



EFFICIENCY STUDY OF A SINGLE DAY SMOKE DRYER

This thesis was submitted to the Department of Chemical & Process Engineering at University of Moratuwa, Sri Lanka in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN POLYMER TECHNOLOGY

Rathnayake. W. G. I. U.

66 "10"

678 (043)
TH

DEPARTMENT OF CHEMICAL & PROCESS ENGINEERING,
UNIVERSITY OF MORATUWA,
SRI LANKA.

2010

96433



96433



DECLARATION

I do hereby declare that the work reported in this project report was exclusively carried out by me under the supervision of Dr. Susantha Siriwardena and Dr. Shantha Walpalage. It described the results of my own independent research except where due reference has been made in the text. No part of this project report has been submitted earlier or concurrently for the same or other degree.

Date: 13/09/2010

.....

Signature of the candidate

(Rathnayake. W. G. I. U.)

To the best of our knowledge above particulars are correct.

UOM Verified Signature

ROUBER
TELAWALA ROAD, RATMALANA

.....

Supervisor

Co-Supervisor

Dr. Susantha Siriwardena,

Dr. Shantha Walpalage,

Head,

Senior Lecture,

Raw Rubber Process Development & Chemical
Engineering Department, Rubber Research
Institute,

Department of Chemical & Process Engineering,

University of Moratuwa,

Sri Lanka.

Sri Lanka

This report is dedicated to

MY PARENTS

ALL MY TEACHERS

MY BELOVED WIFE

&

MY LITTLE DAUGHTER VINETHMEE

ACKNOWLEDGEMENTS

I wish to express my deep sense of gratitude to my supervisors Dr. Shantha Walpalage (Senior Lecture, Department of Chemical & Process Engineering, University of Moratuwa) and Dr. Susantha Siriwardena (Head, Raw Rubber Process Development & Chemical Engineering Department, Rubber Research Institute) who have always been approachable, helpful and extremely patient in their guidance throughout my research project.

I consider it as a pleasant occasion to acknowledge Dr. A. G. T. Sugathapala who has given kind and patient guidance, encouragement and valuable assistance throughout the research project.

My special thanks go to Head of the Department, Chemical & Process Engineering, University of Moratuwa, Director, Rubber Research Institute, Sri Lanka and Head of the Department, Mechanical Engineering, University of Moratuwa, for giving me unrestricted instrumental facilities during the execution of research project. Sincere thanks are also due to other staff members of the University of Moratuwa and Mr. Sarath Siriwardena, Mr. A. K. D. Warnajith, at Rubber Research Institute who helped me in many ways.

Also my sincere thanks go to Mrs. Maddumage and her kind employers at the "*Sixteen Acre Estate*" at Padukka who gave me a great support during this research project.

I take this opportunity to express my sincere thanks to all personalities who could not mention here name by name for helping me in various ways.

I would like to thank my beloved wife Niwanthi who has always behind me patiently during the period of execution of the research project.

Indrajith Rathmayake

CONTENTS

	Pages
ABSTRACT.	1
<u>CHAPTER 1</u>	
INTRODUCTION	2-9
1.1. Outline of the Ribbed Smoke Sheets (RSS) manufacturing process.	4
1.1.1 Latex Bulking.	5
1.1.2 Coagulation.	6
1.1.3 Milling.	6
1.1.4 Smoking in Smoke House.	7
1.1.4.1 Introduction of conventional smoke house.	8
1.1.4.2 Major defects in smoked sheets.	9
<u>CHAPTER 2</u>	
LITERATURE REVIEW	10-22
2.1. Drying Operation.	10
2.2. The Drying Curve.	10
2.2.1. The First Phase of Drying Curve.	11
2.2.2. The Second Phase of drying Curve.	11
2.2.3. The Third Phase of drying Curve.	12
2.3. Heat transferring modes of Smoke House.	12
2.3.1. Conduction.	12
2.3.2. Convection.	13
2.3.3. Radiation	14
2.4. Introduction of Smoke House used in RSS Drying.	17
2.4.1. Furnace inside the Chamber.	19
2.4.2. Furnace outside the Chamber.	19

CHAPTER 3

EXPERIMENTAL (Materials and Methods)	23-29
3.1 Single day Smoke dryer (SS dryer).	23
3.2 Conventional smoke house.	24
3.3 Manufacturing process of rubber sheets.	24
3.4 Drying process	25
3.5 Estimation of energy input from the saw dust burner used.	27
3.6 Determination of the efficiency of the dryer.	28
3.7 Determination of moisture content in rubber sheets.	28
3.8 Evaluation of the Quality of the ribbed smoked sheets.	29

CHAPTER 4

RESULTS & DISCUSSION	30-39
4.1 Energy input from the saw dust burner used.	30
4.2. Temperature Profile inside the SS dryer.	33
4.3. Surface Temperature variations with the time.	34
4.4. Weight Changing of the sample rubber sheets with the time.	38
4.5. Raw Rubber Properties of resultant rubber sheets.	38
4.6. Social Aspects.	39
4.6.1. Operational Practices	39
4.6.2. Labour Requirement	39
4.6.3. Community Health	39

CHAPTER 5.

