



Design, Development and Performance Evaluation of Groundnut Pod Stripper

Roshani Anant^{a++*}, R. K. Naik^{a#}, Geeta Patel^{a†}
and Biswajit Nayak^{a†}

^a Department of Farm Machinery and Power Engineering, SVCAET & RS, IGKV, Raipur, (Chhattisgarh), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This project only removes the pods from their roots so the farmers can work easy and can save time and money as well. It is very efficient and can be available to all at minimum cost. This work focused on the design and fabrication of a groundnut pod stripper machine electrically powered by a 1hp motor. The main components of the developed stripper are stripping cylinder, frame cover to protect the pods from scattering and sieve for cleaning purpose. According to the design dimension the conceptual drawing was built with the help of SOLIDWORKS software. The principle of the designing is based on the horizontal circular rotary motion. The developed pod stripper has a dimension of 1170 x 930 x 560. The performance of the developed pod stripper was tested with three independent parameter i.e. feed rate (kg/h), moisture content (% db) and cylinder speed (m/min) and the dependent parameters were stripping efficiency, cleaning efficiency and damage percentage. It was found that the stripping efficiency is 97% and stripping capacity is 195 kg/h,

⁺⁺ M.Tech Scholar;

[#] Professor;

[†] Ph.D. Scholar;

*Corresponding author: E-mail: roshnianant7@gmail.com;

cleaning efficiency is 87% efficient. There were no losses but the scattering of groundnut pod was 0.83%. The developed machine have output of 10 times more than the traditional method with profit of more than 10 times.

Keywords: Groundnut pods; stripping efficiency; cleaning mechanism; shattering loss.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a leguminous plant that is frequently grown. It's noted for its high-oil edible seeds, making it the world's fourth-largest source of edible oil and third-largest source of vegetable protein. It is also used as ingredients of many sweets, mixtures, snake's food and breakfast items. It is one of the important agricultural commodities exported to many parts of world. Groundnut is grown on 295 million hectares throughout the world, yielding 487 million tonnes at a yield of 1647 kg per hectare. India leads the world in groundnut acreage and is the world's second largest producer with 101 lakh tonnes, with annual all-season coverage of 55.6 lakh hectares. Groundnut is farmed in one or more seasons (*kharif*, *rabi*, and summer), however the *kharif* crop takes up around 80% of the area and produces the majority of the harvest (June-October) Ghaly [1] The study has been conducted to investigate that the groundnut stripping is major problem in all over India, especially in Chhattisgarh. The lack of groundnut processing machine is the major problem in Chhattisgarh. The farmers have no choice but to remove groundnut by hand plucking method or by biting the nuts with the rods. These methods are very time consuming or laboring process and the output was very less and could not satisfy the market demand. In Chhattisgarh total area of groundnut is 67 thousand ha with the production of 70.2 thousand tones and the productivity of 103kg/ha respectively. Groundnut can be cultivated in both *rabi* and *kharif* season in Chhattisgarh. Total area of groundnut in Chhattisgarh is 67.7 thousand ha⁻¹ with the production of 70.2 thousand tones and the productivity of 1036 kg ha⁻¹, respectively Behera [2].

2. SYSTEM STRUCTURE AND DESIGN

The system consists of the stripping unit, the prime mover, sieve unit, gear. The components of the stripping unit are: frame cover, stripping chamber and separation chamber. The prime

mover is an induction motor with 1hp. The weighing units are conveyor belt and pulley. The frame acts as a support for all the machine components, the stripper rim is where the groundnut pods is been fed into. The stripping chamber consists of stripping cylinder and also the separation chamber consists of chaffs outlet and pod collector also an axial flow fan powered by the prime mover connected separately. Sieve unit connected by means of a v-belt and pulley and bevel gear. When the rim rotates the pods of the plant cut and release into the sieve unit without being damaged also when the blower is rotating it generates a steam of air current which blow off the chaffs through chaff outlet and the stripped pods fall freely on the pod collector. The stripped pods were being conveyed by a conveyor for collection and weighing the quantity of the pods with the help of weighing balance.

2.1 Design of Frame

As per coefficient of friction a inclined rectangular structural frame was made for at safety purpose to protect the pods from the scattering losses, aspirator blower and oscillating sieve. The overall dimension of the frame (LxWxH) of 1170 x560 x920mm. The other dimensions as well as isometric views taken were given in Fig. 1 show below.

