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Performance evaluation of a power operated maize sheller

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ABSTRACT : The research was conducted on development and evaluation of power operated maize sheller in Department of Agricultural Engineering during the year 2010-2011. Maize (*Zea mays* L.) is one of the most important cereal crop in the world agricultural economy. It is called as queen of cereals and king of fodder due to its great importance in human and animal diet. It is being used for manufacturing industrial products like starch, syrup, alcohol, acids, etc. The traditional shelling methods are rubbing the maize cobs on one another, rubbing on bricks or stone and by using iron cylinder consisting of wire mesh inside. These methods are time consuming involves drudgery. The study was undertaken to survey the different shelling methods used for maize by the small and marginal farmers and different power operated maize sheller were evaluated for suitability in terms of socio-economic conditions that are prevailing in Karnataka and also to improve its efficiency. To address this, power operated maize sheller was developed and its performance was evaluated. The maize sheller consisted of a cylinder and a concave. The cylinder made up of high carbon steel of size diameter 6.5 cm. The cylinder length 15 cm, having beaters which rotates along the cylinder and separates grains from the cobs. While the concave was fabricated using 6 mm size mild steel rods. The length of concave was 60 cm with slotted opening size of 7.0cm×1.0cm. The developed power operated sheller had the shelling efficiency, total recovery, breakage and shelling capacity of 98.51, 66.62, 1.60 per cent and 402.01 kg/h, respectively, at a cylinder speed of 350 rpm. The cost of shelling 1kg of maize cobs at 13 per cent moisture content was.0.08, only.

KEY WORDS : Maize cobs, Maize sheller, Shelling, Cylinder, Concave

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Maize (*Zea mays* L.) is one of the most important cereal crop in the world agricultural economy. It is said to have originated from Mexico several thousand years back, even before Columbus landed in South America. It is called as queen of cereals and king of fodder due to its great importance in human and animal diet. Maize is next to rice, wheat and jowar with regard to area and production. It is being used for manufacturing industrial products like starch, syrup, alcohol, acids, etc. It is a rich source of starch (60-80%), protein (8-12%), fat (3-5%) and minerals (1-2%) (Hosamani *et al*., 2000). India ranks fifth with respect to area (7.43 million hectares) and seventh with respect to production (18.7 million tonnes) in the world (2009-10, Business standard).

A survey was conducted to study the traditional process of shelling methods are rubbing the maize cobs on one another, rubbing on bricks, stone, and wire mesh by using iron cylinder. These methods are time consuming, labour intensive involving drudgery and in case of existing different shelling methods used for maize by the small and marginal farmers and various power operated maize shellers were evaluated in terms of shelling efficiency (%), total recovery of kernels (%), breakage (%), whole kernels (%), unshelled kernels (%) and shelling capacity (kg/h) and then based on these parameters developed the improved power operated maize sheller and its performance was evaluated.

METHODOLOGY

Description of maize sheller:

The power operated maize sheller was developed and fabricated in the Division of Agricultural Engineering, for removal of maize grain from the cob, winnowing and cleaning.

The following factors were considered while developing the maize sheller

– Suitability of machine to shelling maize cob to separate kernel

– Ease of operation and maintenance

– Low cost of operation and energy efficient
– Minimum damage to kernels

Constructional features:

Details of different parts of the maize sheller:

Frame:

The frame was made up of mild steel. The overall dimensions of frame were 77 cm length, 42.5 cm width and 128 cm height. The sheller unit was fixed to this framework. The frame have bottom set, motor, stand, etc.

Cylinder:

It was made up of high corbon steel of 6.5 cm diameter. The cylinder length was 15 cm, having beaters which rotate along the cylinder and separated grains from the cobs. However, cylinders with beaters are easy for manufacturing and are economical.

Hopper:

The hopper was fabricated in trapezoidal shape, using mild steel sheet of 18 gauge thickness and dimensions of 44.5 cm length, 25 cm width and 42 cm height.

