DOMESTIC TYPE BIOMASS FUELED PADDY DRYER

R. Arunsinth*, R.J. Wimalasiri, N.S. Senanayake

Department of Mechanical Engineering, The Open University of Sri Lanka

INTRODUCTION

Rice is one of the most important and extensively cultivated food crops in the world. Rice is cultivated in more than a hundred countries, with a total harvesting area of approximately 158 million hectares, producing more than 700 million tons, annually 470 million tons of milled rice [1]. The world's largest rice producers are China, India, Indonesia, Bangladesh, Vietnam, Myanmar, and Thailand [2]. It is the staple food of more than 60 percent of the world's population. Rice is the staple food of the inhabitants of Sri Lanka. The total extent of paddy in Sri Lanka is estimated to be about 708,000 hectares at present [3]. Harvesting, threshing, cleaning, drying, and storing, play a significant role in realizing the full benefit of the raised crop by reducing post-harvest losses as well as improving the quality of the harvested paddy. Improper harvesting, threshing, cleaning, drying, and storing, may cause losses to the paddy output. Various harvesting systems can be observed in different locations in Sri Lanka. A wide variety of tools may be used such as knives, sickles, animals, stationary threshing machines, tractor-mounted harvesters, and self-propelled combined harvesters.

The most common systems for paddy harvesting are traditional tools for harvesting (e.g., sickles, knives) and threshing (e.g., threshing racks, simple treadle threshers, and animals for trampling). A pedal thresher is a simple tool to improve manual threshing. Manual reaping and the mechanical threshing process, mainly, consist of a portable thresher which is usually the first step in mechanical threshing. The usage of small stationary machine threshers commonly replaces manual threshing given its high labour requirements. Stationary threshing is generally done in the field, or near the field.

Reaping, which is then followed by machine threshing, cutting, and laying the crop on a windrow is done. Reaping is done using a reaper, threshing by a thresher, and cleaning either manually or by a machine. The combined harvester combines all operations, cutting the crop, feeding it into the threshing mechanism, threshing, cleaning, and discharging grain into a bulk wagon or directly into bags. Straw is usually discharged behind the combined harvester in a windrow.

After the harvest, the paddy would contain high and unequal initial moisture content, depending on the season and harvest time. At harvest paddy has a moisture content varying between 18% to 24%. This moisture level is not suitable for processing and for storage. Therefore, raw paddy must be dried down to about 13%. [4]. Drying is the most important part of post reduction. It is the process to reduce the moisture from grain to a safe level for storage and handling following harvest. It is a critical step for maintaining grain quality and minimizes storage and processing losses.[5].

In Sri Lanka, paddy is predominantly dried in rural areas using sun drying in open yards or on roadsides. This practice has caused significant losses and resulted in quality degradation of rice due to uneven drying of grains. Also, the present practice requires a lot of time and constant attention of farmers over a long period because of requirement of frequent agitation and protect the grains birds and unexpected rains.

Therefore, the objective of the present study was to design a paddy dryer using biomass as fuel for heat generation required for drying purpose, and the dryer is intended for small scale farmers. In the design water was used as heat transfer medium.

METHODOLOGY

A prototype dryer was designed and built as per the required requirements and tested. The dried paddy was then tested under various conditions and analysed for any reduction in the moisture content, operational procedure, and energy consumption which were then recorded and analysed. Using the conclusions drawn from the performed qualitative analysis, further modifications were made to the already built prototype dryer, making the prototype dryer look different from its initial version. The testing procedure was then repeated. The results before the modification of the dryer and after the modification of the dryer were then compared after which the most appropriate and ideal design was recommended. Procedure followed is given below.

1. Construction of the dryer system.
2. Carrying out the drying operation under various conditions.
3. Analysing the reduction in moisture content.
4. Making appropriate modifications to the drying system.
5. Analysing the result before and after modification.
6. Recommending the most appropriate design.