2.2 Design of Base Frame

A base frame is made of MS angle overall dimension frame (LxWxH) is 1170x920x2090 an inclined structure is made which has many supporting angles is used to support all components. Materials of base frame are MS angle. Base frame support the stripping unit and sieve unit. Base frame is covered well with welding arc. It has four angles for sieve unit and four bearing system for bevel gear. Base frame have strong rigidity to avoid distortion of frames during handling and installation, the base frame provides a surface onto which various mechanical components are mounted. Isometric views taken were given in Fig. 1 show below.

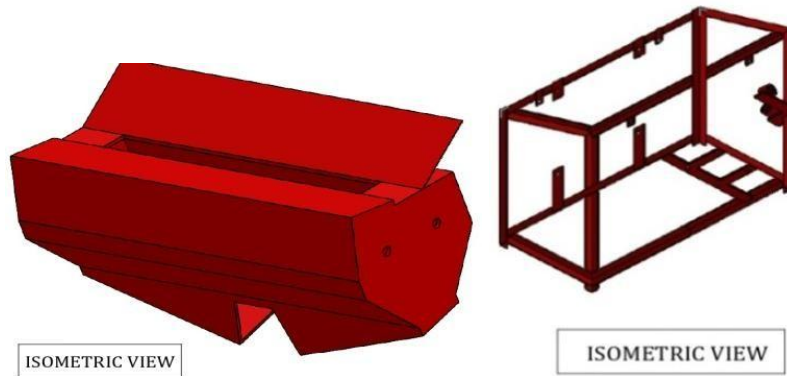


Fig. 1. Isometric view of frame and base cover

2.3 Design of Stripping Cylinder

The stripping cylinder is one of the main parts of an advanced machine. The machine cylinder does two tasks: it removes the pods from the plant and cleans them using impact and frictional force. The following presumptions are taken into account while constructing the cylinder:

2.4 Calculation of Power Requirement for Stripper

According to a study by Abady et al. [3], the tensile force needed to remove a peg from a pod is 22.26 N. The greatest force needed to extract the groundnut pod in this situation, taking into account the weight of the shaft and other mountings, is up to 110 N because we are using up to five groundnut plants. When a peanut is stripped, power is stated as Bhalavignesh [4].

2.5 Power Calculation

$$\text{Power, } P = 2 \pi N T / 60$$

$$\text{Speed required } N = 300 \text{ rpm}$$

$$P = (2 \times \pi \times 110 \times 11.17) / 60$$

$$P = 128.60 \text{ W}$$

Hence for two rotor

$$\text{Power requirement} = 128.60 \text{ W} \times 2 = 257.20 \text{ W}$$

Additional power required by the reciprocating motion in the sieve is approximately 200 W.

$$\text{Hence total power requirement is } = 257.20 \text{ W} + 200 \text{ W} = 457.20 \text{ W} = 0.61 \text{ hp}$$

As the power requirement is 0.61 and taking factor of safety of 1.5 times it will be

$$P = 0.61 \times 1.5 = 0.915 \text{ hp}$$

Hence a single phase one hp motor was selected for stripping and oscillation of sieve.

2.6 Determination of Stripping Rim Diameter

The stripping cylinder diameter can be determined by using following formulae.

$$D_c = \frac{C_{pv}}{\pi \times N_c} \quad (1)$$

Where,

D_c = Diameter of rim;

C_{pv} = Peripheral velocity of cylinder, m/s;

N_c = Speed of cylinder, rpm.

Hence, cylinder diameter is:

$$D = \frac{3.4 \times 60}{3.14 \times 316} = 0.203 \text{ m} = 203 \text{ mm}$$

2.7 Determination of Stripping Cylinder Length

Length of drum (L_d) of stripper is determined by using Winkler formula which is given by

$$L_d = \frac{F_r \times (1 - \delta')}{0.25 \times n \times N \times k} \quad (2)$$

$$L_d = 0.51 \text{ m.}$$

Where,

L_d = Length of drum

F_r = Feed rate of stripper, kg/s; $0.075 n$ = No of rims on stripping cylinder; $3 N$ = Revolution of stripping drum /s;
 $k = 0.17-0.32$ kg per meter length of drum; $\delta' = 1/\delta$;
 $\text{and} = 3$
 δ = Straw grain ratio.

$$\text{Torque, } T = \pi \tau d^3 / 16$$

$$\text{Allowable shear stress, } \tau = 42 \text{ N/mm}^2, \text{ Torque, } T = (3.14 \times 42 \times d^3) / 16 \quad 12.19 = (3.14 \times 42 \times d^3) / 16$$

Hence, Diameter, $d = 16.11$ mm

2.8 Design of Shaft

The maximum shear stress theory, commonly known as guest's theory, was utilized to build the shaft since mild steel was chosen as the material for the shaft. The maximum stress in the shaft is determined using the maximum shear stress theory Chhabra et al. [5].

