frame so that mesh can be tightened/ stretched to a required degree to avoid sagging during continuous use. The mesh tray was fixed horizontally and powered by a1 hp motor giving 240-250 oscillations per minute in the vertical plane as shown in Plate 1. A vibrating feeder was fabricated and attached at one end to the Self Cleaning Sifter. The feeder facilitated regular and even feeding of tea to the machine and thereby increased its output from about 80 kg/ hr to above 180 kg/hr. The rate of feeding is controlled by adjusting the speed of the vibrator.

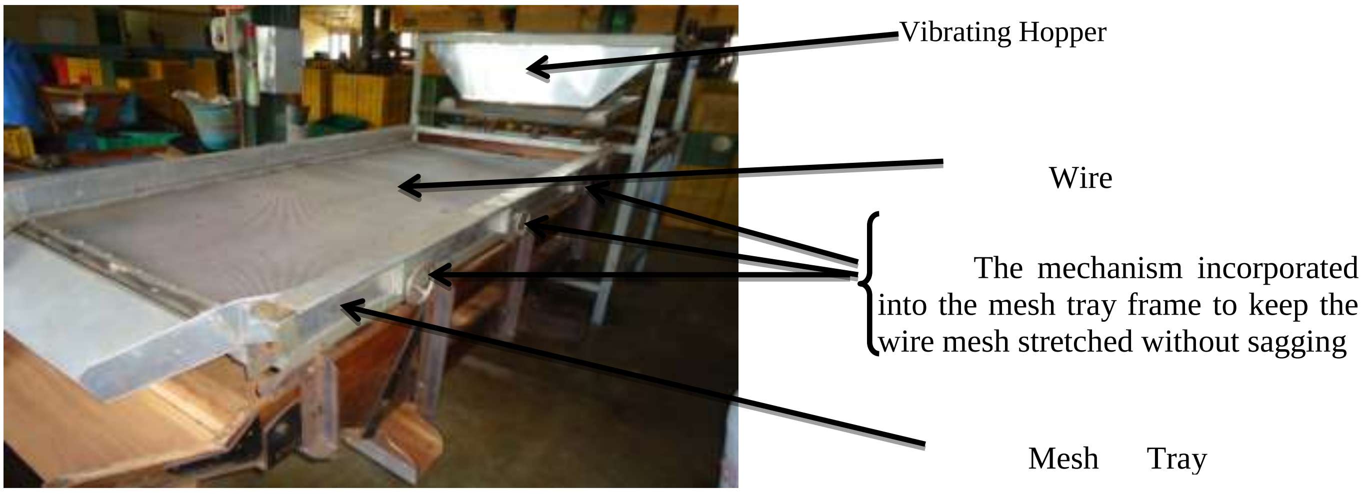

Plate 1 Self-Cleaning Sifter

As shown in Figure 5, a ½"×½" mesh tray is fixed 2.8" below the sifting wire mesh making a separate chamber. This chamber is separated into six compartments by fixing 6 triangular shaped wooden battens as shown in the Figure 4. Bouncing balls of 1" in diameter were placed in each compartment as mesh cleaners.

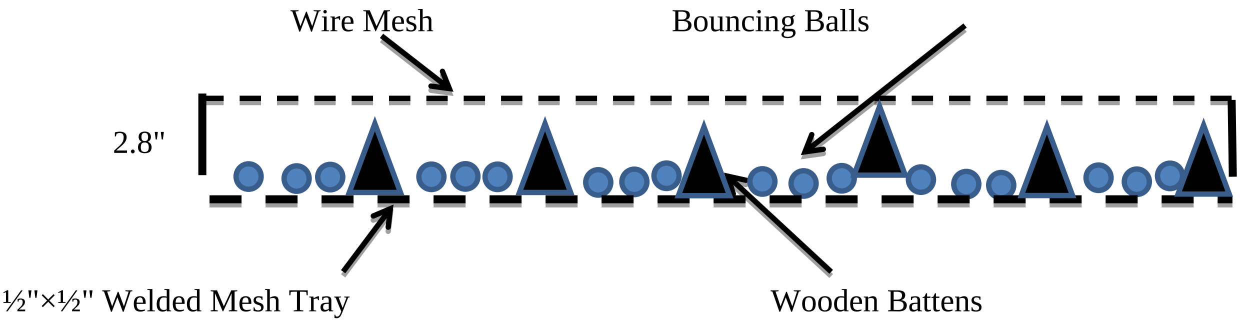

Figure 4 Ball tray arrangement along the mesh tray (cross sectional view)

Due to an oscillatory motion in a vertical plane of the sifter and the shape of the wooden battens fixed in each compartment the bouncing balls directly hit the sifting mesh above. As shown in Figure 5, the bouncing action of balls is confined to each compartment and continuously dislodges the clogging particles by direct contact with the wire mesh.

