International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Performance Evaluation of Solar Power Operated Paddy Winnower

Samreen[1] and M. Madhava[2], A. Rama Rao[3]

1. Ph.D Scholar, Dept. of Process & Food Engg., College of Agricultural Engineering, Bapatla, Andhra Pradesh
2. Asst. Professor, Dept. of Process & Food Engg., College of Agricultural Engineering, Bapatla, Andhra Pradesh
3.Ph.D graduate, College of Agricultural Engineering, Bapatla, Andhra Pradesh

ABSTRACT

The solar power operated paddy winnower was developed and performance was carried out at three feed rates for PLR 1100 type paddy variety 171.43 kg/h, 200 kg/h and 240 kg/h and for RGL 2537 type paddy variety 200 kg/h, 240 kg/h, 267 kg/h respectively. The paddy winnower was mounted with 0.25 hp DC motor and connected to a 150 watt photovoltaic solar panel. The highest cleaning efficiency of about 94% was achieved for feed rate 171.43 kg/h at main outlet. The highest output capacity of 223.47 kg/h was achieved at feed rate of 267 kg/h. It was observed the cleaning efficiency of both the paddy varieties was decreased on increasing the feed rate. But the percentage of blown grain decreased upon increase in cleaning efficiency.

KEYWORDS: Solar paddy winnower, Cleaning efficiency, Output capacity, Cost of operation.

Introduction

Paddy is very important crop amongst all food grains. Three forth of total world population consumes rice as staple food as major constituent of their daily diet. India is world's second largest producer and consumer next to china. In India rice occupies an area of 42.56 million hectares with production of 95.33 million tones and productivity is 2.2 tons per hectare. After manual threshing or by using hold on type threshers for threshing paddy crop winnowing operation is necessary.

In rural India winnowing is done by pouring grains from higher elevation to ground in the prevailing wind direction so that draft of air will blow away straw from clean grains and clean grains can be collected at ground. But this method is time consuming, uncomfortable and laborious and totally depends on wind conditions. Labour is required to stand at higher platform and pour grains from higher to lower elevation with unsuitable body conditions which increases drudgery of labour. In its simplest form it involves throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery.

Considering these limitations in winnowing basket, now-a-days small fans are used but it also involves same drudgery, labour has to stand in front of fan and pour grains in prevailing direction of wind. This method has also one limitation that percentage of blown grain was high due to improper position of operator. Also these operations are carried out in open yard and subjected to inclement weather conditions.

Now a day's wooden winnower are used by the farmers to clean the paddy. The winnower may be hand operated or power operated. Hand operated winnower require two persons for operation, one for operating the fan and another one for feeding the grain to winnower. Effectiveness of separation of winnower may be less in case of hand operated winnowing due to non uniform speed of the blower as it was operated manually. Power operated winnower has the high effectiveness of separation due to uniform blower speed, but requires electrical power to run the blower motor. In many rural locations in most developing countries, grid-connected electricity and supplies of other non-renewable sources of energy are either unavailable and unreliable or too expensive (Xingxing *et al*., 2012). In such conditions, photovoltaic powered winnower useful in areas with no utility lines. Photovoltaic systems are often cheaper and require less maintenance than conventional electrical power. (NYSERDA, 2009. EREC, 2013). Keeping all these points in view, it was proposed to develop and evaluate photovoltaic power operated paddy winnower.

Materials and Methods

The study was conducted at Annapurna rice mill located nearby college of Agricultural Engineering, Bapatla, Andhra Pradesh, India two paddy varieties namely PLA 1100 and RGL 2537 (Srikakulam Sannalu) was used evaluating the solar photovoltaic powered winnower. 10 kg of sample was used for the each experiment and each experiment was replicated three times. The performance was carried out at three feed rates for PLR type paddy variety 171.43 kg/h, 200 kg/h and 240 kg/h and for RGL type paddy variety 200 kg/h, 240 kg/h, 267 kg/h respectively.

Winnower

Winnower consists of wooden frame, housing, blower, feed hopper, feed and purity adjustment mechanisms (Figure 1), grain outlet, immature grain outlet, chaff and dust outlet with gear and pulley mechanism.