The shaft diameter was calculated as 16.11 mm, but with factor of safety of 1.5 times it will be 24.15 mm. As per the availability in market the shaft diameter was taken as 25 mm.

Diameter of shaft, $d = 25$ mm. Shaft length used, $L = 1570$ mm

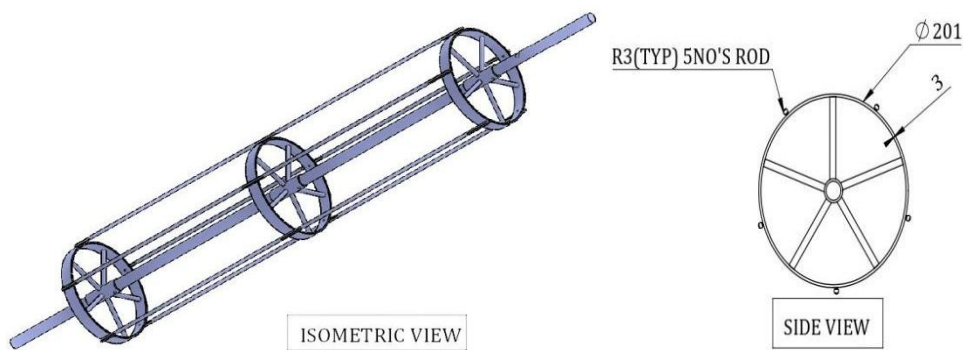


Fig. 2. Isometric view of rim

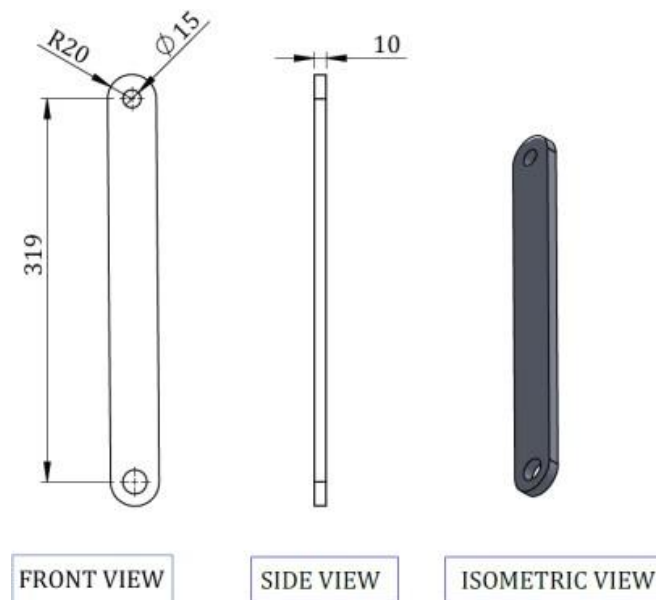


Fig. 3. Isometric view of shaft

2.9 Determination of Pulley Dimension

The peripheral speed needed for stripping of pods was determined as 300 rpm. To obtain that amount of peripheral speed the following calculation are done for determination of size driving and driven pulleys the equation given by Davies [6] were used as:

$$N_1 D_1 = N_2 D_2 \quad (3)$$

Where,

D_1 = Diameter of the drive pulley, mm;
 D_2 = Diameter of the driven pulley, mm;
 N_1 = Speed of the drive pulley, rpm; and
 N_2 = Speed of the driven pulley, rpm.

Selection of motor and pulleys:

Capacity of motor - 1 HP Speed of motor – 1425 rpm
 Diameter of smaller pulley (Mounted on motor shaft) – 50.8 mm
 Diameter of bigger pulley (Mounted on rotor shaft) – 228.6 mm
 Speed at the rotor shaft – 316.6 rpm.

