Performance evaluation of Solar Operated Maize Sheller

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ABSTRACT: Maize production is the second major activity adopted by the farmer because of its several advantages on different fields. Concerning the maize production a maize sheller was developed .The sheller is evaluated for three different varieties of maize Shresta NHM 731, Angad 1217 and NK30 and each variety is divided into two categories based on the length of maize cob *i.e.,* Category A (maize length less than 12 cm) and category B (maize length greater than 12 cm).The developed sheller has total weight 79.5 kg and the unit cost of the machine is Rs 17150/. The performance of manual plucking and hand held shelling (hexagonal hand held sheller) is also evaluated for comparison. The output capacity of developed sheller was evaluated at three different feedings and 2.5 kg maize feeding was found highest among all the feeding. The shelling efficiency and output capacity of variety Angad 1217 Category A were found maximum 99.45% and 174.33 kg/h respectively. Percentage of unshelled grain on maize sheller was found on variety Shresta NHM 731 category A was highest 1.62. The highest cleaning efficiency was found on variety NK30 category B 99.20 percent. The operational cost of developed sheller is 44.771 Rs/h. The cost required to shell 1 kg of maize cob was found Rs 0.226. The total operational cost of The hand shelling (manual plucking) and hand held sheller was found 37.5 Rs/ h. shelling of 1 kg of maize into maize grain required 3.05 Rs/kg in case of manual plucking and 1.37 Rs/kg in case of hand held sheller.

Key words: Development, dehusked cob, maize shelling, solar energy

Maize has a wide range of consumption such as poultry feeding, animal feeding, human nutrition etc.).In the various sector, the maize produced in India is consumed. At present consumption of produced maize includes poultry feed (52%), human food (24%), animal feed (11%), starch (11%), brewery (1%) and seed 1% (Kumar, 2017).

Maize contains reach quantity of nutrition such as carbohydrate, protein, fat, etc. There is the various method of maize shelling of varying capacity *i.e.,* Hand held shelling device, Motor operated sheller etc. Farmers of Chhattisgarh is still using the traditional method to shell the maize *i.e.,* Manual plucking, Rubbing the maize with each other that causes injury on palm hand, tiredness of finger etc. There is various design of maize sheller has been developed and still finding some improvement. Among all the existing maize shelling methods capacity of traditional (by Hand) was 9.12 kg/h, Hand held (cylindrical manual) was 20.32kg/h and motorised maize shelling was 41 qts/h. (Amare, 2017). Apart from the motorised sheller hand operated and foot operated shelling machine was also developed with different capacity depends on the design. The existing foot operated corn deseeding machine deseed the one cob in 10 second (Sushrut, 2017). The hand operated maize dehusker sheller was also developed and ergonomically evaluated (Singh, 2013).Chhattisgarh is the place where maize farming is done in patches. Chhattisgarh is the state located in the Centre-East of the country and it is one of the warmest region in India with an average daily high temperature of 33 degrees centigrade. In Chhattisgarh the hours of sunshine per day is ranges 9 to 11 (Rai, 2011). Different idea has been adopted to use sun energy at farms. Photovoltaic (solar electric panels) can be used for farm operations and agricultural operations. The people of the place where electricity can't be available are also using traditional methods. An attempt has been made to use the solar energy at farm operation and study was undertaken to develop and evaluate the performance of solar maize sheller to reduce the drudgery and avail the facility to the farmer where electricity is absent.

MATERIALS AND METHODS

Three variety of maize was taken for the performance evaluation. The maize taken is Shresta NHM731, NK30 and Angad 1217.Each type of variety was divided into two categories namely category A and category B. Category A comes under the maize having a length less than 12 cm whereas category B comes under the maize having maize length greater than 12 cm. the physical property of maize and maize kernel is taken for the development of solar maize sheller. The physical property of maize and maize kernel is shown in Table 1.

Constructional detail

Before starting manufacturing we have to follow some design procedure. The design of solar maize sheller is done with the help following procedure

1. Detailed, clear and complete statement of the machine.
2. Selection of desired mechanism for machine.

3. Forces acting and energy requirement.
4. Material which best suited for machine development.
5. Identify the importance and necessary and application of the machine
6. Detailed drawings of the machine are made with complete specification of materials and manufacturing methods.