Figure 1. Photovoltaic power operated winnower

Frame was designed so that the paddy would fall at a distance of 12" (0.305m) from the fan outlet. Blower consists of 4 curved blades mounted horizontally on a shaft with two ball bearings. The shaft carries a small gear at its one end that meshes with bigger gear. The bigger gear (driven pulley) is driven by motor shaft (drive pulley) by a v-belt which can run by electrical DC motor.

As the mixture falls into the air current, the lighter material and chaff are blown through the opening for chaff and husk outlet by the air blast, while the good grains being heavier fall directly below and guided out by the grain outlet. Immature grains that are relatively lighter will be carried by the blast a little away from the good grains outlet and collected by the immature grain outlet (Fig. 1). Purity adjustment mechanism is a wooden plank kept in between the grain and immature grain outlets in the air flowing path and is raised or lowered by the rack and pinion arrangement.

A 0.25 horse power DC motor was used to run the winnower. Dynaflux make DC motor with 1500 RPM speed, 24 V, 9.7 Ampere of S1-Duty type motor was used.

Solar Photovoltaic Panel

Sonali solar make poly crystalline solar panel with maximum power (P) of 150 W, rated voltage (V) of 18.5 V, and rated current (I) of 8.10 A was used to run the DC motor of the winnower.

Power Transmission

Motor shaft pulley was fitted with 10 cm (4-inch) diameter pulley and blower shaft was fitted with 30.5 cm (12 inch) diameter pulley (Fig. 1). By using specific pulley diameters 3:1 speed reduction was achieved. To transmit the power from driving pulley (Motor pulley) to driven pulley (Blower pulley), the pulleys were connected with V-belt.

Measurement of Speed

Lutron type digital tachometer (model number DT2235B) is used which displace the revolutions per minute on digital screen. Lutran 4201 anemometer was used to measure the wind speed during the experiment.

Performance Evaluation of Solar Winnower

Measurement of performance is primary importance and will be carried under controlled conditions to obtain reliable data on machine, such that work capacity, quality of work, adaptability to different kinds of crop in comparison with local methods. The effect of three feed rates on different parameters like cleaning efficiency, output capacity of winnower were also determined.

a) Determination of grain ratio

Weight of sample of paddy grain, weight of clean grain and impurities was measured and the grain ratio was calculated using equation 1(Kadam, 2016).

$$\text{Grain ratio} = \frac{weight\ of\ grain\ in\ sample}{total\ weight\ of\ sample} \times 100 \qquad \ldots 1$$

b) Percentage of blown grain

The sound grain carried away along with the straw and chaff was calculated (Kadam, 2016).

$$\text{Percentage of blown grain} = \frac{F}{A} \times 100 \qquad \ldots 2$$

Where,

F= Quantity of whole grain collected at chaff outlet per unit time, kg.

A= Total grain input per unit time by weight, kg.

c) Cleaning efficiency

Cleaning efficiency of the winnower can be defined as the ability to separate the sound grains from a mixture of dust, straw and chaff (Kadam, 2016).

$$\text{Cleaning efficiency } (\eta) = \frac{I}{J} \times 100 \qquad \ldots .3$$

where,

I =Weight of whole grain per unit time at main grain outlet, kg.

J= Weight of whole material per unit time at the main outlet, kg.

Theoretical Considerations

a) Optimal fan wind speed and corresponding required rpm

It was found that the optimal wind speed for this application was 800-1300 ft/min, or 4.1-6.6 m/s. In order to achieve this wind velocity, a specific rotational speed (rpm) would be required of the shaft of the centrifugal fan. This was calculated using the fan affinity law (Ngadi, 2013).

$$\frac{n_1}{Q_1} = \frac{n_2}{Q_2} \qquad \ldots .4$$

where,

Q_1 = first air flow rate (m^3/min)

n_1 = rotational speed corresponding to Q_1 (rpm)