Fly wheel:

The fly wheel was provided to transfer the power coming from belt pulley to the cylinder sprocket. This wheel was fitted to the horizontal steel shaft which was connected to the pillow bearings and at the top chain sprocket attached to shelling cylinder.

Perforated concave:

The concave was fabricated using 6 mm diameter M.S. rods. The length of concave was 25 cm with slotted opening size of 7.7cm ×1.0cm. It was designed by considering average size of maize cobs and kernels. It was designed in such way that kernels should not fall through the slots. It was fabricated using two half round rings, on which 6 mm M.S. rods were welded at a spacing of 1 cm. The clearance between concave and cylinder was maintained at 2.5 cm.

Outer cover:

It was made up of 18 gauge M.S. sheet and was bended to semicircular shape of diameter 18 cm and was rigidly fixed to give protection to the cylinder and avoid grains spilling out. It has the provision for attaching to a hopper. A flange was attached to it along the length to facilitate cleaning of inner cylinder.

Rotor shaft:

It was one of the key components of the machine; other parts flats of cylinders and bearings were mounted on the shaft. The standard size and length of the shaft were selected based on the shaft design. The pulley was attached to give drive to shaft from motor.

Outlet:

The outlet for separated grains was made at the bottom of the shelling cylinder. It was made up of metal sheet to collect grains without shattering outside.

Following are three power operated maize shellers were compared with each other.

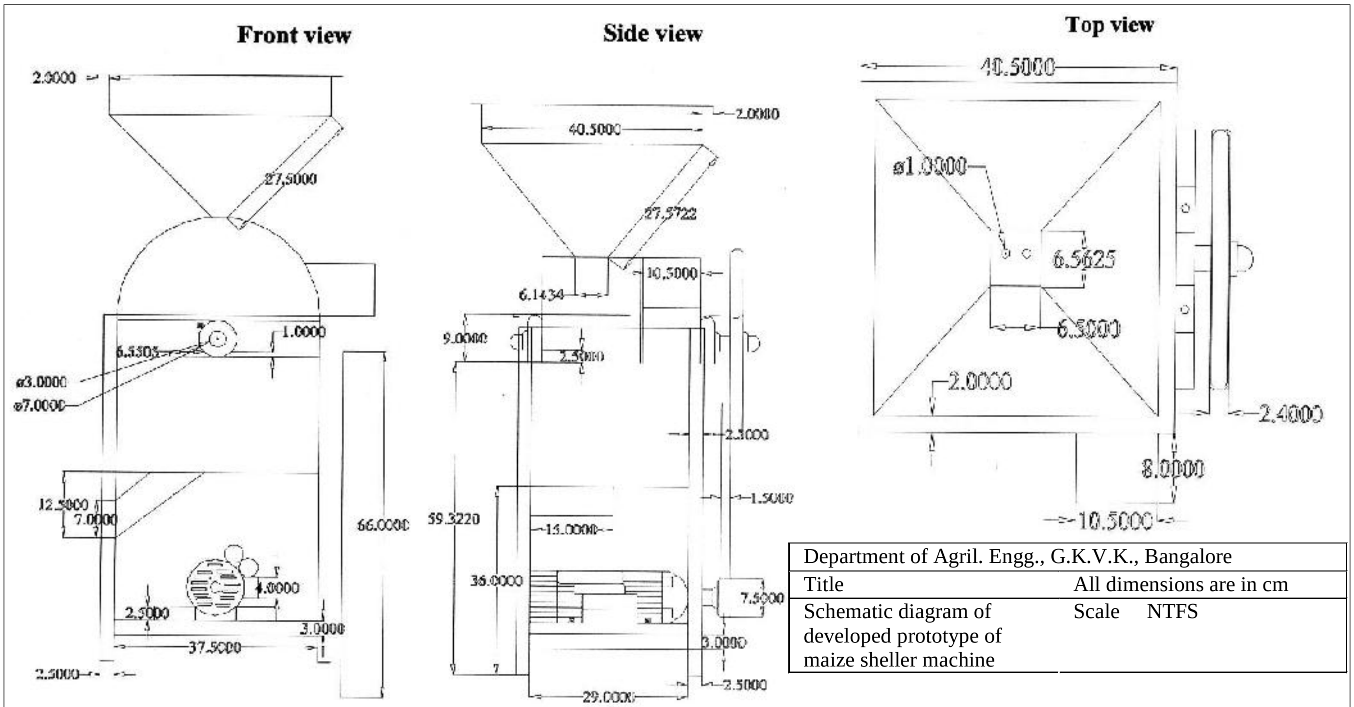
Treatments:

M_1- Existing power operated maize sheller

M_2- Existing power operated maize sheller

M_3- Improved power operated maize sheller (Plate 1 and 2).

Plate 1 : Developed Power operated maize sheller machine (M_3)



Item No.	Qty.	Description	Item No.	Qty.	Description
1	1	M.S Frame	7	1	Belt
2	1	Hopper	8	1	Electronic motor
3	1	Rotating cylinder	9	2	Bearings
4	1	Concave plate	10	16	Screws and nut
5	2	Pulley	11	16	Washers
6	1	M.S Shaft	12	1	Blower

Plate 2 : Schematic diagram of developed prototype of maize scheller

Some problems were observed in case of above existing power operated maize shellers related to its low efficiency so as to modified these constraints and developed the improved maize sheller and tests were conducted for above three different treatments of same sample size, moisture content of 13 per cent and cylinder speed of 350 rpm. The concave clearance of the sheller was constant for each treatment and it was 2.5 cm.

The results with respect to effect of treatments, on time taken for shelling and cylinder speeds and shelling efficiency (%), breakage (%), unshelled kernels (%), whole grains (%) and shelling capacity (kg/h) of machine are presented in Table A. And also tests were conducted for improved sheller at varying moisture content, speed and concave clearance as results shown in the Table B. It showed that there was significant difference between treatments.

Working of sheller:

The developed sheller was tested as per standard procedures for combination of various treatments. Before

Table A : Performance comparison evaluation of existing and improved power operated maize shellers at 13 % moisture content (wb), 3cm concave clearance and 350 rpm cylinder speed

Treatments	Wt of feed (kg)	Time of operation (min)	Damaged grains (%)	Whole grains (%)	Unshelld cobs (%)	Shelling efficiency (%)	Capacity (kg/h)
M_1	20	3.48	3.58	63.88	3.16	96.83	347.65
M_2	20	3.44	1.81	66.05	2.13	97.86	352.08
M_3	20	3.16	1.35	66.83	1.63	98.36	382.09
S.E.			0.04072	0.031893	0.028101	0.027563	7.756279
'F' Test			*	*	*	*	*
C.D. (P=0.05)			0.12548	0.098271	0.086587	0.084927	23.89947
CV %			5.39862	0.659511	3.62738	0.379024	24.04754

Table B : Performance evaluation of modified power operated maize sheller

Treatments	Wt of feed (kg)	Cylinder speed (rpm)	Time of operation (min)	Moisture content (%)	Concave clearance (cm)	Damaged grains (%)	Whole grains (%)	Unshelld cobs (%)	Shelling efficiency (%)	Capacity (kg/h)
M_3	20	250	3.42	12	2.0	1.31	66.83	1.67	98.32	352.51
M_3	20	300	3.16	14	2.5	1.35	66.83	1.63	98.36	382.09
M_3	20	350	3.01	13	3.0	1.60	66.62	1.48	98.51	402.01
S.E.±						0.0414	0.01264	0.03087	0.03087	6.24059
'F' Test						*	*	*	*	*
C.D. (P=0.05)						0.12757	0.03894	0.09511	0.09511	19.2292
CV %						6.76618	0.25794	4.75195	0.41727	18.4156

starting the actual testing, belt tension, direction of rotation of pulleys were checked. The clearance between cylinder and the concave was determined using vernier calipers. The cylinder speed was also recorded using a tachometer. The cylinder speeds were fixed at 250 rpm, 300 rpm and 350 rpm separately during respective treatment combination. After preliminary set up, machine was placed at an angle equal to or greater than angle of repose for maize, so that maize movement took place properly inside the sheller, then the motor was started and the speed was adjusted at particular rpm using speed cone as per treatment combination planned. Maize cobs were then fed through the hopper continuously.