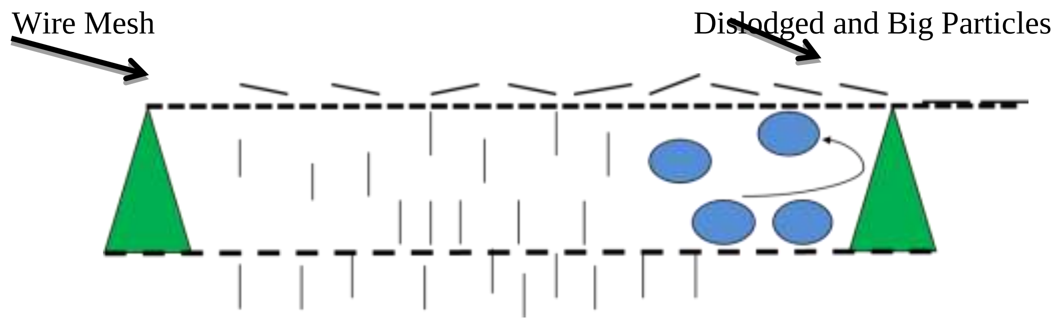

Figure 5 Wire Mesh cleaning by Bouncing Balls

The tea particles sieves through the sifting mesh easily goes through the second mesh below (½"×½" Welded Mesh that is used to hold the bouncing balls) and deposit in the bottom tray of the sifter from which the teas are unloaded.

2. METHODOLOGY

Performance of the self-cleaning sifter incorporated with ball tray arrangement was found to be improved at the speed of 228 rpm and it was compared with the conventional Michie sifter which was operated at the conventional speed of 270 rpm. Tea samples from same day manufacture were used to minimize sampling error. Dried-dhools of a days' manufacture were passed through Middleton Stalk Extractor incorporated with 05 mm and 07 mm bubble trays. Teas derived as Large Size Fraction (LSF) was further sifted using michie sifters with No. 4 and 6 and tea obtained through both sifters were taken as feed tea sample for the test as shown in Figure 6.