Q_2 = second air flow rate (m^3/min)

n_2 = rotational speed corresponding to Q_2 (rpm)

n_1= 324 rpm

Q_1 = (Cross-sectional area) (wind velocity)

= (0.35×0.15) (210) = 11.025 m^3/min

Q_2 = (0.35×0.15) (178)

$$\frac{324}{11.025} = \frac{n_2}{9.345}$$

n_2 = 275 rpm

b) Pulley diameter

To size the correct dimensions of the pulley, a ratio between RPMs and pulley diameter was used (Ngadi, 2013).

$$n_1 d_1 = n_2 d_2 \quad \text{……..} 5$$

where,

d_1 = diameter of driver pulley, cm

n_1 = rotational speed corresponding to d_1, rpm n_1

d_2 = diameter of driven pulley, cm

n_2 = rotational speed corresponding to d_2, rpm

c) Belt length

After sizing the 2 pulleys, the length of the V-belts between the motor and fan shaft is calculated by finding the angle of contact between each pulley. The Angle of contact was found using the following equations (Ngadi, 2013)

Angle of contact of small pulley = $\theta_d = \pi - \sin\left(\frac{D-d}{2C}\right)$ ... 6

Angle of contact of large pulley = $\theta_D = \pi + \sin\left(\frac{D-d}{2C}\right)$ ... 7

where:

D = diameter of large pulley (cm, in) = 30.5

θ_D= Angle of contact of large diameter pulley (rad)

d = diameter of small pulley (cm, in) = 10

θ_d = Angle of contact of small diameter pulley (rad)

C = Length between the pulley centers = 36.5

$$\theta_d = \pi - \sin\left(\frac{D-d}{2C}\right) \quad \text{…}8$$

$$\theta_D = \pi + \sin\left(\frac{D-d}{2C}\right) \quad \text{…}9$$

When the angle of contact was found between the two pulleys, the total outer length of the belt was calculated using the following equation:

$$\text{Length of belt} = \sqrt{[4c^2 - (D-d)^2]} + \frac{1}{2}(D\theta_D - d\theta_d) \quad \text{…}10$$

In cost economics, fixed and operating costs of the solar winnower was also calculated **(**Kadam, 2016**)**

Results and Discussions

It is noticed that there is huge increment in feed rate capacity of developed machine and also good increment in cleaning efficiency was observed.

Table 1 showed that the amount of sound grains blown with impurities and received in secondary outlet with immature grains and the net amount received in main grain outlet. The study reveals that on increasing the cleaning efficiency the percentage of grain loss is decreases.

Table 1 Effectiveness of cleaning the paddy grains

Sample	Main outlet (clean grain) ,g	Secondary outlet(sound grain + immature grain),g	Impurities outlet (mature grains+ dust and chaff)	Grain loss (sound grain in secondary outlet + sound grain in impurity outlet)
100	87.3	5.7(2.6+3.1)	7.0(0.9+6.1)	3.5
100	88.9	4(1.2+2.8)	7.1(1.22+5.88)	2.42
100	90.4	3.2(0.7+2.5)	6.4(0.87+5.53)	1.57

Grain ratio increases on increasing the cleaning efficiency while percentage grain loss decreases on increasing the cleaning efficiency as shown in Table .2.

Table 2 Percentage grain loss, percentage blown grain and grain ratio

Percentage grain loss (%)	Percentage blown grain, (%)	Grain ratio
3.50	0.90	0.9080
2.42	1.22	0.9132
1.57	0.87	0.9197

For evaluating the performance of developed solar power operated paddy winnower. Three samples of each variety (PLA 1100, RGL 2537) was cleaned and observations for each outlet (first outlet, second outlet, impurity outlet) was noted. On the basis of the result different parameters like cleaning efficiency, output capacity, feed rate, percentage grain loss was calculated as shown in Table 3.