The rotating peg teeth produced two kinds of forces namely impact and shearing which caused to remove grains from maize cobs, then the outlet door was opened and kernels were collected at the end. The outer shell which was broken was passed through the slots provided in the concave. Two labourers were engaged for these operations, one for feeding maize cobs at hopper and the other for opening the outlet door and collecting the grains at the outlet. Weight of whole grains, broken grains and unshelled cobs were recorded and time of operation to calculate shelling capacity and efficiency were also recorded.

RESULTS AND DISCUSSION

The results were analysed with respect of effect of different moisture content, concave clearance and speeds on shelling efficiency (%), total recovery of kernels (%), breakage (%), whole kernels (%), unshelled kernels (%) and shelling capacity (kg/h) of machine were presented in Table A.

Shelling efficiency:

The shelling efficiency of maize (98.51 %) was found significantly higher when maize of 13 per cent moisture content fed to sheller rotating at the speed of 350 rpm compared to other combinations (Table B). It might be due to the fact that, proper arrangement of machine parameters like uniform distance found between threaded cylinder beaters, concave clearance between cylinder, fan and pillow bearing arrangements and size and position of hopper. The cost of power operated shelling was less compared to processing with other traditional shelling methods. There was significant effect of speed on shelling efficiency. The higher shelling efficiencies were observed at 350 rpm rotor speed, 13 per cent moisture content and 3cm concave clearance, but damage was little higher at 350 rpm speed, as obviously if speed increased brokens also high. Performance of shelling efficiency and shelling capacity were more using this combination (Fig. 1 and 2).

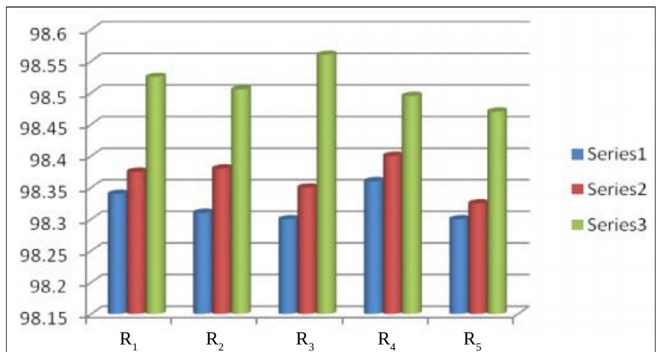


Fig. 1 : Shelling efficiency under different treatments

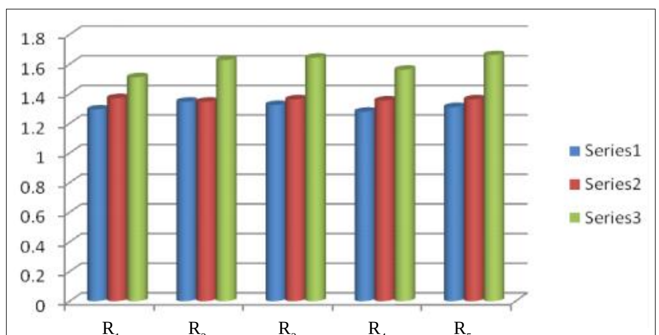


Fig. 2 : Grain damage percentage under different treatments

Percentage of whole grains:

The whole kernel recovery was significantly affected by different cylinder speeds at moisture contents. The higher percentage recovery of whole kernels (66.62 %) was found having 13 per cent moisture content of maize cobs fed to sheller rotating at 350 rpm, which was more than any other combination of treatments (Fig. 3).

