

**BUSITEMA  
UNIVERSITY**  
*Pursuing Excellence*

**FACULTY OF ENGINEERING  
DEPARTMENT OF CHEMICAL & PROCESS ENGINEERING  
FINAL PROJECT REPORT**

**DESIGN & CONSTRUCTION OF A HYBRID RICE DRYER WITH A HEAT  
RECOVERY SYSTEM**

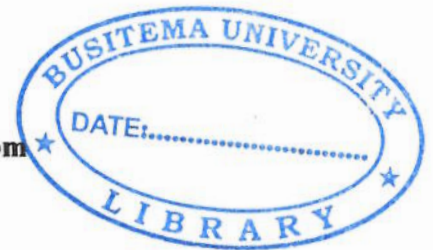
By

**MAGABO DERICK**

**Reg. No.: BU/UP/2015/170**

**Email: magaboderick1212@gamil.com**

**Tel: 0772877015**



**Supervisors:**

**Main supervisor: KABASA MARY SALLI**


**Date of submission: MAY 2019**

***A Final Year Project Report Submitted to The Department of Chemical and Process  
Engineering in Partial Fulfilment of The Requirements for The Award of The BSc. In Agro-  
Processing Engineering of Busitema University.***

**May, 2019**

Declaration

I **MAGABO DERICK** declare that the work presented here is out of my own research except where due references are made. It has not been partially or wholly submitted for any academic award to any institution of higher learning any award whatsoever.

SIGN.  .....



Approval

This is to certify that this research proposal has been carried out under my supervision and that it is ready for submission to the department.

**SUPERVISOR NAME: MRS. KABASA MARY SALLY**

**SIGN.....**

## ABSTRACT

Rice (*Oryzae sativa*) is one of the most important foods in Uganda supplying as much as half of the daily nutritional requirements and calories to the Ugandan population. (MAFSC, 2009). About 80% of rice farmers in Uganda are small scale farmers with acreage of less than 2 hectares who use *poor drying* methods such as open sun drying involving spreading of the crop on ground, tarpaulin, woven mat and road sides and also, to a small extent, it's done by artificial forced air dryers, these methods are associated with proneness to weather conditions, long drying time and high energy losses due to dryers' inefficient use of energy as almost all the energy input in the dryer is wasted in the atmosphere. This creates a need to design and construct a hybrid rice drier (fired by both solar and biomass) with a heat recovery system which can recover the energy that can be used to preheat the ambient air, and the heating system can then heat the preheated air to a final temperature.

A solar-biomass energy system in this study was developed and achieved through data collection which involved literature surveys and reviews and internet surfing, designing the system components, constructing the prototype which was tested and the results analyzed.

In this project, the solar concentrator gave temperatures of 35<sup>0</sup>C, 40<sup>0</sup>C and the maximum was 45<sup>0</sup>C at noon while the biomass chamber gave temperature increment of 45<sup>0</sup>C and 47<sup>0</sup>C.

The heat recovery system recovered 50% of the temperatures required for drying (35<sup>0</sup>C)

Therefore, the dryer was 67.9% efficient and the heat recovery system was 55% efficient

## Contents

Declaration.....	i
Approval .....	ii
ACKNOWLEDGEMENT .....	iii
ABSTRACT.....	iv
1 CHAPTER ONE.....	1
1.1 INTRODUCTION.....	1
1.2 Background.....	1
1.3 Significance of the study.....	2
1.4 Objectives of the study.....	2
1.4.1 Main objective.....	2
1.4.2 Specific objectives.....	2
1.5 Scope of the project.....	3
1.6 Justification of the study.....	3
2 CHAPTER TWO.....	4
2.1 LITERATURE REVIEW.....	4
2.2 paddy production in Uganda.....	4
2.3 Post-harvest operations in paddy value addition chain.....	4
2.3.1 Drying.....	4
2.3.2 Drying paddy/ rough rice.....	5
2.3.3 Paddy drying systems.....	9
2.3.4 Solar drying.....	14
2.4 Project Economic evaluation techniques.....	19
2.4.1 Payback period.....	19
2.4.2 Return on investment.....	19
2.4.3 Net present value (NPV).....	20
2.4.4 Life cycle costing.....	20
3 CHAPTER THREE.....	21
3.1 METHODOLOGY.....	21
3.2 Design Considerations.....	21
3.3 Construction and mode of operation of the machine.....	22
3.3.1 Construction.....	22

