CHAPTER 4

RESULTS & DISCUSSION

4.1 Energy input from the saw dust burner used.

To calculate the energy input from the saw dust burner, following data were collected and tabulated in following Tables (tables 7-9).

Table 7: Temperature of water container with heating period

Heating period (min)	Temperature of water (^{0}C)
0.0	27
30.0	90
60.0	95
96.0	90

Table 8: Weight readings of the water container

Weight of the empty container(kg)	0.2
Weight with water (kg)	5.4
Weight after 96 minute period (kg)	1.4

Table 9: Weight of saw dust and dried rubber sheets of SS Dryer

Weight of the saw dust used (kg)	40
Total wet weight of sheets (kg)	75
Total dry weight of sheets (kg)	47.35

Following data were collected to investigate the fire wood consumption of the conventional smoke house.

Table 10: Weight of wood and dried rubber sheets of Conventional Smoke House

Day	**Weight of wood utilized (kg)**	**Weight of rubber sheets (kg)**
1	50	No output
2	48	79
3	54	73
4	63	130
5	47	86
6	50	136
7	56	48
Total	368	552

Following data table were tabulated to calculate the saw dust consumption of the SS dryer.

Table 11: Weight of saw dust burner

Weight of the empty barrel (kg)	4.5
Weight of the burner (kg)	20.5
Weight after 96 minutes (kg)	13.1

Moisture percentages of relevant materials were also measured by using the moisture balance .

Table 12: Average Moisture percentage of different materials used in the study

RSS dried in SS dryer	1.63
RSS dried in a conventional dryer	2.83
Saw dust used for the study	35.23
Fire wood	45.51