Table 3 Performance evaluation of solar power operated winnower

TOTAL MASS (kg)	First outlet (kg)	Secondary outlet (kg)	Impurities outlet (kg)	Feed rate (kg/h)	Wind velocity (m\s)
PLA 1100 type paddy variety					
10	9.2	0.6	0.2	171.43	3
10	9	0.7	0.3	200	3.5
10	8.78	0.8	0.42	240	4
RGL 2537 type paddy variety					
10	9.34	0.5	0.16	200	2.6
10	8.76	0.92	0.32	240	2.9
10	8.38	1.12	0.5	267	3.4

Air velocities of blower were measured at different distance from blower shaft to impurity outlet are given in Table 4.

Table 4 Measurement of air velocities at 5-inches below hopper outlet.

Trail	Air Velocity (m/s)
1	5.6
2	5.6
3	5.7
4	5.9
5	6
Average wind velocity	5.76

Graphical representation cleaning

efficiency showed the quantitative and qualitative improvement of different parameters in compare to previous existing winnowing machine. The blower speed was measured and found to be 320 rpm and air flow rate was 5.76 m/s.

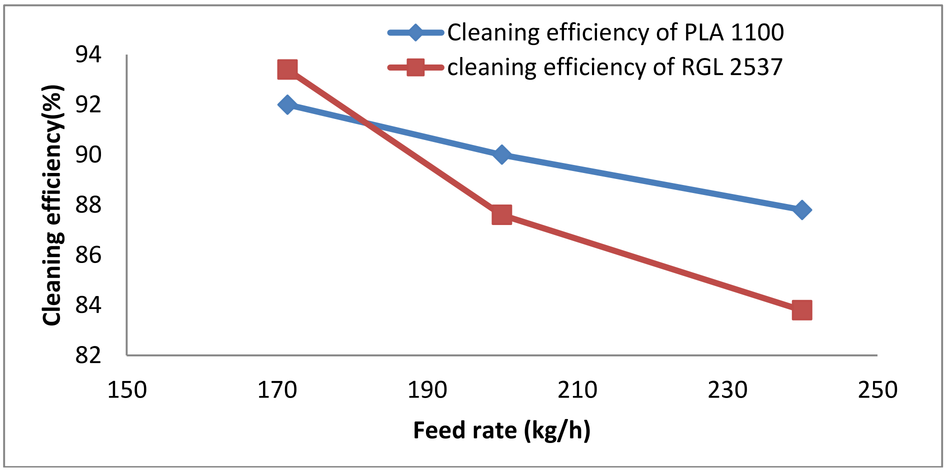

Fig. 3 Effect of feed rate on cleaning efficiency

Figure 3 revealed that the cleaning efficiency of both the varieties (PLA 1100 and RGL 2537) decreases on increasing the feed rate. But the cleaning efficiency of variety – B (RGL 2537) decreases at faster rate than that of variety-B (RGL 2537). This difference was observed due to the variation in thickness and length of both varieties. The variety-A was thick and short in size while variety-B was long and thin in size. Cleaning efficiency at main outlet for PLA 1100 type paddy variety was found to be 86%, 90% and 87.8% for first, second and third feed rate, respectively. Cleaning efficiency at main outlet for RGL 2537 type paddy variety was found to be 84%, 87.6% and 93.4% for respective feed rates.

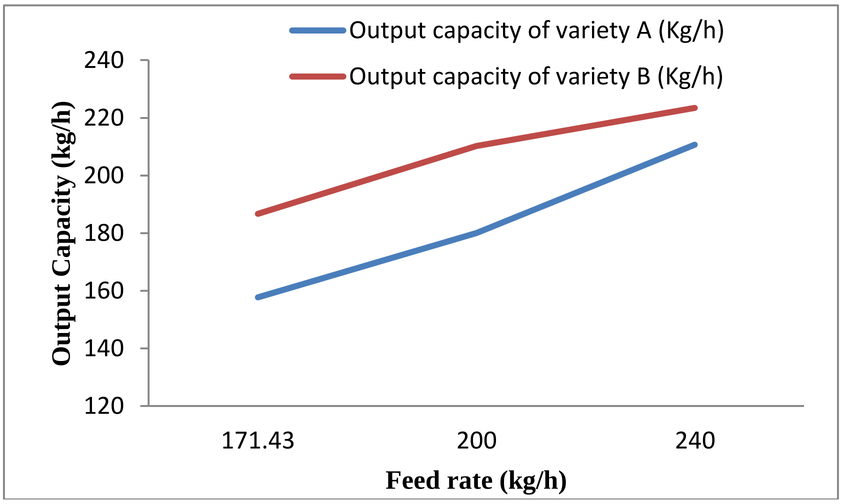

Fig. 4 Effect of feed rate on output capacity (for PLA 1100 and RGL 2537)