3.3.2	<b>Conceptual drawing for the proposed hybrid paddy dryer.....</b>	22
3.3.3	<b>Mode of operation .....</b>	22
3.4	<b>Design of the proposed dryer components.....</b>	23
3.4.1	<b>Design of the drying chamber .....</b>	23
3.4.2	<b>Determining the amount of water to be removed from the paddy.....</b>	23
3.4.3	Final relative humidity or equilibrium relative humidity, ERH [%] .....	24
3.4.4	<b>The quantity of heat required to effect the drying.....</b>	24
3.4.5	<b>Design of the air vent .....</b>	26
3.4.6	<b>Design and sizing of blower fan to convey the drying air. ....</b>	27
3.4.7	<b>Design of a blower .....</b>	27
3.4.8	<b>sizing and selection of the fan .....</b>	28
3.4.9	<b>The quantity of heat required to evaporate the desired water:.....</b>	28
3.4.10	<b>Design of the required solar collector Area to provide the required heat.....</b>	28
3.5	<b>Design of the biomass chamber. ....</b>	29
3.5.1	<b>Heat loss QI through the double walls of the combustion chamber:.....</b>	30
3.6	<b>Determination of system energy.....</b>	30
3.7	<b>Design of the heat recovery system.....</b>	31
3.7.1	<b>Determination of the heat energy recovered by the system.....</b>	31
3.8	<b>FABRICATION AND ASSEMBLING THE COMPONENTS OF THE DRYER.31</b>	
3.8.1	<b>Selection of Materials. ....</b>	31
3.8.2	<b>Construction of the prototype.....</b>	31
3.9	<b>PERFORMANCE EVALUATION OF THE DRYER.....</b>	33
	Dryer or drying process efficiency therefore is given as;.....	34
3.10	<b>ECONOMIC EVALUATION OF THE MACHINE.....</b>	35
4	<b>CHAPTER FOUR .....</b>	36
4.1	<b>Results .....</b>	36
Design results .....	36	
Construction result.....	38	
4.1	<b>Discussions .....</b>	41
4.2	<b>Economic viability of the system.....</b>	42
5	<b>CONCLUSION AND RECOMMENDATIONS .....</b>	44
5.1	<b>Conclusions:.....</b>	44

<b>5.2 Recommendations:</b> .....	44
References.....	45
APPENDIX.....	46
Appendix 1.....	46
Appendix 2.....	46

**List of figures**

Figure 1: Theoretical drying curves (grain temperature red and moisture content blue) with different drying period Source: (IRRI, 2013). ..... 8

Figure 2: Deep layer drying ..... 11

Figure 3: Section showing the principle of a vertical shallow-layer batch dryer. .... 12

Figure 4: The principles of a continuous-flow dryer ..... 13

Figure 5: Forced convection direct solar dryer mechanism ..... 15

Figure 6: indirect solar drier ..... 16

Figure 7: draft view of the fabricated dryer. .... 17

Figure 8: the designed crop drier. .... 18



**List of tables**

Table 1 shows Equilibrium Moisture Contents (EMC) of paddy at different storage temperatures and RH ..... 6

Table 2 : Overview on different drying methods and technologies..... 13

Table 3 Design Specification and Assumption..... 21

## 1 CHAPTER ONE.

### 1.1 INTRODUCTION

This chapter describes the background information of the project, the problem statement, significance, purpose, objectives and scope of the study. The problem statement describes the research problem and identifies potential causes and a solution. The significance describes the importance of the project. The specific objectives presented will achieve the main objective.