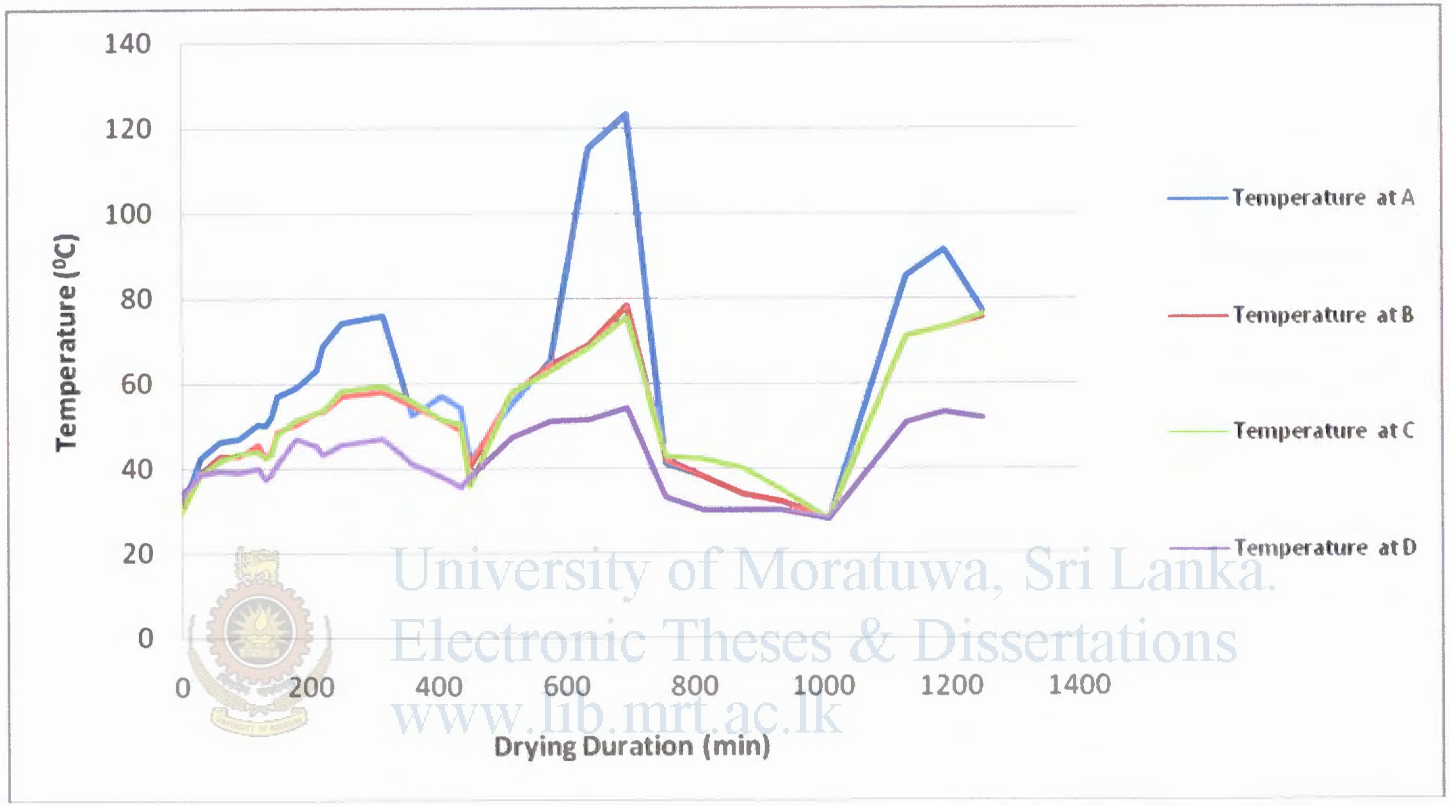

Figure 14: Temperature variation at different locations in the SS dryer vs drying duration

4.2. Temperature Profile inside the SS dryer.

It can be seen in the Figure 14 that temperature inside the dryer (B & C profiles) varies between 40 ^{0}C to 65 ^{0}C, which lies between the recommend drying temperature for sheet rubber. Further, it is evident from the temperature profiles that temperature inside the dryer remains almost same irrespective of the height of the location in question from the burner. However, instant temperature rises and drops that can also be seen in the dryer may be probably due to slow or high air flow influenced by improper adjustment of top and bottom ventilators or the changing environmental factors (ambient wind velocity). The temperature at just over the burner (point A) maintained the highest temperature throughout the entire drying period. The peak temperature at 10.6 hour (695 min) perhaps may be due to a human error in taking the reading such as measuring the surface temperature of the cover plate of the barrel of saw dust burner. In contrast, temperature at the exit of the chimney (point D) shows the lowest temperature during the entire drying period. This may be due to the dilution effect of flu gas with ambient air. The lowest temperature recorded for all points at 6.00 am morning reflects an operational problem in this type of drying operation as the feeding of firewood during the night is not effectively supervised and carried out.

The temperature profile of the fully loaded dryer was maintained at a temperature range of 55 ^{0}C - 65 ^{0}C. It can be seen that the temperature has risen above 55 ^{0}C within two hours after the commencement of heating and it was maintained in that the range afterwards. The graph also indicates the inability of maintaining the temperature inside the dryer at a constant value even though, it maintains within the set range. It should be noted that this is a low temperature drying process and use of sophisticated methods to adjust the temperature was deliberately avoided in order to simulate the field level operational practices. The temperature range was maintained in the dryer by adjusting the top and bottom ventilators manually. It can be inferred that the dryer was capable of maintaining at least 30 ^{0}C degrees above the ambient temperature throughout the drying period except at the commencement and finishing ends of the heat source.

4.3. Surface Temperature variations with the time.

Figure 15 presents the temperature variation of the surface of the dryer with the drying period. It shows the similar temperature pattern with the temperature inside the drying tower. It is an expected pattern as the surface temperature of the dryer is determined by the temperature gradient across the insulated double layer wall. It should also be noted that average temperature difference between the surface temperature and the ambient temperature is remains approximately at six degrees and therefore, it can be inferred that heat loss due to the radiation could be neglected. In other hand, this low surface temperature compared with inside temperature shows the effectiveness of the insulation used in this dryer.

Figure 16 shows the variation of air flow rate of exit duct during the drying cycle of the sheets in question. It is evident from the figure that the variation of rate of air flow is not uniform or no well defined pattern. Therefore, it can be inferred that the dryer has failed to establish a uniform air flow rate during the drying operation. In fact, there is no inlet air flow control mechanism and is determined by the environmental conditions such as ambient wind speed, its direction and etc. This non-uniform air flow rate through the dryer could be one of the reasons for variations of the temperature seen in side the dyer (Figure 14) during the drying cycle. However, introduction of additional control systems to maintain a uniform air flow is not only increase the cost of the dryer, but it increases the complexity of the operation practices too making it is not suitable for this low temperature drying operation operated by small scale RSS manufactures scattered in the country. On the other hand, this type of system is not essential as the drying and smoking of RSS sheets can be carrier out in a wide temperature range (55 ^{0}C – 65 ^{0}C) with out adverse effects on the quality of rubber(5).