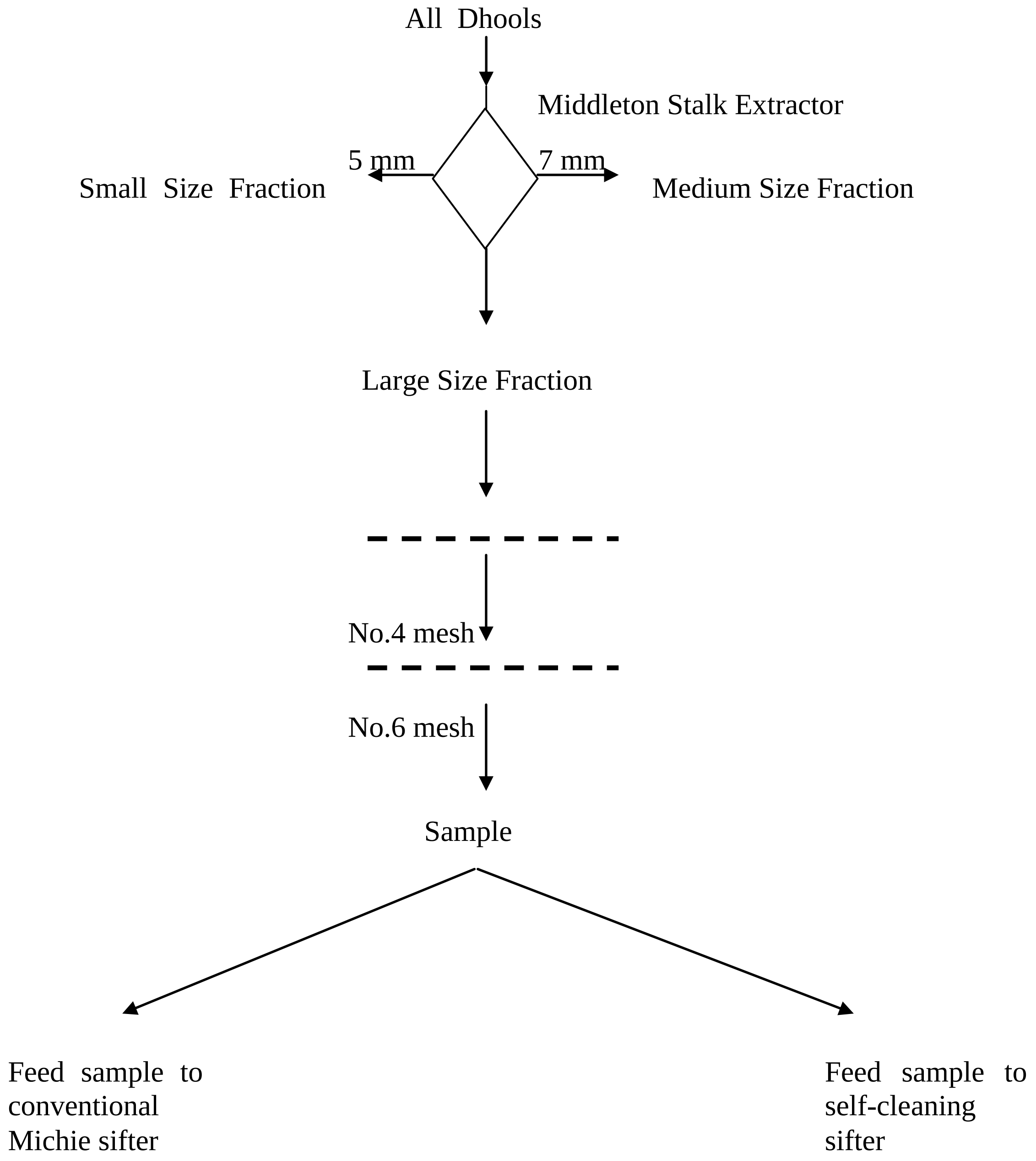

Figure 6 Preparation of test feed sample

The feed tea samples were bulked and divided into two equal quantities. Each lot were sent to existing michie sifter and self cleaning sifter. Durations taken to pass through the machines, quantities obtained through and over the meshes were recorded. Quantities came through and over the meshes were processed by adopting following grading procedure (Figure 7 and 8) to obtained final grades. The teas were first sent through Middleton Stalk Extractor to separate into different grades and even the particles size in the grades. The separated tea grades were now sent through winnower to obtain heavier and lighter fractions. Final weights of the grades were recorded. Samples from the final grades were sent to two professional tea tasters to obtain valuations. Average of the two valuations and throughputs of the machineries were compared.