DESIGN OF THE DRYER

The initial biomass paddy dryer was designed with a water chamber and a feedwater supply. In this system hot water is used as the drying heat source. It was mounted directly on top of the biomass furnace, with the top surface serving as a drying surface and it is designed to feed 30 kg of paddy at a time, and it is equipped with high stack and primary and secondary air inlets.

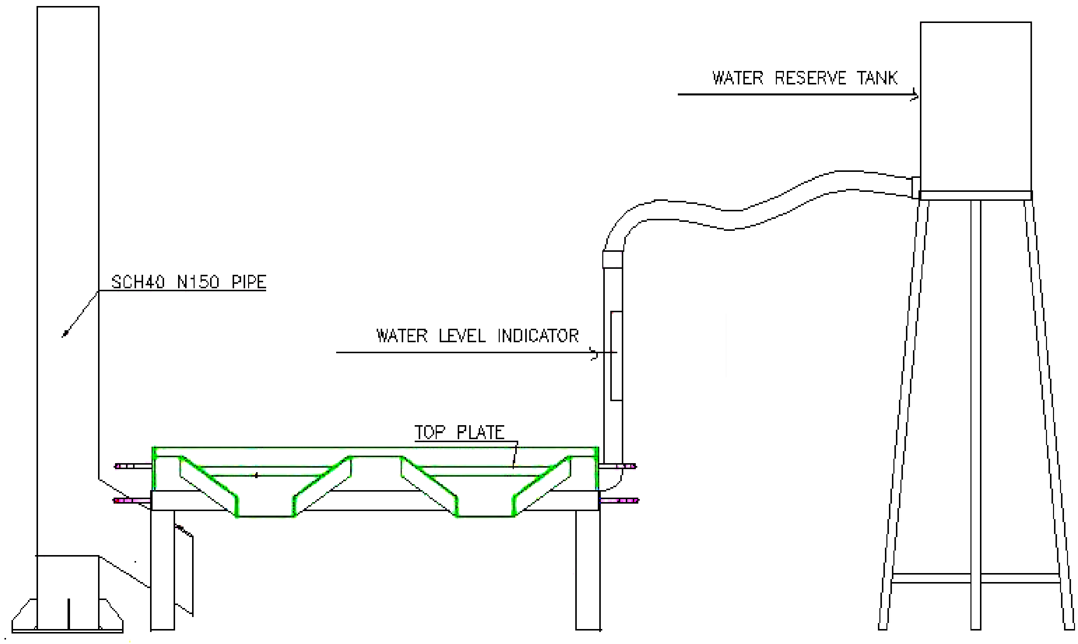

Figure 1 Initial Design of biomass paddy dryer

The design shown in Figure 1 was constructed and tested, and it could not achieve the desired performance during testing due to some construction deviations in the dryer. Following are the observations made during initial testing.

1. The burning process was inefficient as it used a large amount of firewood for one cycle.
2. As a result of inefficient burning, the operation made a lot of smoke.
3. It was discovered that the temperature on the dryer was not evenly distributed and could not be controlled.
4. There was no indication that the dryer surface has reached its ideal temperature.

To improve the dryer, it was decided to incorporate a stirring mechanism, and a turning mechanism and forced convection system to improve drying efficiency. To make the procedure much easier than before, it was decided to redesign a prototype dryer with a separate water heater system to deliver thermal energy to the paddy dryer. For this, an open-loop thermo-siphon water heating system was used.

In the thermo-siphon principle, water is heated in a separate water heater by a biomass stove and then convectively pumped into the paddy dryer, heating the paddy dryer's surface. Following that, cold water was pumped into the water heater to be heated. Water flow is slow in a thermo-siphon system. This system is simple with low-maintenance, and it consumes less energy. This is primarily used in vehicle radiators and solar water heaters, among other applications.