Figure 15: Changing of Surface Temperature with Time

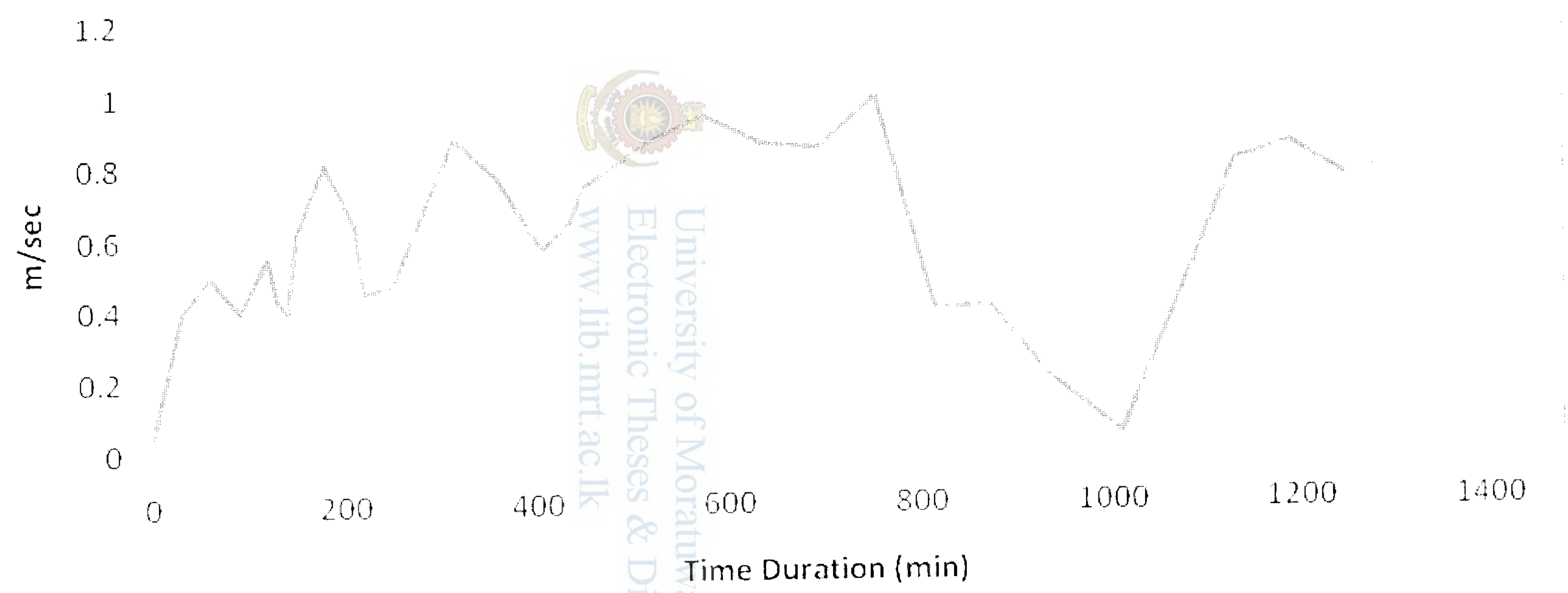

Figure 16: Air Flow rate of exit duct vs Time

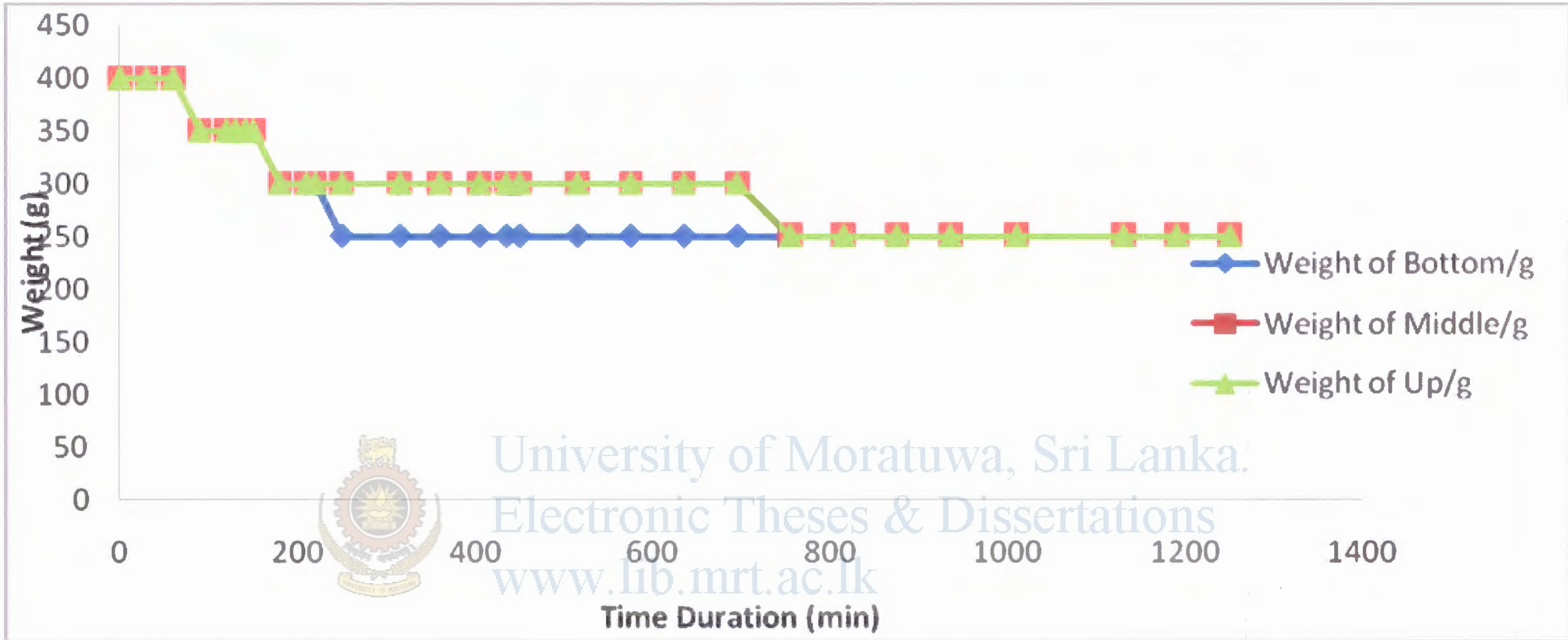

Figure 17: Weight Changing with Time of Samples at three different locations of the smoke house.

4.4. Weight Changing of the sample rubber sheets with the time.

Figure 17 presents the weights of three sample rubber sheets dried in different positions of the dryer. The weights of the samples are gradually decreased with the drying period and finally it reaches a constant value of 250 g. This results-show that the weight reduction is independent from the location of sheets are hanging. Therefore, it can be inferred that drying rate of rubber sheets uniform in the dryer suggesting dryer design is success for this type of application.

Table 13: Raw rubber properties of RSS sheets dried in the SS dryer

Property	SS Dryer	Conventional Smoke House
Volatile matter	0.48	0.38
Dirt	0.46	0.67
Ash	0.24	0.28
Plasticity	42	44
Plasticity Retention Index (PRI)	87	89

4.5. Raw Rubber Properties of resultant rubber sheets.

It can be seen from Table 13, that the raw rubber properties of the RSS sheets that were dried in SS dryer are comparable with the raw rubber properties of the sheets that were dried in a conventional smoke house. Careful examination of these results show those sheets dried in the SS dryer has a lower volatile matter content with compared to the sheets dried in the conventional dryer. This suggests the drying efficiency is higher in the SS dryer with compared the SS dryer. Further, dirt and ash contents of the sheet rubber dried in SS dryer are lower than that of the sheets dried in the conventional smoke house. A gravel layer which was introduced over the perforated metal plate may act as strainer for ash particles leading to have low values for dirt and ash. Easiness of maintenance of smokehouse at a cleaner environment may have also contributed to these lower dirt and ash contents of the sheets dried in SS dryer.