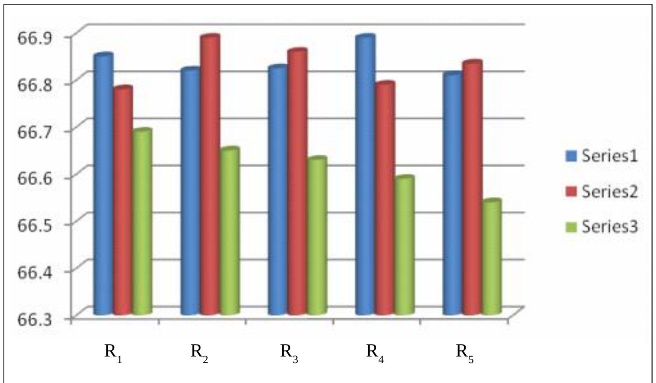


Fig. 3 : Whole grains percentage under different treatments

Percentage of unshelled cobs:

The percentage of unshelled cobs were found less when speed of cylinder increased (1.48 %) with 13 per cent moisture content of maize cobs fed at cylinder speed of 350 rpm, as obviously speed increased it increased shelling performance as compared to slow speeds of operation (Fig. 4).

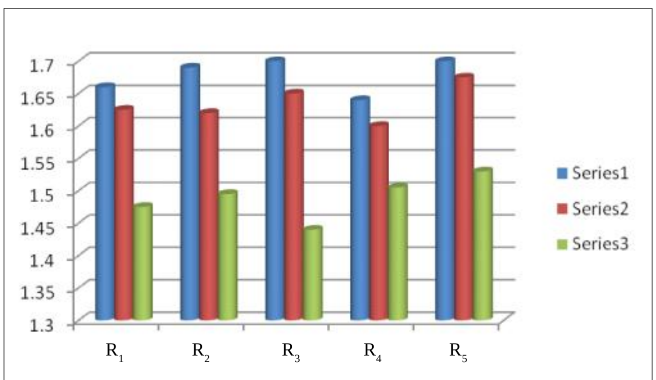


Fig. 4 : Unshelled cobs percentage under different treatments

Capacity of sheller:

The capacity of sheller was found significantly different for each sheller arrangement and speed combination at moisture contents. Higher capacity of shelling (402.01 kg/h) was found when maize having 13 per cent moisture fed to sheller having cylinder rotating at a speed of 350 rpm. This was because the time of shelling was minimum compared to other treatment combinations (Fig. 5).

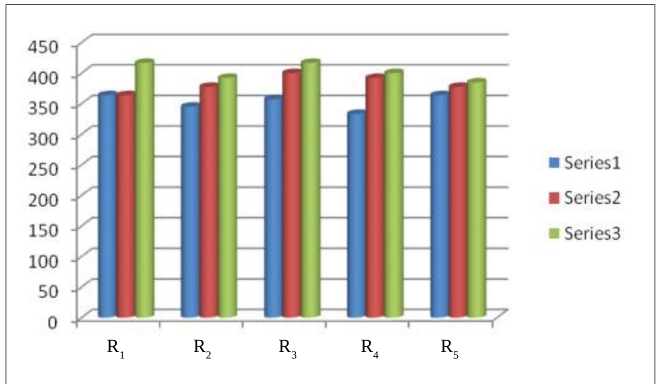


Fig. 5 : Shelling capacity (kg/h) under different treatments

Conclusion:

Using improved power operated sheller. It was found that shelling efficiency and capacity of the sheller were 98.51 per cent and 402.01 kg/h, respectively. By considering all factors such as percentage of whole kernels, efficiency, unshelled kernels and capacity, it was found that shelling process of maize having 13 per cent moisture content, fed at cylinder speed of 350 rpm gave better results but there was considerable damage as compared to slow speed of operation.

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