To determine the value of N_2 the following calculation is done.

$$N_2 = \frac{V}{\pi D} \quad (4)$$

Where,

V = Peripheral velocity required for stripping of groundnut = 3.79m/sec
 = 3.79 × 60 = 227.4 m/min
 D = Diameter of stripping cylinder = 228 mm = 0.228 m

$$N_2 = \frac{227.4}{\pi \times 0.228} = 316.66$$

2.10 Determination of Length of Belt

Length of open belt can be determined by following formula

$$L = \frac{\pi}{2}(D + d) + 2C + \frac{(D - d)^2}{4C} \quad (5)$$

Length of cross belt can be determined by following formula

$$L = \frac{\pi}{2}(D + d) + 2C + \frac{(D + d)^2}{4C} \quad (6)$$

Where,

C = Distance between the drive and driven pulley, mm;
 D = Diameter of drive pulley, mm; and
 d = Diameter of driven pulley, mm.

2.11 Design of Sieve

$$P_{oc} = \frac{W_{si} \times f \times 2\mu \times 2y}{4500} + \frac{W_{si} \times f \times 2\mu \times 2x}{4500} \quad (7)$$

P_{oc} = Power required by oscillation mechanism, kW;
 W_{si} = Weight of sieve component along with threshed material, N;
 f = Frequency of sieve oscillation, rad/s;
 μ = Coefficient of friction of moving component; and
 x and y = Horizontal and Vertical component of the sieve, m

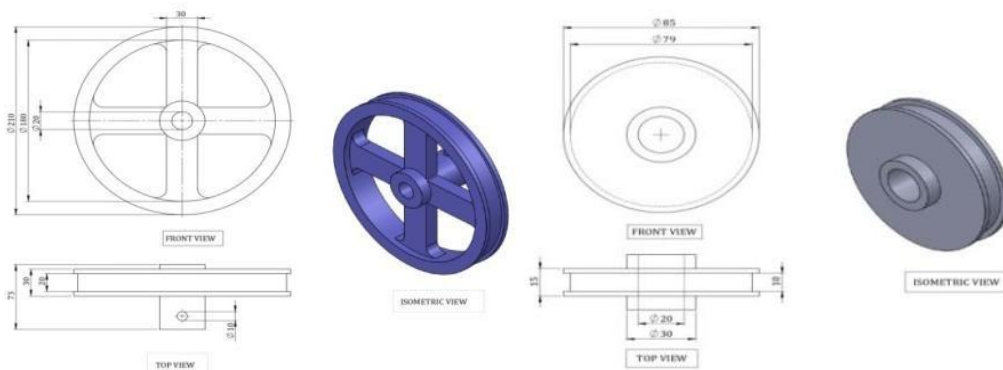


Fig. 4. Isometric view of pulley used in the machine



Fig. 5. V-belt view used in the machine

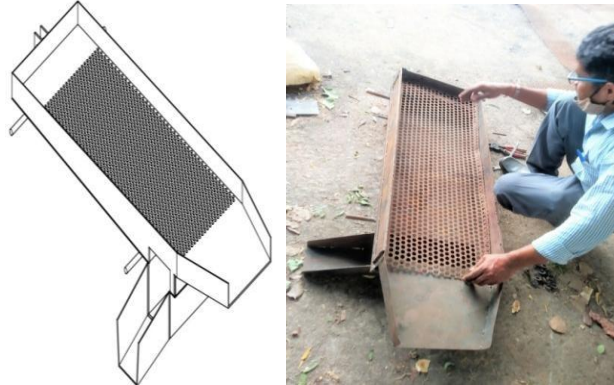


Fig. 6. Sieve Unit

2.11 Power Transmission System in Groundnut Pod Stripper

The power transmission systems of groundnut pod stripper deliver the power from prime mover to stripping unit through v-belt and pulley. Power is transmitted from motor to the driven pulley. The driven pulley shaft has a smaller pulley having 4 inch diameter on the same shaft. The 4 inch smaller pulley has a cross belt arrangement with a pulley having same diameter. It helps in

transmission of power to the adjacent shaft which rotates in opposite direction. The opposite rotation of pulley helps in detachment of the groundnut pods easily from their pegs. A smaller pulley having 2.5 inch diameter has an open belt arrangement with a pulley having diameter 5 inch. The 5 inch diameter pulley attached to the shaking mechanism of the developed stripper. The power is transmitted from the 2 inch diameter pulley via bevel gear having 22×16 teeth.