However, minimum plasticity (P_0) and Plasticity Retention Index (PRI) of the sheets dried in SS dryer possess almost similar values to the same properties of the sheets dried in the conventional smoke house. Therefore, it could be concluded that the raw rubber properties of the sheets smoked in the SS dryer have no adverse effect on their raw rubber properties in comparison of the sheets dried in a conventional smoke house. In other words, sheets dried in the SS dryer meet the guaranteed quality requirements of sheet rubber.

4.6. Social Aspects.

4.6.1. Operational Practices

In this new system, trolleys are loaded and unloaded in an open area outside the enclosure. It is a much easier and efficient operation compared to the current practice of the conventional smoke house. One of the major advantages of this new system is that operation is very cleaner and easy and hence labour attractive.

4.6.2. Labour Requirement.

In the SS dryer, sheets are hung on trolleys which could be moved out of the drying cabinet. This practice is much easier and faster and therefore, labour output would be increased. Trolleys are moved out only once during the drying period to turn over sheets. During this period, the dryer is kept closed and heat is retained on the gravel layer which act as a heat storage unit.

4.6.3. Community Health.

In the new drying system, one does not need to enter inside the smoke chamber with the introduction of trolleys. In addition, efficient energy utilization and efficient burning have reduced the emission of the environmentally harmful gases such as CO/ CO_2.