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Energetic Analysis of Rice Processing Plant: A Case Study of Hisar District in Haryana

Parmod Sharma[1], Yadvika[1], Kanishk Verma[1*], Y. K. Yadav[1] and Ravi[1]

[1]Department of Renewable and Bio-Energy Engineering, CCSHAU, Hisar-125 004, Haryana, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors PS and Y designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KV and YKY managed the analyses of the study. Author R managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to find out electrical and manual energy use pattern in post harvest rice processing operation in modern rice Plant at Hisar district of Haryana. Planting capacity of rice Plant is 200 tons per day and Plant operated 20 hours in one day. The processing operation adopted in modern rice Plant viz, parboiling, drying, polishing & dehusking, sorting & grading and packaging. In processing of rice, modern rice Plant utilized total electrical and manual energy were 64965.5 and 987.84 MJ/day. It was found that the electrical energy consumption of Plant in parboiling 10010.88, drying 16663.80, polishing & dehusking 22936.32, sorting & grading 14445.09 and packaging 1054.18 MJ/day were required. Operation wise manual energy used during the parboiling & drying 235.2, polishing & dehusking 188.16, sorting & grading 94.08 and packaging 470.40 MJ/day.

Keywords: Rice processing plant; energetic analysis; rice plant; energy utilization pattern.

1. INTRODUCTION

Agriculture sector is the main income generating source of rural community in India helping in enhancement of their living standards. Among cereal crops, rice is main food crop of India and the second most important crop in the world. More than fifty percent of the world's population

Corresponding author: E-mail: sharma.parmod2008@gmail.com;

is consuming rice as a food [1-2], which is found in almost every kitchen. According to statistics of Ministry of Agriculture and Farmers Welfare, India produced about 16.85 Plantion tonnes of rice in 2016-17 and contribution of India is nearly 21.89% towards world production. After the green revolution, share of rice production in the country has been consistently increasing [3].

This crop has seen around 40-45% increase in production during the last few decades. Raw rice is covered by two different layers: one inner layer called bran and other is outer layer called husk. Different Planting processes are required to extract white rice or edible rice from kernel of paddy. In the first step, husk is removed from paddy kernel and in second step, bran layer is removed and output is the edible rice, ready to cook [4-5]. The former process is known as hulling and latter is known as Planting of paddy. Rice Planting is the oldest and largest industry of our country in agro-processing. It has a turnover of more than 36,500/- crores per year and processes about 85 Plantion tonnes of paddy annually [6]. More than half of overall rice production is processed by modern Plants in India [6]. India has about 82,000 registered single huller units, 2,600 double hulling units, 5,000 units of disc sheller cum polisher and 10,000 units of rubber roll sheller. Average capacity of these units ranges between 2-10 tonnes per hour. Among different Indian states, Haryana also produces large quantities of rice and has 907 registered shellers. The state processes 25,60,240 MT of rice annually.

In Haryana, rice was grown over an area of 1.2 Mha with a total production of 4.20 Mt with a productivity of 3503 kg/ha during 2018-19 (http://agriharyana.gov.in/). Kurukshetra, Karnal, Kaithal, Hisar, Panipat and Sonipat are the main paddy growing and paddy Planting districts in the state. Rice Planting industry is the largest agro-based industry in India and one of the major energy consuming sectors [7]. Information related to energy auditing in rice Plants is important for developing work plan to acquire better control over processing operations. With energy-exergy analysis of any Plant, possible improvements can be identified and corrective measures could be recommended for improving overall efficiency of the system. Important utilities in any rice Plant are manpower, electricity and water. Mostly feeding of paddy, cleaning, bagging etc. are done manually in rice Plants, so manual energy should be included in the energy auditing analysis. Electrical energy is used to run motors, pumps, blowers, conveyors, fans, lights etc. thus, plays a very important role in energy consumption pattern of any rice Plant [6]. Hence, the present work was performed with an aim to analyse the energy use pattern in a rice Plant. This study was performed as a guideline for Plant owners to understand the electrical and manual energy consumption pattern for each processing unit in their rice Plants. This information can also used for enhanced decision making on energy saving.

2. MATERIALS AND METHODS

The energy utilization pattern of Jain Rice Plant (JRM Foods) at Hisar (Haryana) was studied for carrying out the energy auditing work. The Plant is situated on area of 13 acres having Planting capacity 200 MT/day. It is one of the largest Plants of Haryana which is processing rice for export purpose. It is fully automatic plant with most of the machines being used for Planting being imported from abroad. This rice Plant uses a different machine for each processing operation i.e. cleaning, shelling, separating, bran removal and grading. Conveyors are used to move the paddy from one machine to next. The rice processing plant employing, boiler, dryer, polisher, elevator for conveying material and furnace for production of thermal energy.