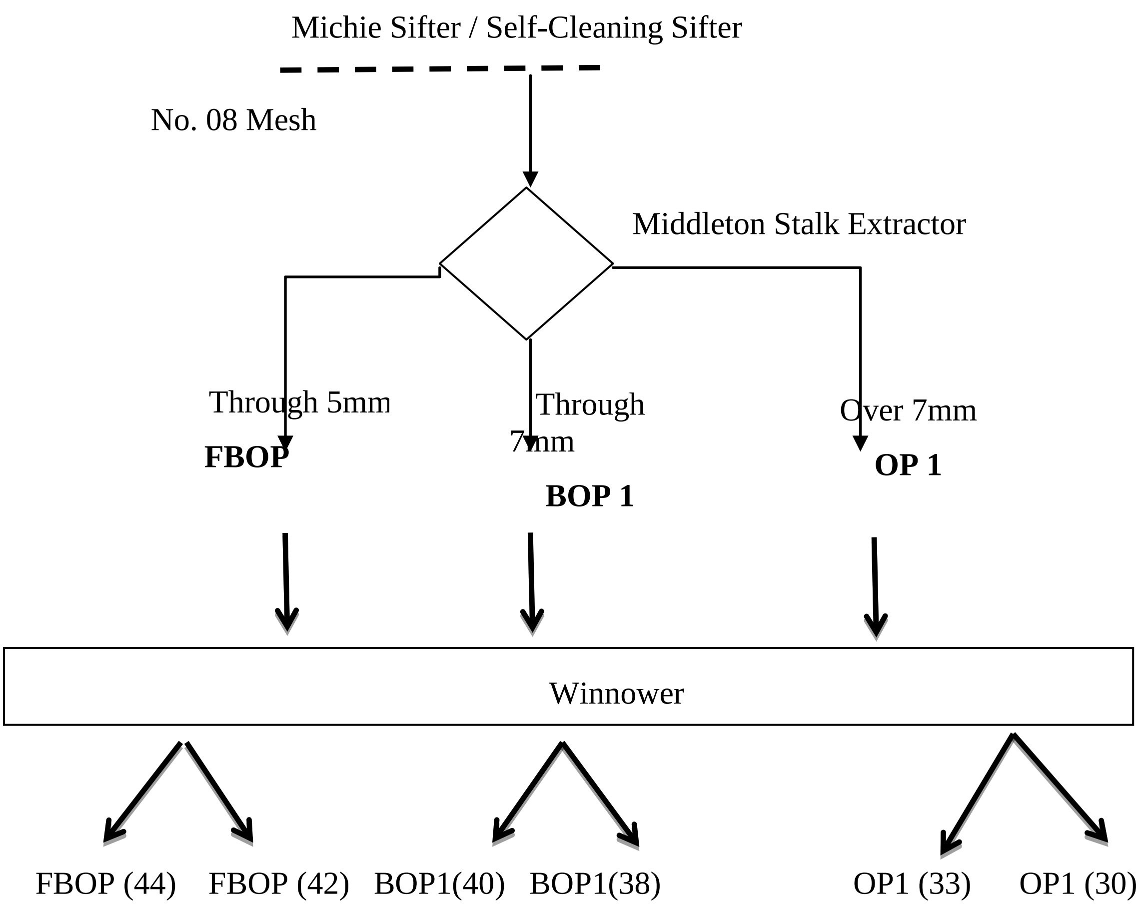

Figure 7 Grading procedure for teas obtained through mesh No.8

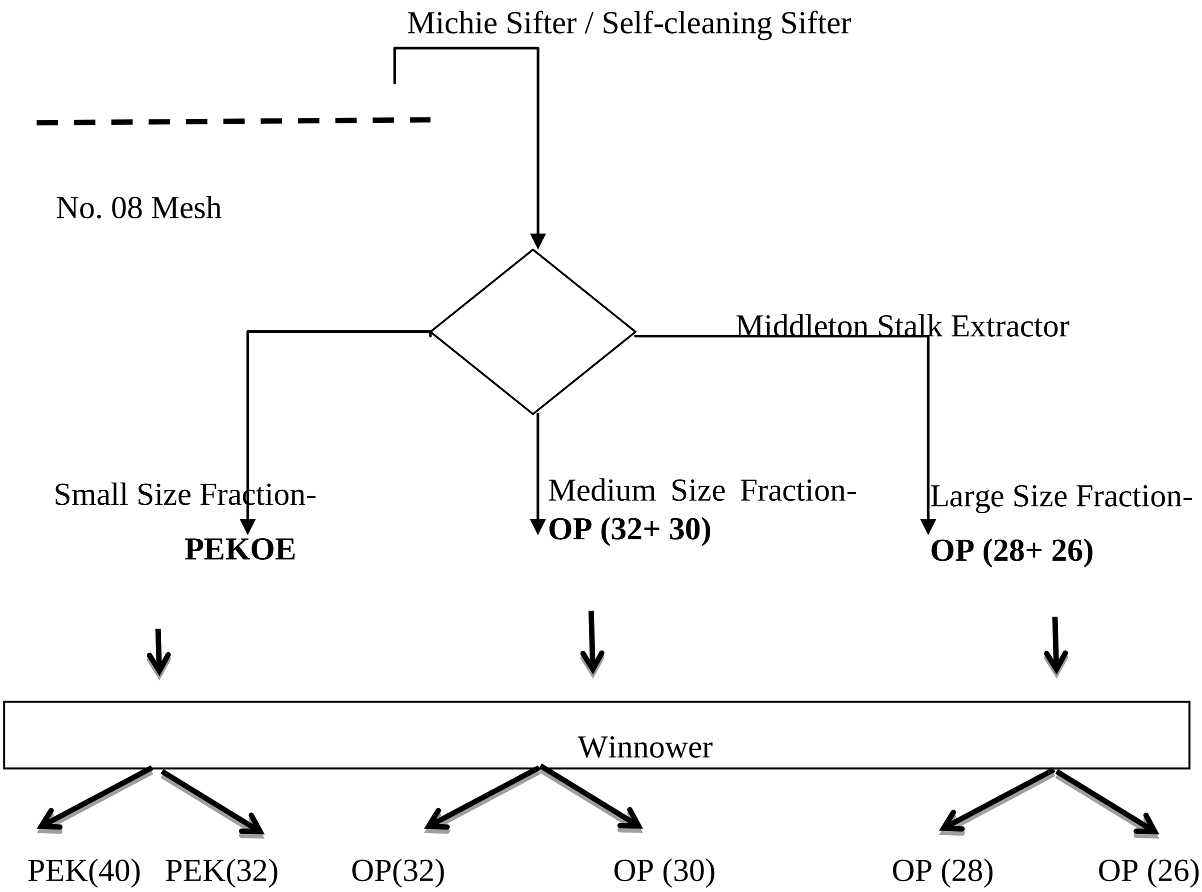

Figure 8 Grading procedure for teas obtained over mesh No. 8

3. RESULTS

The results obtained by adopting above procedures are given in Table 1 and Table 2

Table 1 Off Grade Percentage and Throughput

Sifter	Throughput (kg / hr)	Off Grade Percentage
Existing Michie Sifter	187	18.3
Self-Cleaning Sifter	170	15.6

Table 2 Grade Percentage and Valuation

			Existing Michie Sifter			**Self-Cleaning Sifter**		
		Grade	**%**	**Average Valuation**	**Price (Rs)**	**%**	**Average Valuation**	**Price (Rs)**
Over Mesh	**Heavy**	**OP (28)**	17.6	505.00	8,883.00	21.2	502.50	10,652.70
		OP (32)	15.7	530.00	8,295.00	12.8	535.00	6,864.70
		Pekoe (40)	17.2	560.00	9,617.70	18.0	565.00	10,165.30
	Sec	**OP (26)**	4.6	435.00	1,988.20	6.0	425.00	2,548.80
		OP (30)	5.7	465.00	2,640.60	5.9	460.00	2,694.60
		Pekoe (32)	6.5	470.00	3,059.60	6.4	465.00	2,983.30
Through Mesh	**Heavy**	**OP 1 (33)**	5.4	555.00	2,997.90	5.7	590.00	3,373.80
		BOP 1 (40)	4.7	525.00	2,472.30	4.3	545.00	2,356.30
		FBOP (44)	0.6	530.00	293.60	0.4	550.00	230.10
	Sec	**OP 1 (30)**	1.0	350.00	339.30	0.8	345.00	288.70
		BOP 1 (38)	2.4	450.00	1,059.60	2.2	435.00	970.70
		FBOP (42)	0.6	500.00	277.00	0.6	510.00	284.50
		Off Grades	18.3	345.00	6,313.50	15.6	370.00	5,772.00
				Average Selling Price (Rs/kg)	**482.30**			**492.00**