Table 1: Physical property of maize

S. No.	Particulars	Category	Anagad 1217	NHM 731	NK 30
1	Length (mm)	A	108.5	110.4	109.0
		B	173.7	178.6	186.5
2	No of grain per cob	A	388.0	318.0	403.0
		B	533.0	475.0	570.0
3	Weight of maize cob (g)	A	135.1	133.16	141.5
		B	249.8	214.64	226.4
4	Weight of maize core (g)	A	25.14	22.44	24.17
		B	45.98	20.36	35.22

Design Consideration

Power requirement to shell maize

$P_T = P_{Shaft} = T_{shaft} \times V_{shaft}$

T_{shaft} = Mass of iron chain × acceleration due to gravity × radial distance

= 2.1 kg X 10m/s^2 X 0.16 m

= 3.36 Nm

Angular velocity of the shaft

$V_{shaft} = \frac{2 \times p \times N}{60}$

N = revolution of the shaft

$V_{shaft} = \frac{2 \times p \times 370}{60}$

= 38.74 m/s

P_T = 3.36 Nm X 38.74 m/s

= 130.1875 watt » 130 watt

Length of chain

Chain Length can be determined by using the following formula according to Khurmi and Gupta (2005).

$$L = \frac{12.7}{2}(17+21)+2\times360+\frac{\frac{p}{2}\left(\text{cosec}\left(\frac{180^0}{21}\right)-\text{cosec}\left(\frac{180^0}{17}\right)\right)^2}{360}$$

L = 961.48 mm H» 962mm

No. of links = 962 / 12.7 = 75.70 links » 76 links

Drawing

The 3D drawing of the developed solar maize sheller is made with the help of solid modelling (Creo parametric). The design helps to visualize the machine design, both as the interaction between all parts of the machine and individual parts. The developed sheller 3D design is depicted in Fig 1. The sheller consists mainly frame, shelling assembly, drive shaft, sieve, D. C. motor, chain and sprocket, solar panel, battery to perform a specific work.

Fabrication of the machine

In Fabrication of machine the all the raw material is welded together to make the frame of the solar maize sheller and outer synder of sheller with inlet and outlet unit. Fabrication of the maize sheller is done in the workshop of Swami Vivekanand College of Agricultural Engineering Technology and Research Station, Indira Gandhi Krishi Viswavidyalaya , Raipur(C. G.).

Component

The main components of developed solar maize sheller and description are shown in Table 2

Solar panel

A solar panel is a device that is the best source of direct current. The solar panel is an arrangement of the solar cell. The solar cell is made up of silicon and work based on photovoltaic effect it produces energy with the help of sunlight. it uses photons of sunlight to convert it into energy. The solar panel used is 12 volt. 2 unit of 40 watts solar panel are used.

Table 2: Specification of main component of solar maize sheller

S. No.	Component	Material used	Specification
A	Weight of machine (kg)		79.5
B	DC motor		
	Diameter of shaft (mm)		8
	rpm		3000
C	Shelling assembly	G. I. Sheet	
	Cylinder Diameter (mm)		390
D	Battery	dry	2 unit
	volts(v)		12
	current (Ah)		7
E	Solar panel		2 unit
	Volts (v)		12
	Power (watts)		40

Performance Evaluation

Performance of the developed solar maize sheller was evaluated at the farm of Swami Vivekanand College of Agricultural Engineering Technology and Research

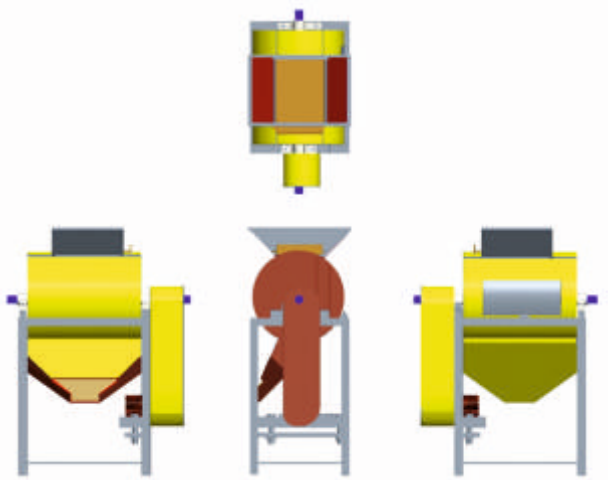

Fig. 1: 3D view of developed solar maize sheller

Station, Indira Gandhi Krishi Viswavidyalaya, Raipur(C. G.).The performance is evaluated at the month of September- October. The performance evaluation consider the determination of different parameters such as the cleaning efficiency (%), shelling efficiency (%), percentage of unshelled grain, percentage of cracked and broken grain (mechanical damage), shelling capacity(kg/h). the different formula were used for calculating above performance parameter(IS: 7052- 1973)

Unshelled grain (%) $= \frac{W_{un}}{G} \times 100$ … (1)

Where,

W_{un} = Weight of unshelled grain in kg.

G = Total weight of sample in kg.

Cracked and broken grain (%) $= \frac{W_{cb}}{W_o} \times 100$ …(2)

Where,

W_{cb} = Weight of the cracked and broken grain in kg.

W_o = Total weight of grain in the outlet in kg.

Shelling capacity

Shelling capacity is the weight of the product shelled in unit time. Shelling capacity is generally expressed by kg/h.