CALCULATIONS	40-50
5.1 Energy input from the saw dust burner used.	40
5.2 Total energy requirement to dry sheet rubber in SS dryer.	41
5.3 Drying efficiency Of SS dryer.	42

5.4 Dry rubber wood consumption for drying of sheet rubber in the Conventional Smoke House.	43
5.5 Dry rubber wood consumption for drying of sheet rubber in the SS dryer.	44
5.6 Comparison of firewood cost for drying of rubber.	44

CHAPTER 6

CONCLUSIONS AND FUTURE WORKS 51

6.1. Conclusions. 51

6.2. Future Works. 51

CHAPTER 7

REFERANCES 52-54



List of Tables

Tables No:	Name of the Table	Page Number
Table 1:	Production of raw rubber by different types between year 2000 and 2007	3
Table 2:	Time taken for several steps of RSS production	8
Table 3:	A brief comparison of the cost involved in different size conventional smoke houses	17
Table 4:	Specifications of the SS dryer	23
Table 5:	Details of the conventional smoke house	24
Table 6:	ISO numbers and description of raw rubber properties	29
Table 7:	Temperature of water container with heating period	30
Table 8:	Weight readings of the water container	30
Table 9:	Weight of saw dust and dried rubber sheets of SS Dryer	30
Table 10:	Weight of wood and dried rubber sheets of Conventional Smoke House	31
Table 11:	Weight of saw dust burner	31
Table 12:	Average Moisture percentage of different materials used in the study	31
Table 13:	Raw rubber properties of RSS sheets dried in the SS dryer	38
Table 14:	Data to be used to calculate the energy input rate from the saw dust burner	40
Table 15:	Data to be used to calculate the Total energy requirement to dry sheet rubber in SS dryer.	42
Calculation Table 1:		
	Calculation of $m_r c_r \theta$ (for Dry rubber content), $m_w c_w \theta$ (for water content), λm_{vp} (Energy needed for evaporation of Water) and Total energy	46
	Calculation Table2: Total Moisture Content of RSS in the Dryer	48

List of Figures

Figure No:	Name of the Figure	page number
Fig 1:	Process flow chart of RSS manufacturing	4
Fig 2:	Coagulation in pans	5
Fig 3:	Tank used for the coagulation	6
Fig 4:	Sheets are kept under sunlight for dripping of water	7
Fig 5:	Conventional type Smoke House	7
Fig 6:	Typical drying curve of a product	11
Fig 7:	Heat transferring through a plan wall	13
Fig 8:	Graphical representation of Heat transferring mode of the SS dryer	16
Fig 9:	Full view of the SS dryer	25
Fig 10:	Rack system of the SS dryer	25
Fig 11:	External view of the drying chamber	26
Fig 12:	Trolley system for hanging sheets of the dryer	27
Fig 13:	Moisture Balance	28
Fig 14:	Temperature variation at different locations in the SS dryer	32
Fig 15:	Changing of Surface Temperature with Time	35
Fig 16:	Air Flow rate of exit duct vs Time	36
Fig 17:	Weight Changing with Time of Samples at three different locations of the smoke house.	37
Fig 18:	Energy consumption and total energy vs time	47
Fig 19:	Drying Curve (Changing of Moisture Content with Time)	59

ABSTRACT

The energy utilization and the time required to dry RSS using conventional type smoke house are significantly high. Also the conventional type smoking-room used for producing RSS gives large differences of temperature and velocity; these result in non-uniform drying of the rubber sheets. In a conventional smokehouse, the energy losses due to loading and unloading of the sheets as well as time required for complete dryness is very much high.

A Compact, well insulated drying unit with multipurpose gravel layer was designed and fabricated new operational practices for efficient energy utilization of Ribbed Smoke Sheet (RSS) Drying were also introduced. The overall drying performance was evaluated in term of drying efficiency and firewood consumption. Quality of the end product was also evaluated. A comparison also made against the performance of conventional smoke house. Social issues also compared with conventional system. The new system reduces the drying period from 5 days to one day, while space requirement also reduce by the same percentage when comparing with the conventional smoke house.

No Significant difference of the quality of sheets dried using SS drying system against sheets dried in conventional smoke house was observed. However, dirt content in the sheets dried in the new system is lower than that dried in a conventional system. The Single day Smoke dryer (SS dryer) has the efficiency of 51.7%, it is a very good value compared with a conventional smoke dryer which has the efficiency of 31%. The most interested feature of the SS dryer is the low space utilization compared with the conventional type smoke house and also the time requirement for fabrication of the SS dryer is very short. In addition to the above advantages, the dryer can be operated by one person and the health issues are very limited to compare with the conventional smoke house.