In the existing Michie sifter grading is forced and therefore off grade percentage is higher by 2.7% than that of the self-cleaning sifter. It indicates that the breakage of particles during sifting is less in the self-cleaning sifter. Also, the difference in the throughputs of these machines is not considerable compared to increased output of the sifters with the addition of vibrating feeder. Average selling price of grade mix obtained by using Self-cleaning sifter is Rs. 9.70 higher than that obtained using the existing Michie Sifter. In a factory, if the quantity of tea available for grading by using Self-cleaning sifter is 20 % of the total made tea production, an increase of Rs. 1.94 /kg MT could be expected in their NSA.

Actual cost of fabricating self cleaning mechanism for existing michie sifter including vibrating feeder is Rs.80,000.00 as at July 2014. Expected expenditure for the modification and installation of the machine by an Engineering Firm is Rs.200,000.00. If the daily graded tea production is 2000 kg and number of operating days per month is considered as 25, simple payback period will be two months. If the saving on worker is considered it will be even shorter.

4. CONCLUSIONS

The self cleaning sifter makes the process a continuous one without any clogging of tea particles. When compared to the existing michie sifter, breakages to tea is less and percentage of off grade production is reduced. As a result, made tea quality increased and that lead to higher NSA. Further, the worker requirement is reduced by 1. The self cleaning mechanism could easily be applied to Michie Sifters incorporated with mesh No. 04, No. 06 and No. 10. Conveyorization and automation is possible with the use of the self cleaning sifter.

The Tea Research Institute of Sri Lanka

229th MEETING OF THE EXPERIMENTS AND EXTENSION FORUM

25 July 2014

A STUDY ON CAST IRON COMPONENTS OF AIR HEATERS OF TEA DRYERS

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ABSTRACT

Firewood-fired air heaters are commonly used in tea factories to generate hot air for drying fermented wet dhools. Failure of cast iron components, especially cast iron tubes of air heaters are quite common. Failures invariably lead to smoky teas and sometimes a fire that can have serious consequences. A study was done by visiting tea factories to find out reasons for failures. Observations revealed poor operational and maintenance practices, aiming for higher operating temperature beyond the capacity of the air heater and poor firewood management practices as main causes of failures.

Samples of damaged cast iron tubes collected from air heaters were analyzed for their chemical composition. Chemical composition of the cast iron is the key parameter which determines the ability to withstand high temperature. Temperature regime inside the air heater and status of the flue gas was recorded using data loggers and flue gas analyzer with dry and wet fire wood. Temperatures of flue gas as high as 830 ^{o}C were recorded at the inlet of first pass to cast iron tube bank. This study confirmed that temperatures inside the air heater are primarily related to operational practices. It also revealed that the quality/chemical composition of collected cast iron samples from the failed components of tubes in air heaters may not be satisfactory to withstand the temperatures observed.

Key Words: Firewood-fired air heaters, Cast iron chemical composition, Temperature

1. INTRODUCTION

Tea dryers require clean air for drying fermented wet dhools in order to eliminate any risk of smoke taint in processed tea. Heat is transferred from hot flue gas to fresh air using tubular type air heaters. Over the years, designs have achieved higher efficiencies by incorporating additional heat exchange areas. "Five - Pass Heater" which is popularly used at present has five flue passes through tubes, first pass through Cast Iron tubes (oval cross section) and the other four through Steel tubes (round cross section). Recent concerns of tea processing factories have been primarily related to frequent failure of Cast iron tubes, which are the hottest, and on occasion failure of the coldest Steel tubes, obviously due to low flue gas temperature.

In an Air Heater used in the Industry, tubes are considered failed when there is contamination of fresh air supply by flue products due to damage to tubes. When fresh air supply is contaminated, it leads to an undesirable smoky taste in tea which requires immediate rectification. Maintenance is costly and down time caused by frequent breakdowns of a heater can lead to overall disruption of process and therefore significant losses. Smoky tea leads to lower prices and if unattended eventual rejection by tea buyers and at worst, a fire which can damage the asset causing severe financial loss.

Unlike in the past, at present nearly all Tea Dryers and Heaters as well as most spare parts are imported from India. There is reliable evidence that some of the foreign suppliers of these tubes get casting work done via smaller sub-contracting units who probably lack quality control and assurance. Casting facilities available in Sri Lanka, particularly those serving Tea Industry have not expanded over the time, primarily due to difficulties in competing with imported products in an open import policy environment.

Tea processing organizations requested the Tea Research Institute to examine this problem and come out with remedial measures. This study is a result of that request.