Shelling efficiency (%) $= \frac{W_s}{G} \times 100$ … (3)

Where,

W_s = Weight of shelled grain in kg.

G = Total weight of sample in kg.

Another formula used for calculating shelling efficiency (IS: 7052- 1973).

Shelling efficiency(%)=100–Percentage of unshelled grain. … (4)

Cleaning efficiency (%) $= \frac{W_C}{W_o}$ .....(5)

Where,

W_c = Weight of clean grain in outlet in kg.

G = Total weight of grain in the outlet in kg

The developed solar maize sheller is analysed by comparing the performance of other manual shelling methods. The analysis is done among the treatment (various shelling method) to determine the significant difference between treatments. The performance of the different treatment is compared and shown in Table 2.

T_1 = Manually shelling (by hand plucking)

T_2 = Hand held device

T_3 = Solar maize sheller

The output capacity of developed solar maize sheller is evaluated at different feeding and found the feeding 2 is suitable for shelling the maize. The observation is shown in table 3. Feeding 2 capacity ranges between 153 – 163 kg/h. The shelling capacity of solar maize Sheller is found very high in comparison to both the shelling method.

RESULTS AND DISCUSSION

Shelling efficiency

Shelling efficiency of different treatment were compared after observation. The shelling efficiency in manual plucking and hand held sheller was 100 percent whereas the shelling efficiency in solar maize sheller was ranged 98 – 99.54 percent. Shelling efficiency of variety Shresta NHM 731 category B was found minimum 98.06% and

Table 2: Performance parameter of manual shelling and hand held sheller

Treatment	Category	Shelling Efficiency (%)	Unshelled (%)	Cleaning efficiency (%)	Visible damage (%)	Capacity (kg/h)
Manual shelling	A	100	0	99.98	0	9.36
	B	100	0	99.99	0	10.38
	Mixed	100	0	99.98	0	8.63
Hand held device	A	100	0	99.99	0.031	15.83
	B	100	0	99.99	0.031	18.12
	Mixed	100	0	99.98	0.038	12.54

Table 3: Performance of machine at different feeding

Category	Maize (kg)	Shelling Efficiency (%)	Unshelled (%)	Cleaning efficiency (%)	Visible damage(%)	Capacity (kg/h)
A	1.370	98.57	1.43	99.2	0.26	117.48
	2.50	99.49	0.51	98.79	0.25	162.17
	3.099	99.09	0.91	98.54	0.43	118.72
B	1.27	97.46	2.54	98.63	0.85	108.94
	2.507	99.7	0.29	99.37	0.2	153.97
	3.107	99.1	0.89	98.95	0.5	121.47

Table 4: Performance of machine at different Maize Variety

Treatment/ variety	Category	Shelling Efficiency (%)	Unshelled (%)	Cleaning efficiency (%)	Visible damage (%)	Capacity (kg/h)
Shresta NHM 731	A	98.37	1.62	98.45	0.27	161.54
	B	98.06	1.17	98.18	0.31	166.77
Angad 1217	A	99.54	0.45	99.02	0.35	174.33
	B	99.52	0.47	98.82	0.69	171.56
NK30	A	99.37	0.63	98.93	0.19	153.55
	B	99.21	0.78	99.20	0.33	161.06

variety Angad 1217 Category A was found 99.45 % maximum because the size of the category A is not varying too much in comparison to category B.

Percentage of unshelled grain

Percentage of unshelled grain was not found in manual shelling and hand held sheller because of 100 percent shelling efficiency but in solar maize sheller category A of variety Shresta NHM 731 is found highest 1.62 percent of unshelled grain whereas category A of Angad 1217 was found minimum 0.45 percent of unshelled grain.

Cleaning Efficiency

The average cleaning efficiency of three variety was calculated and found that the highest cleaning efficiency was variety NK30 category B. Manual plucking and hand held shelling have cleaning efficiency nearly 100 per cent.

Percentage of cracked and broken grain (visible damage)

During the shelling of maize, there is mechanical damage in the maize kernel. The visible mechanical damage in manual shelling was none whereas visible damage in hand held sheller was ranged between 0.031 to 0.038 percent. In solar maize sheller variety Angad 1217 Category B was found maximum visible damaged grain 0.69 percent and variety NK30 category A found minimum visible damaged grain 0.19 percent.

Shelling capacity

The capacity of varieties ranges between 153 – 175 kg/ h. The variety NK30 of category A was found minimum output capacity 153.55 kg/h and the variety Angad 1217 of category A found maximum output capacity 174.33 kg/h.

CONCLUSION

From the result conclusion is drawn that the developed maize sheller use full for the small farmer of remote area where electric power is not sufficient and also the developed solar maize sheller is reliable and satisfactory for the selected variety of maize. Overall the variety Angad 1217 of category A was found best based on evaluation. The developed maize sheller is recommended for small scale farmers.

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