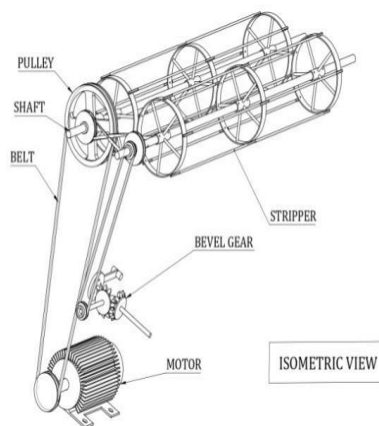


Fig. 7. Power Transmission System



Fig. 8. Developed view of the machine

2.12 Specification of Developed Machine

Particulars	Detail specifications	Particulars	Detail specifications
Type	Hold on type	Total length of stripper cylinder(mm)	1020
Power unit	1 hp single phase electric motor	Ring diameter(mm)	25
Type of drive	V-belt and pulley	5. Oscillating sieve	Shaker type:
Main crop	Groundnut	Diameter(mm)	18
Overall dimensions(LxWxT) mm	1220 x1080x1220 mm	Length(mm)	400
Main components		Drive	v-belt and pulley
1. Rim		Pulley diameter(mm)	20
No. of rim	6	Sieve Dimension (LxW)mm	415x380
Diameter of rim(mm)	20	Size of hole(mm)	12mm
2. Mainframe(LxWxH) mm	1170x560x990	6. Main pod outlet	
Shaft Diameter(mm)	25	Location	LHS of sieve
Length(mm)	1570	Height from ground level (mm)	200
3. Main drive	V-belt and pulley	7. Blower	152mm
Size of pulley:	Drive 2 diameter and driven 9	Fan diameter(mm)	
Size of belt:	V belt 65A	No. of blade	4
4. Stripping cylinder		Size of blade(mm)	640x476, 2mm thick MS plate

2.13 Performance Evaluation of Groundnut Pod Stripper

The stripper was run at a specific speed of 1425 rpm in a no-load situation for 10 minutes in order to measure the power consumption during this time. It was noted that during the operating condition, there was no belt slippage, bearing temperatures increasing, or part or belt slackness (IS: 11234, 1985).

3. EXPERIMENTAL RESULTS

3.1 Stripping Efficiency, (%)

The interaction effect of moisture content at different cylinder speed, on stripping efficiency was shown in fig 12. It was found significant effect of moisture content and speed on stripping efficiency ($\alpha=0.05$). The highest stripping efficiency was observed at 20% moisture content and 384 m/min peripheral speed and lowest stripping efficiency was observed at 35% moisture content and highest speed 480 m/min. stripping efficiency of groundnut pod stripper decreases as increasing of moisture content from 20% to 35%. Similar types of results were also obtained by many researchers in stripping of

different crop including groundnut Gojiya et al. [7], Kepner et al. [8], Kamble et al. [9].

3.2 Stripping Capacity, (%)

Stripping capacity was obtained as highest 195 kg/h at 20% moisture content and 480 m/min cylinder speed. Stripping capacity increases as increasing of peripheral speed from 384 m/min to 480 m/min.

3.3 Cleaning Efficiency, (%)

Cleaning efficiency was obtained as highest 97.473 at 20% moisture content, and 480 m/min cylinder speed. Cleaning efficiency increases as increasing of peripheral speed from 384 m/min to 480 m/min. (Fig. 14). Behera et al. [2], Simonyan and Yiljep [10].

3.4 Shattering Losses, (%)

It was also observed that loss percentage was lowest (0.637%) at 230 kg/h feed rate, and 384 m/min cylinder speed. Loss percentage was increase as increasing of feed rate and speed. Similar types of results were also obtained by many researchers for different crops [1] Olaoye et al. [11], [12-18].