2. MATERIALS AND METHODS

Literature survey revealed that standards on Grey Iron castings such as BS 1452:1977 – British Standard Specification for Grey Iron Castings (1) specifies the requirements for several grades of Cast iron based on the tensile strength only. This standard as well as its 1990 version (2) and the Indian Standard IS210:1993 (reaffirmed 1999) – Grey Iron castings –Specification (fourth

Revision) (3) are silent on suitability of a Casting for use under high temperature environment. Further, these standards have refrained from stating the chemical composition of castings and leave it to be decided between the purchaser and the manufacturer.

Handbooks on cast iron, for example FOSECO Foundryman's Handbook (4) clearly explains the role played by component elements of cast iron and provides guidelines for compositions suitable for use in high temperature environments.

In order to assess how widespread the problems are, tea processing sector associations were requested to assist in collation of information on failures. On receipt of that information, few selected factories were visited to assess the severity, observe operational practices, gather photographic evidence and collect samples of failed tubes for analysis of chemical compositions. Reports on Carbon, Silicon, Manganese, Sulphur, Phosphorus and Chromium contents of Cast Iron of a few failed tubes were obtained from the Industrial Technology Institute, Colombo and Ceylon Steel Corporation Limited, Athurugiriya.

Two local foundries that produce Cast Iron tubes for the tea industry were visited to examine the facilities available and to assess their efforts in quality control and assurance. It appeared that there is hardly any knowledge on temperature regimes actually present inside an air heater. Information on this aspect was generated by measuring temperatures in a Five- Pass Air Heater used at Tea Research Institute's St Joachim Tea Factory in Ratnapura.

Temperature measurements were made using insulated K-type thermocouple wires coupled to Data Loggers (Testo 175-T3) and industrial thermo probes supplied by Sri Lanka Sustainable Energy Authority, Colombo.

3. RESULTS AND DISCUSSION

Based on observations made during visits to factories shortcomings in operation and maintenance of furnaces, lack of quality assurance in the process of casting of tubes and unsuitability of the chemical composition of Cast Iron are identified as possible causes of failures.

(a) Shortcomings in operation of furnaces

Observations made in shortcomings in operation of furnaces are listed below.

- Operating the heater for long continuous periods and ignoring the need for cleaning of tubes and ash removal from collection points (Plate 1).
- Targeting temperatures higher than the design level.
- Use of poor quality firewood, particularly wet or raw firewood having high moisture level which require overloading of the combustion area (Plate 2), switching OFF of main fan for short periods etc. These unwise practices lead to exposure of tubes to high temperature.
- ID fan temperature should be maintained little above 120^{o}C. Otherwise scale (creosote) formation and condensation in steel tubes will occur. Consequently corrosion will start in steel tubes (Plate 3).
- Faulty ID fan temperature and inadequate space for cleaning tubes also will contribute to the failures (Plate 4).

(b) Shortcomings in maintenance of furnaces

Some shortcomings observed in maintenance of furnaces are badly maintained fire bars, Induced draft & Forced draft fans, combustion air controls and dryer itself and untidy dryer surroundings. Not balancing the flue path to get an even flow on Right and Left sides. This omission leads to live flame getting sucked into one side causing accelerated decay (Plate 5). The practice of temporarily blocking defective tubes, without replacing them on time, which increases the work load of other, tubes (Plate 6).

(c) Lack of quality assurance in the process of casting of tubes

Tubes with uneven thickness were found among failed tubes. While on average thickness is around 8mm, cross section of a failed tube revealed the thicknesses as low as 3 mm (Plate 7). This is due to core shift defect in casting.

Some newly purchased tubes had pin holes in the casting sometimes visible in the surface and blow holes surreptitiously hidden by applying a covering paste and painting thereafter.

Plate 1 Large quantity of ash collected, probably due to long hours/days of work

Plate 2 Large heap of firewood within the combustion chamber

Plate 3 Corrosion caused by low flue gas temperature

Plate 4 Faulty ID temperature and inadequate space for cleaning tubes

Plate 5 Flame get sucked in towards left hand side

Plate 6 Blocked oval tubes

Plate 7 Uneven thickness of an oval tube

(d) Unsuitability of the chemical composition of Cast Iron

Chemical composition is important in deciding the suitability of using the cast iron in high temperature environment. Therefore, failed cast Iron tubes were analyzed for chemical composition. Results of composition of some important elements are given in the following Table 1.

Table 1 Composition of failed Cast Iron tubes.

Element	Sample 1	Sample 2	Sample 3
Total Carbon	3.04%	2.91%	3.21%
Silicon	1.17%	1.35%	1.16%
Manganese	0.33%	0.25%	0.23%
Sulfur	0.094%	0.113%	0.105 %
Phosphorus	0.045%	0.051%	0.047 %
Chromium	0.02%	0.09%	0.02%

Compositions of failed Cast Iron tube components are falling into the category of “Un alloyed” Cast Iron. However, as per Foundryman’s Handbook recommendation, “Un alloyed” Cast Iron without any Chromium is suitable for use up to a temperature level of 600 °C only.