### 1.2 Background

Rice (*Oryza sativa*) is one of the most important foods in Uganda supplying as much as half of the daily nutritional requirements and calories to the Ugandan population. (MAFSC, 2009)

According to (MAAIF, 2010), rice is a major source starch, proteins, vitamins and essential minerals in the human health. Uganda's production area is presently 140,000 ha and total annual rice production stands at 140,000 MT of milled rice representing about 70% of the national rice demand estimated to be 200,000 MT (MAFSC, 2009). The eastern region of the country is the leading producer in the country in districts of Kamuli, Butaleja, Iganga, Bugiri, Jinja and Palisa with Palisa and Iganga leading. Iganga producing 31,492 Mt on a total area of 3,676 Ha and Palisa producing 22,865Mt on an average area of 6,247Ha

Fedesele, (2012), rice post-harvest handling and value addition chain involves different unit operations like threshing, *drying*, milling and packaging. According to the International Rice Research Institute, drying is the process that reduces grain moisture content to level where it is safe for storage. Drying is the most critical operation after harvesting a rice crop. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses. (IRRI, 2013)

About 80% of rice farmers in Uganda are small scale farmers with acreage of less than 2 hectares who use *poor drying* methods such as open sun drying involving spreading of the crop on ground, tarpaulin, woven mat and road sides and also, to a small extent, it's done by artificial forced air dryers, these methods are associated with proneness to weather conditions, long drying time and high energy losses due to dryers' inefficient use of energy because almost all of the energy input in the dryer is wasted in the atmosphere. This creates a need to design and construct a hybrid rice drier (fired by both solar and biomass) with a heat recovery system which can recover the energy

## References

- Anon., 2016. Chapter 16 – Grain crop drying, handling and storage. In: *Rural structures in the tropics: design and development*. s.l.:s.n., pp. 363-385.
- FAO, 2000. Rice post-harvest operations. *post-harvest compedium* .
- IRRI, 2013. Paddy Drying. *Postharvest Unit, CESD, Volume 2*.
- JOHN, F. T., 2012. *POST-HARVEST HANDLING OF RICE PADDY AND ITS EFFECTS ON PADDY QUALITY*, s.l.: s.n.
- Lamul Wiset, G. S. R. H. D. C. N. P. S., 2014. *Effects of High Temperature Drying on Rice Quality*, s.l.: s.n.
- MAAIF, 2010. Agriculture Sector.
- MAFSC, 2009. *National Rice Development Strategy, Ministry Of Agriculture Food Security.*, s.l.: [http://www.riceforafrica.org/downloads/NRDS/tanzania\\_en.pdf](http://www.riceforafrica.org/downloads/NRDS/tanzania_en.pdf).
- Mukobozi, R., 2017. s.l.: s.n.
- NABIRYE, J. N. P. O.-L. M. W. K. S. W. H. O. V., 2003. Farmer-participatory evaluation of cowpea integrated pest management (IPM) technologies in Eastern Uganda. *Crop Protection.*, pp. 22, 31-38..
- Patil., R. T., 2016. post-harvest technology of rice. *post harvest engineering and technology*.
- Tibagonzeka, J. A. G. K. F. A. A. W. J. B. J. a. M. a. M., 2018. Post-Harvest Handling Practices and Losses for Legumes and Starchy Staples in Uganda. *Agricultural Sciences*, 9, 141-156. , Volume 9, pp. 148-152.
- von Grebmer, K. T. M. O. T. F. H. W. D. Y.-h. Y. S. L. a. v. O. C., 2011. Global Hunger Index.. *The Challenge of Hunger: Taming Price Spikes and Excessive Food Price Volatility. Deutsche Welthungerhilfe, International Food Policy Research Institute, and Concern Worldwide, Bonn, Washington, DC, and Dublin.*
- Wilfred, O. R., 2006. *FINAL SURVEY REPORT ON THE STATUS OF RICE PRODUCTION, PROCESSING AND MARKETING IN UGANDA* , s.l.: s.n.