SPECIFICATIONS OF THE DRYER

- Dryer designed capacity: 7 kg
- Paddy layer height: 40 mm
- Inlet moisture content of paddy as harvested ranges from 20% to 25%
- Estimated period of drying per batch: 2-3 h
- Operating temperature: 50-65 ℃

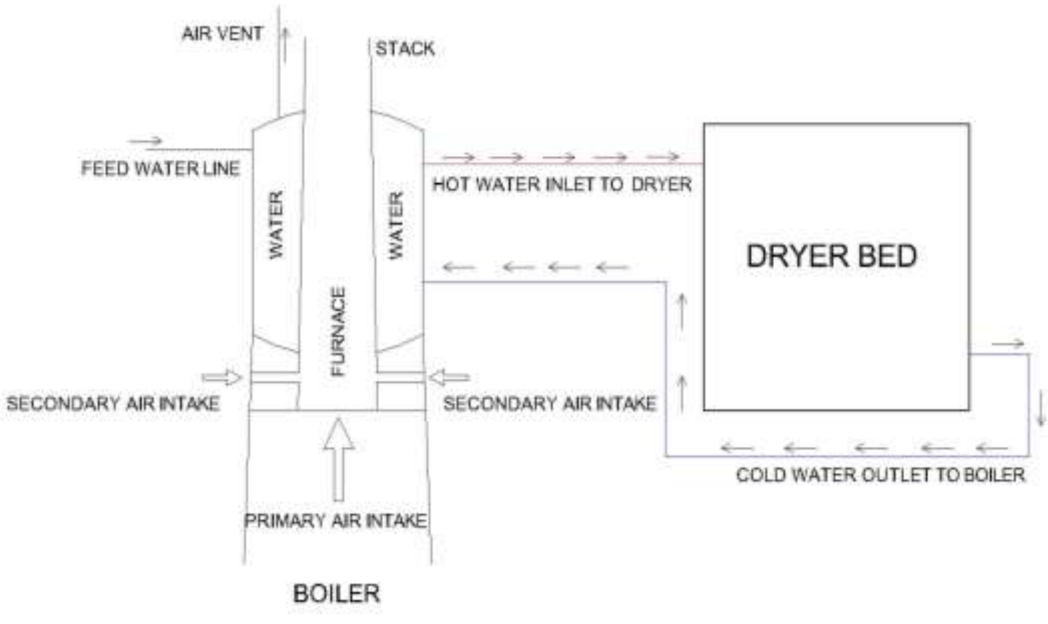

Figure 2 Schematic diagram of the modified drier system

RESULTS AND ANALYSIS

The modified dryer was tested using 7 kg of paddy with 5 replicates. The testing was conducted on the same day. The results are shown in Table 1 below.

Table 1: Results of trials

Batch No.	Batch size (kg)	Initial moisture (%)	Final moisture (%)	Drying time (min)	Firewood consumption (kg)	Avg Dryer Temp/℃	Ambient Temp. (℃)	RH (%)
01	7	24.1	13.8%	140	1.5	54.85	30	59
02	7	23.9	13.7%	140	1.3	55.92	32	58
03	7	23.3	13.4%	140	1.2	54.35	30	57
04	7	23.1	13.1%	140	1.1	55.78	31	57
05	7	22.8	13.4%	140	1.1	56.24	30	56

Figure 3 below shows the variation of moisture content of paddy over the drying period for batch No. 1 and it exhibits steady drop of moisture from 24.1% to 13.8 % in 140 mins.