The study was designed in such a way that each unit operation was studied closely and the energy input determined experimentally. The electrical energy consumption was measured with an electrical energy meter. The energy meter was connected in the electric circuit of individual machines. For calculation of manual energy, one man hour was taken as 1.96 MJ and one woman hour 1.57 MJ Mittal et. al..

3. RESULT AND DISCUSSION

The unit wise energy consumption during operation of boiler in rice Plant is shown in Table. 1. It is clear from the table that force draft fan(FD fan) represents the largest energy consuming unit followed by induced draft fan (ID fan) among all the units whereas motor of cyclone separator is undoubtedly the smallest. Water separator, cold water pump and hot water pump consumed equal amount of energy i.e. 3.21 %. Pump, conveyor, motor of boiler and RO system contributed 17.66, 4.82, 1.93 and 15.41 % respectively. Table 2 depicts the unit wise electrical energy consumption during the operation of dryer. It is clear from the Table 2 that among the total electrical energy consumption, elevators was found to be the major unit of energy consumption followed by blowers (31.94 %), conveyor(13.31 %) and drum motors in dryer(9.13 %). Total manual energy used during the operation of boiler was 235.2 MJ/day. Table 3 illustrate the unit-wise electrical energy use pattern of polishing and dehusking operation for processing of rice crop. There were ten main machine used which consumed electrical energy during polishing and dehusking operation of rice processing. Polishers machine was the main energy consuming unit which consumed 58.01 % of total energy followed by blower which contributed around 13.81 %. Screw conveyor for husk played a least role in energy consumption. Other operations contributed between 9.12% to 0.83%. Manual energy utilising during operation of polishing and dehusking was 188.16 MJ/day. It can be seen from Table 4, the grinder machine consumed large energy i.e. more than 60 % of the energy used in other machines. Grader consumed 12.72 % and the second largest energy consuming machine. Conveyer, blower, colour sorter and cleaner unit consumed electrical energy were 11.84, 10.97, 1.62 and 1.32 % respectively. While bag sealing machine unit has the smallest role to play in electrical energy consumption. Manual energy utilising during operation of sorting and grading operation was 94.08 MJ/day. The unit wise energy consumption during operation of packaging in rice Plant is shown in table 5. It is clear from the pie chart that light represents the largest energy consuming unit followed by air conditioner among the entire electrical appliance whereas flood light is undoubtedly the smallest. Other operations contributed between 4.11 to 8.20 %. Total manual energy consumption during packing operation was 470.4 MJ/day.

Table 1. Electrical energy consumed during operation of Boiler

Machines	Quantity	Power(hp)	Energy(MJ)/day	Total energy(MJ)/day
FD fan	1	40.0	2534.4	2534.4
ID fan	2	20.0	1267.2	2534.4
Pump	1	20.0	1267.2	1267.2
Pump	1	7.5	475.2	475.2
Conveyor	1	7.5	475.2	475.2
Motor of boiler	2	1.5	95.04	190.1
Motor of cyclone separator	1	1.0	63.36	63.36
Water separator	1	5.0	316.8	316.8
Cold water pump	1	5.0	316.8	316.8
Hot water pump	1	5.0	316.8	316.8
RO system	1	15.0	950.4	950.4
	1	5.0	316.8	316.8
	1	3.0	190.08	190.1
	2	0.5	31.68	63.4
Total				**10010.88 MJ**

Is there any duplicate data? (No)

Table 2. Electrical energy consumed during operation of dryer

Machines	Quantity	Power(hp)	Energy (MJ)/day	Total energy (MJ)/day
Elevators	16	7.5	475.2	7603.2
Blowers	2	15	950.4	1900.8
	2	12	760.3	1520.6
	4	7.5	475.2	1900.8
Drum Motors in dryers	8	3.0	190.18	1520.6
Conveyors	2	10	633.6	1267.2
	1	15	950.4	950.4
Total				**16663.8 MJ**

Put it down there (Done)