Handbook also recommends the following composition (Table 2) for temperatures up to 700 °C & 850 °C. Composition for 700 °C is more or less tallies with the composition used decades ago by one of the leading tea Dryer/Furnace manufacturing companies in Sri Lanka.

Table 2 Composition of Cast Iron recommended for higher temperatures

Element	(A) Suitable for up to 700 °C	(B) Suitable for up to 850 °C
Total Carbon	3.4 - 3.7%	3.4 - 3.7%
Silicon	2.3%	2.3%
Manganese	1%	1%
Sulfur	<.12%	<.12%
Phosphorus	0.3% max	0.3% max
Chromium	0.6%	0.6%
Aluminium		1.0%

Further for temperatures up to 850°C, Handbook recommends addition of 1% Aluminium to composition (A). This is expected to reduce oxidation and scaling losses and increase the life to about five times that of unalloyed Cast Iron. With higher Aluminium content, Handbook cautions about defects caused by entrapment of Aluminium Oxide in the castings.

Temperature regimes inside the Air heater:

After a few preliminary trials to measure the temperature inside the air heater, two final trials were conducted, first with good quality firewood, i.e. well-split dry firewood, and the second with well-split not so dry firewood. Firewood, kg per load and frequency of feeding had to be adjusted for best performance. Most important recorded temperatures are summarized in Table 3 and hot air temperature profile is depicted in Figure 4.

Table 3. Comparison of key parameters – Well split, dry firewood vs well Split, Not-so-dry firewood

	Dry/Split FW at 15% moisture	Not so dry/Split FW at 40% moisture
Target Air Temperature, ^{o}C	115	115
Firewood feeding frequency, minutes	15	10
Firewood, kg/hr	187	300
Achieved Average Air Temperature, ^{o}C	115	103
Achieved Maximum Air Temperature, ^{o}C	120	108
Maximum flue Temperature entering cast iron tubes, ^{o}C	805	830
Flue Gas Temperature, ^{o}C	131	133

Comparisons between normal dry Firewood (15% MC) and not so dry Firewood (40% MC) revealed the following.

- With Dry Firewood at 187 kg/hr, target air temperature was achieved (Figure 1) and was maintained with acceptable fluctuations. Whereas with not so dry Firewood even at 300 kg/hr, target was short by 12 ^{o}C, as evident in Table 3.

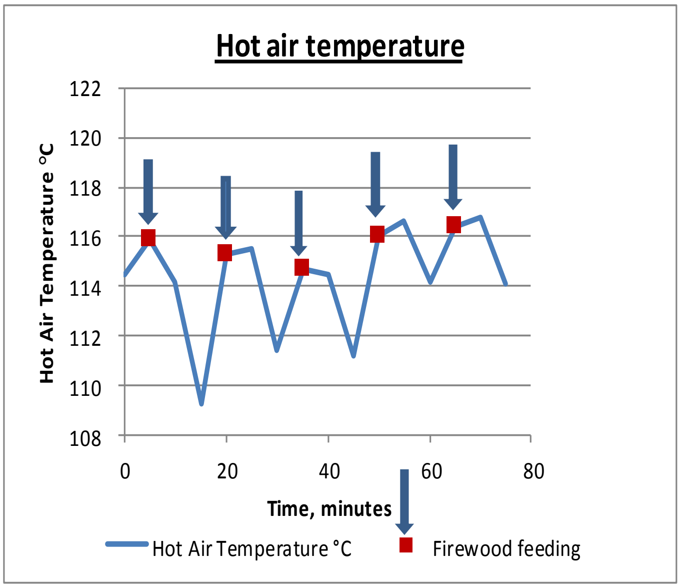

Figure 1 Hot air temperature, °C (Note: target =115 °C)

- While there was hardly any difference between the average temperatures of flue entering Cast Iron tubes, with not so good firewood, fluctuations of temperature was wider. Further, there was a significant increase in the maximum, rising up to 830 ^{o}C. At this higher temperature there is a serious possibility of decay and scaling of unalloyed Cast Iron.
- There was no difference in Flue temperature at the Induced Draft fan.
- In Trial 2, Firewood had to be heaped up to get closer to the target air temperature. Unit is at a serious risk due to possibly of live flame entering the tubes.

Flue gas temperature entering First pass Cast Iron tubes

Air Heater is fed batch-wise, every 10 or 15 minutes by opening the feeding door. During this period, a large volume of air enters the combustion chamber, which brings down the flame temperature. Further, heap of burning firewood is stoked once midway during this period to encourage burning. Temperature of flue gas temperature entering first pass cast iron tubes and important stages of this cyclic process are marked as point numbers in Figure 2.

Point 5 – Doors opened and firewood fed

Point 6 – Temperature drops probably due to large quantity of ambient air entering the combustion chamber and due to heat utilized for removal of moisture from firewood.

Point 7 – Temperature increases after closing the door

Point 8- Temperature fairly constant. Slight drop in temperature may be due to ash coating on burning logs which prevents aggressive burning.