Fig. 4 shows that the output capacity for both the varieties (PLA 1100 and RGL 2537) increases on increasing the feed rate. The output capacity is concerned it was found to be 186.8 kg/h, 210.24 kg/h and 223.47 kg/h for RGL 2537 type paddy variety and 151.72 kg/h, 180 kg/h and 210.72 kg/h for PLA 1100 type paddy variety at main outlet for respective feed rates. As the feed rate increases, cleaning efficiency decreases, as same draft of air employed for cleaning more quantity of grains.

Conclusions

The highest cleaning efficiency of 93.4 percent was found at feed rate of 200 kg/h and highest output capacity of 223.47kg/h was found at feed rate of 267 kg/h for RGL 2537 type paddy variety. The percentages of blown grain were less than 1.5 percent in case of all three feed rates. The power consumption also was approximately same for all three feed rates i.e 0.150- 0.186kWh. The cleaning efficiency of both the varieties (PLA 1100 and RGL 2537) decreases on increasing the feed rate. The output capacity for both the varieties (PLA 1100 and RGL 2537) increases on increasing the feed rate.

References

- Arafe, G.K., Ebaid, M.T and El-Gendy, H.A. 2009. Development of a local machine and grading flax seed. *Misr J. Ag. Eng.* 26(1): 343-385.
- Abayineh, A.N. 2015. Design and development of tef grain and chaff separating and cleaning machine. School of Natural Resource and Environmental Engineering.
- EREC, 2013. Energy efficiency and renewable energy cleaning house. Agricultural Applications of Solar energy. United States Department of energy, Merrifield. www.p2pays.org/ref/24/23989.htm.
- Kashayap, M. M and Pandya, A. C. 1966. Air velocity requirement for winnowing operations. *J. Agric. Eng. Res.* 11(1): 24-32.
- Kashayap, M. M and. Pandya, A. C. 1965. A qualitative theoretical approach to the problem of winnowing. *J. Agric. Eng. Res.* 10(4): 348-354.
- Muhammad , U.S., Abubakar, L.G., Isiaka, M and Davies, R.M. 2013. Design and evaluation of a cleaning machine. *Applied Science Reports*. 1(3): 62-66.
- NYSERDA.2009. New York State Energy Research Development Authority, New York. Introduction to Solar Energy Applications for Agriculture. www.powerpaturally.org
- Rouzegar, R.M., Khalifeh, A A., Askari A. E and Gilandeh, A.Y. (2013). Study effects of moisture content, feed rate and fan revolution on separation efficiency in a paddy laboratory winnower. *International Journal of Agriculture and Crop Sciences.* 52576-2578.
- Rahul gajanan, K and Dhande, K.G. 2016. Performance evaluation of power. Operated paddy winnower. *International Journal of Agricultural Engineering* . 9: 47-52. Singh, S.P and Gite, L .P. 2007. Ergonomical evaluation of a hand operated paddy winnower by women workers. *Journal of Agricultural Engineering.* 44(4):15-71.
- Swain, S.K., Biswal, T.K., Das, D.K and Geol, A.K. 2002 . Performance evaluation of a hold on type power operated paddy thresher-cum-winnower. *Agricultural Engineering Today,* 26:17-22.
- Xingxing, Z., Xudong, Z and Jihan, X. 2013. Design, fabrication and experimental study of a solar photovoltaic/loop-heat-pipe based heat pump system. *Solar Energy.* 97:551-568.
- Xingxing, Z., Xudong, Z and Jihan, X. 2013. Design, fabrication and experimental study of a solar photovoltaic/loop-heat-pipe based heat pump system. *Solar Energy.* 97:551-568.