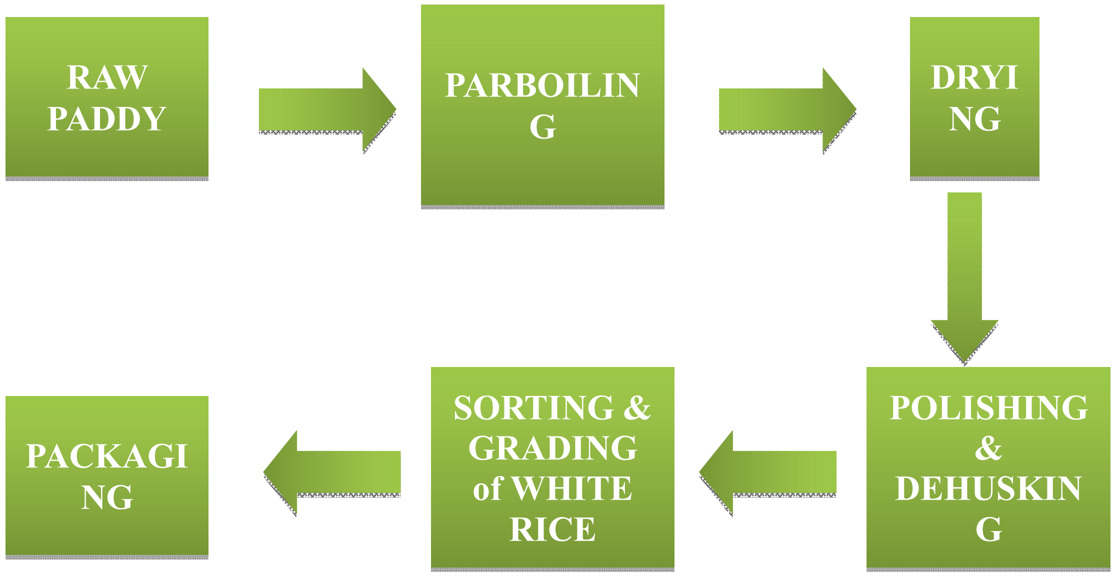

Fig. 1. The process flow diagram of the plant

Table 3. Electrical energy consumed during operation of planting (polishing and dehusking operation)

Machines	Quantity	Power(hp)	Energy (MJ)/day	Total energy (MJ)/day
Conveyors	11	1.5	95.04	1045.4
	1	5.0	316.8	316.8
	1	1.5	95.04	95.04
Cleaners	1	10.0	633.6	633.6
	1	5.0	316.8	316.8
Roller 1	1	10.0	633.6	633.6
	1	5.0	316.8	316.8
	1	1.5	95.04	95.04
Roller 2	1	10.0	633.6	633.6
	1	5.0	316.8	316.8
	1	1.5	95.04	95.04
Paddy separator	1	10.0	633.6	633.6
Destoner	2	1.5	95.04	190.08
1st polisher	1	60.0	3801.6	3801.6
2nd polisher	1	50.0	3168.0	3168.0
3rd polisher	1	50.0	3168.0	3168.0
4th polisher	1	50.0	3168.0	3168.0
Blower	1	50.0	3168.0	3168.0
Air lock	1	1.5	95.04	95.04
	2	1.5	95.04	190.1
	1	2.0	126.7	126.7
Husk blower	1	10.0	633.6	633.6
Screw conveyor for husk	1	1.5	95.04	95.04
Total				**22936.32 MJ**

Table 4. Electrical energy consumed during operation of planting (sorting and grading operation)

Machines	Quantity	Power (hp)	Energy (MJ)/day	Total energy (MJ)/day
Cleaner	1	3	190.081	190.08
Grinder	2	70	4435.2	8870.4
Blower	1	10	633.6	633.6
	1	15	950.4	950.4
Grader	29	1	63.36	1837.4
Conveyor	5	2	126.7	633.6
	17	1	63.36	1077.1
Colour Sorter	1	4	233.4	233.4
Bag sealing machine	1	0.3	19.01	19.0
Total				**14445.09 MJ**

Table 5. Electrical energy consumed during operation packaging

Appliances	Quantity	Power(W)	Energy (MJ)/day	Total energy (MJ)/day
Lights	150	40	3.456	518.4
Sodium lights	10	100	4.32	43.3
Flood light	4	100	4.32	17.28
Air conditioner	3	1500	129.6	388.8
Fan	20	50	4.32	86.4
Total				**1054.18**

4. CONCLUSION

Among all type of rice Planting operation polishing & dehusking operation consumed maximum energy followed by sorting & grading operation. Packing operation consumed least electrical energy among all the operation. The maximum manual energy was used in packaging operation. Four stage polishers were the most electrical energy consuming unit among the entire unit. Blower secured second position in term of consumption of electrical energy. In dryer section, elevators consumed maximum energy followed by blowers, conveyors and drum motors in dryers. In Planting (2nd stage), grinders consumed maximum energy followed by graders and conveyors. Bag sealing machine consumed minimum energy. In boiler section, fans consumed maximum energy followed by pumps, RO system and conveyors. The minimum energy was consumed by cyclone separator. In lighting section, light bulbs consumed maximum energy followed by AC's, fans, sodium and flood lights. It is revealed from the study that Planting owner used oversized motors in machines. So it has been suggested to replace these oversized motors and use motors according to working load of machinery.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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