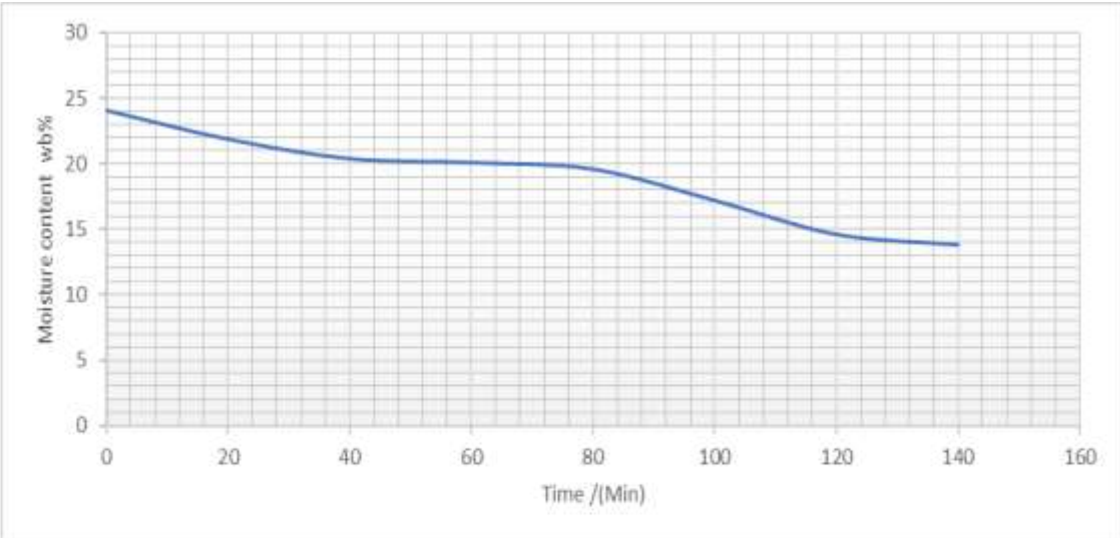

Figure 3 Variation of moisture content of paddy with time

In the previous design, the burning process was inefficient, and one batch of drying required a large quantity of firewood. Because that the updated design burnt firewood more efficiently than the prior design, each batch of drying consumed much less fuelwood. Because of the effective burning, it emitted less smoke. When compared to the old design, the new one used 25% less fuel and took 25% less time because paddy was continuously mixed.

Figure 4 below shows the modified drying system showing different components.

Figure 4 The modified dryer system

CONCLUSIONS

The developed prototype is very viable to be manufactured in large quantities that are both commercially and economically viable while being extremely valuable for small-scale farmers who face difficulties drying their paddy during bad weather. The analysis performed on the operations of the dryer after its modifications proved that the fuel consumption was significantly lower than that of the prior design. Roughly 3 kg of firewood was used during the initial heat-up, at a temperature of up to 58 degrees Celsius.

This prototype has been conceptualized and designed as an economical and commercially viable alternative to the natural process of sun-drying. The paddy thickness was maintained at 40mm and mixed at every 30-minute intervals.

REFERENCES

Seck, P. A., Diagne, A., Mohanty, S., & Wopereis, M. C. S. (2012). Crops that feed the world 7: Rice. Food Security, 4(1), 7–24.

IPI, (2006) Drying systems - IRRI Rice Knowledge Bank. (2017). Rice Knowledge Bank.http://knowledgebank.irri.org/step-by-step-production/postharvest/drying/drying-systems#mechanical-drying-systems%20[Accessed%206%20Sep.%202017].

Fao.org. (2017). Grain storage techniques ... - Drying methods - Mechanical dryers. [online] Available at: http://www.fao.org/docrep/T1838E/T1838E0W.HTM#Mechanical dryers [Accessed 18 Sep. 2020].

Surachai Hemhirun, and Pracha Bunyawanichakul (2020). Effect of the initial moisture content of the paddy drying operation for the small community, Journal of Agricultural Engineering, ISSN: 2239-6268, Vol: 51, Issue: 3, Page: 176-183.

Md. Ashraful Alam, Chayan Kumer Saha, and MM Alam (2019). Mechanical drying of paddy using BAU-STR dryer for reducing drying losses in Bangladesh, Progressive Agriculture, 30:42-50, DOI: 10.3329/pa. v30i0.41556