Point 9 – Doors opened and firewood stoked to dislodge ash and to loosen the fire bed

Point 10 - Temperature drops due to large quantity of ambient air entering the combustion chamber

Point 11 – Temperature increases after closing the door. More aggressive fire was visible. Point 12, 13 -Temperature steady

Point 14 – Doors opened and firewood fed

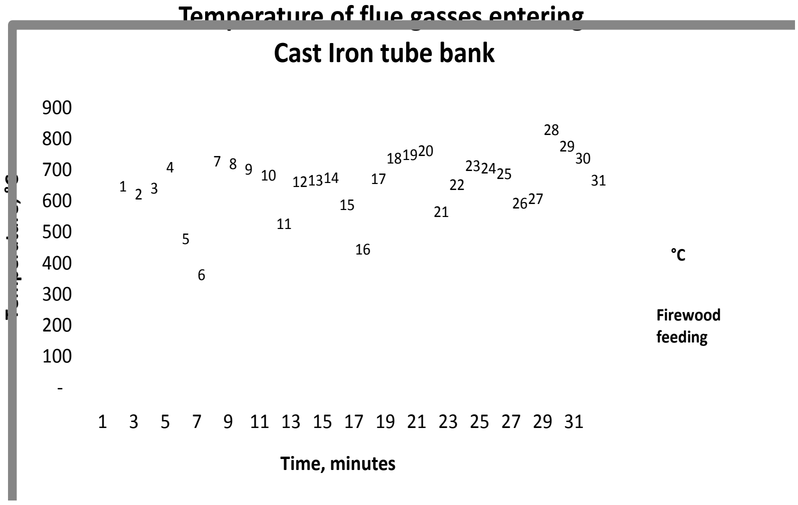

Figure 2 Temperature of Flue gasses entering Cast Iron tube banks

4. CONCLUSIONS

Main failure is at the hot end of the first cast iron tube bank. This is due to flue gas entering at high temperature. In worst case is entering of flame. Other failures experienced are crack and corrosion in tube banks. Frequency of failure of tubes could be reduced to a great extent through proper operational practices of furnace. Allowing adequate time for attending to routine maintenance is equally important to minimize failures. Measured flue gas temperature at the hot end of the tubes was often between 650 to 700 °C. Chemical composition of collected cast iron samples shows those compositions are not suitable to temperatures higher than 600 °C according to Cast Iron Handbook. For working temperatures up to 700 °C, Composition (A), where there is 0.6% Chromium is recommended. For working temperatures up to 850 °C, Composition (B), where in addition to 0.6%

Chromium, 1% Aluminium is recommended. The Handbook states that Aluminium content is very critical as it has other adverse effects.

Generating sizeable volume of demand with suggested composition of Cast Iron tubes to cope up with much higher temperatures up to about 850 °C needs industry-wide commitment.

ACKNOWLEDGEMENTS

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GENERAL DISCUSSION

In view of making use of the deliberations of the 229th E&E Forum under the theme "*Improvements for Tea Processing to Meet Present Day Requirements*", Dr I S B Abeysinghe, Director of the Institute opened up the technical discussion seeking clarifications and useful comments from the audience.

Dr. S. S. B. D. G. Jayawardena, Chairman, Tea Research Board quoted cost of production, energy security, post harvest losses and quality sustenance as important sensitive areas in tea manufacturing in Sri Lanka and resultantly the challenges ahead in meeting the global requirements. He supported with TRI's R&D approach in fulfilling practical industry needs locally, ensuring national targets given by the government and challenges in global tea exports. He urged the audience to adhere to TRI's recommendations on GMPs and assist the government targets especially to meet the Rs. five billion target in the year 2020 through increased productivity, improved quality, value addition and exports of quality Sri Lankan teas.

Questions on Modifications towards Fluid Bed Drying to Suit the Present Day Orthodox-rotorvane Tea Processing:

Q: (Mr S. Sheriff)

What is the recommended floor area for fermenting dhools for leafy manufacture with available floor area of 525 sq ft. for a factory capacity of 22000 kg?

A: (Mr Raveendran)

Area for fermenting dhools depends on the spreading rate.

Q: (Mrs. Nimal Shanthi)

Is the sample size adequate enough to get statistically valid results in your studies?

A: (Mr Raveendran)

Yes, the studies have covered comparisons of individual type machines and the results have been proved through taster's reports.

Q: (Mr. Lalith Munasinghe)

What are the ways to adjust manufacturing according to consumer requirements?

A: (Director)

Changing manufacturing to leafy grades to Kenyan grades for instance.

Questions on Causes for Failures of Cast Iron Tubes in Air Heaters:

Q: (Mr. Sarath Sirisena)

Substantial amount of cast iron being imported and used and what steps need to be done?

Comment: (L Peris)

As in the past, imports should be restricted to countries like UK with quality assured materials.

A: (Director)

A procedure to evaluate specifications with a certificate is proposed.