Fig. 9. Preliminary test of groundnut pod stripper



Fig. 10. Final testing for groundnut pod stripper

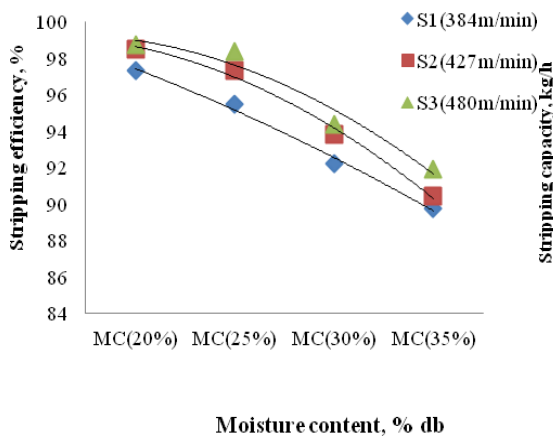


Fig. 11. Effect of moisture content at different speed for stripping efficiency

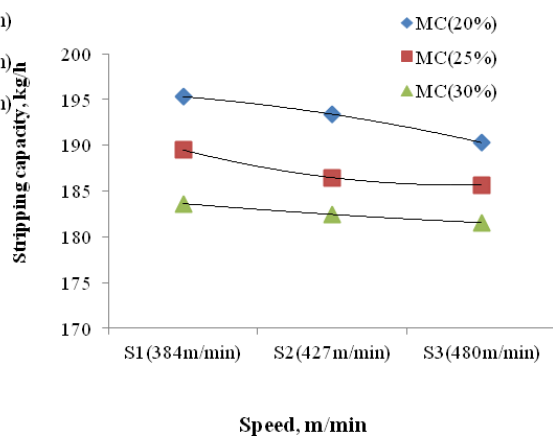


Fig. 12. Effect of moisture content at different speed for stripping capacity

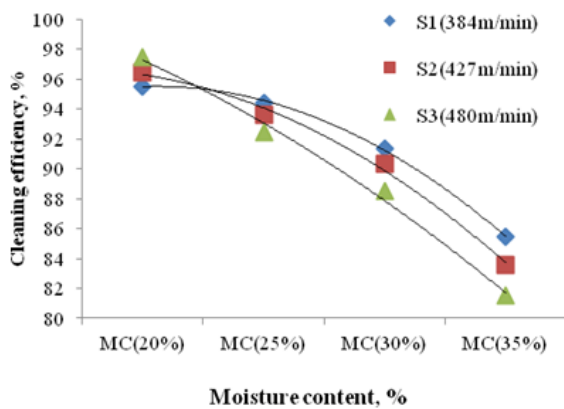


Fig. 13. Effect of moisture content at different speed for cleaning efficiency

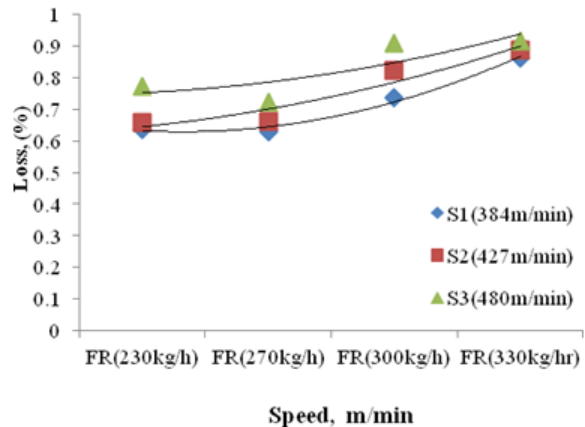


Fig. 14. Effect of moisture content at different speed for shattering losses

4. FUTURE SCOPE

1. The agriculture is the basic profession of vast of population world-wide. Some modifications can be done in this machine

and it will be used over long scale. This machine provides better help to farmers so that they can get proper income of them crop. The scope in agricultural field is tremendous. It will definitely be a vast

sector to work on to minimize man power and improve efficiency of operation, decrease cost of operation, decrease efforts.

2. The world is growing so fast and all want healthy food for healthy life. This food comes from agriculture. So the crop handling techniques should be efficient to keep it healthy. The new innovations in agriculture field will not only help farmer but also beneficial to fulfill demand by not causing price-hike.

5. CONCLUSIONS

This work presents the design and development and performance evaluation on groundnut pod stripper machine. Our groundnut stripper machine will help to improve the stripping efficiency of small farmers where electricity is not available. It will also help to reduce both stripping cost and stripping time. Requirement of more number of workers will be eliminated as only two workers can carry out the complete stripping operation. The project objectives originally are to build a groundnut pod separator and cleaner using engineering principles to process groundnut. It was found that the stripping efficiency is 97% and stripping capacity is 195kg/h, cleaning efficiency is 87% efficient. There were no losses at the but the scattering of groundnut pod was 0.83%. The total operational cost for groundnut pod stripper was found to be Rs 99.15/h and Rs 0.31/kg, which saves 85 % in cost and 95 % in time from old traditional method. The developed machine have output of 10 times more than the traditional method with profit of more than 10 times.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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