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Design, Fabrication and Performance Evaluation of Power Operated Groundnut Decorticator

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***Abstract*:- Groundnut cultivation in India is done by small scale farmers. The biggest problem in the production of groundnut in our country like India is the non-availability of better use of groundnut decorticating machines with the farmers. In this paper a low-cost groundnut decorticating machine has been designed and manufactured which will help small farmers to decorticate the finished groundnut and it can easily be manufactured by local artisans. This paper uses drums with rubber linings glued on the periphery of rotating drum or decorticating tool. Rubber pads/ linings are used for free crushing of groundnut to reduce the damage. This decorticator gives more output in less time with less effort. Machine performance was assessed in terms of decorticating efficiency, damage kernel percentage, unshelled pods percentage, and decorticating output. The main parts of the machine are hopper, crushing chamber, cylindrical tool, semi-circular sieve, kernel collecting tray and blower.**

Key words: Groundnut, groundnut decorticator, decorticating efficiency, damage kernel percentage

I. INTODUCTION

Groundnut botanically known as Arachis hypogea belongs to the Leguminosae family. India is the second largest producer of groundnut after China. It is reported that South America was the site from which peanut cultivation began and spread to Brazil, southern Bolivia and north-western Argentina. Groundnut was brought from Brazil to West Africa and then to South-West India by the Portuguese in the 16th century. Groundnut is a major oilseed crop in India. Out of more than 18 million hectares of land under edible oil is available only from groundnut seeds. India is the largest producer of groundnut in the world (32% of world production). Between (1950–1951) and (1998–99) there has been a significant increase in crop area (68.5%) and production (63%). The maximum growth in area has been recorded in the decades (1950–51) and (1960–61) (43.8%), while the decades (1980–81) and (1990–91) have been very favorable in terms of production (50%). Crop area has increased at the cost of cotton, *jowar*, *bajra* and cotton. Groundnut is a popular crop of South India. The four peninsular states - Andhra Pradesh, Tamil Nadu, Karnataka and Gujarat together contribute to more than 80% of groundnut area and production in the country.

Andhra Pradesh is the third largest producer, accounting for 24.69 per cent of the country's total area and 18.79 per cent of the total crop production. Maharashtra ranks fifth in the country in terms of area (7.07%) and production (10.04%) of groundnut. Madhya Pradesh contributes to the country's total area (3.19%) and groundnut production (2.77%). Groundnut is also produced in various states like Rajasthan, Uttar Pradesh, Orissa and Punjab. In addition to oil extraction ranked 6th in the world's oil production from vegetable and sea peanuts, groundnut kernels are used to prepare varieties of food for human consumption. Equally good number of groundnuts are used for breakfast; hence this crop is of vital importance in India. Decorticating groundnuts is a difficult and time-consuming process. The job of the decorticator is to remove the kernels from the pods. The mechanical decorticators thus developed were used in the oil milling industries where the broken kernels as well as the sound kernels were crushed to extract the oil. The general trend in the village was that the dried groundnut pods were crushed with a stone thus separating the husks and kernels. This practice damages the viability of seeds thereby affecting germination. The use of a suitable decorticator will reduce both the time and labor required to decorticate the kernels and increase the income of the farmers. Due to the lack of storage facilities and the simple way of processing groundnuts, large quantities of groundnuts were destroyed every year. The process of separating the kernel is called decortication. Groundnut should not be decorticated in places with high humidity. The moisture content of 9% (w.b.) was found to be suitable for decomposition by Bahera et al. (1995). The minimum clearance should be chosen in such a way that only the pods are deformed, not the kernels. Demonstrated automatic groundnut decorticator with 95% shelling efficiency and output range 20-25 kg/h, Singh et al. (1993). The reciprocating peanut sheller achieved 95.32% shelling efficiency, damaged seeds 6.12% and unshelled seeds 4.68%, according to Helmy et al. (2001). The manually operated roasted peanut seed peeler has a peeling chamber which greatly reduces the amount of breakage during peeling with 85% peeling efficiency, Ikachukwu et al. (2014). Kumar et al. (2018) researched on Elixir for Connect and Disconnect of Agriculture.The peanut pod and shell stripper removed barriers to open peanuts with a rotational mechanism, studied by Karthik et al. (2018). Pedal operated sheller can be used for groundnut decortication and is advantageous in view of low operating cost with shelling efficiency of 75-85% by Meshram et al. (2018). Electric powered peanut peeling machine saves electricity consumption and is easy to operate

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and transport. The machine can be used for both domestic and industrial purposes (Vishwakarma et al. 2015). To simplify the removal of husk from groundnut pods, a simple mechanism-based machine was introduced in which the mode of operation can be manual and electrically. This machine has stable performance with long life, high shelling rate, high output, less damage and quality kernel. It can be suitable for processing various types and sizes of blanched peanut seeds. This work includes design and manufacturing of Power Operated groundnut (Peanut) Decorator which is powered by 0.50 HP, 1440 rpm electric motor.

II. MATERIALS AND METHODS

The machine was constructed with major components viz. Electric motor, pulley, shaft, bearing, supporting frame of power operated device, cylindrical device, sieve, decoration chamber and electric blower as shown in Fig. 1 to 4. An electric motor of 0.50 hp was installed on the angle frame to give power. A pulley D_1 of 64 mm diameter was fixed along the motor shaft. One end of the middle shaft was attached with a pulley of size 228 mm in diameter (D_2). Pulley D_2 was connected with the motor shaft pulley D_1 with the help of a V-belt to obtain motor power. The machine is fitted with a shaft which is supported by ball bearings. The cylindrical tool is made of mild steel and the length size is 559 mm. The tool is mounted on a transmission shaft of 965 mm in length and 25.4 mm in diameter. The decoration chamber is made up of a cylindrical drum of length 600 mm with a diameter of 410 mm. Power transmission system is fixed with suitable frame. The main frame is made of angle iron of size 40×40×5 mm. It provides a base made of two angles of 686 mm each width and 762 mm in length. All parts of the machine were supported on this angle iron frame. V-belts are chosen with the required length, width and height of 1778 mm, 12.7 mm and 7.9 mm. When selecting the belt, mainly considering the speed ratio of the pulley, the diameter of the pulley on the machine shaft, the rotational speed of the pulley on the machine shaft, the diameter of the motor pulley, the rotational speed of the motor shaft and the power to be transmitted. Cylindrical tool is used for high production rates and uniform decortications with six toothed plates mounted in a cylindrical arrangement and made of mild steel. The plates are arranged in a cylindrical form with the help of two circular rings. The semi-circular sieve is one of the main parts that provides friction with the motion of the circular tool helping to remove the pods.

Semi-circular sieve is made of 1.5 mm thick slotted MS Sheet. The dimensions of the slotted sieve are 600×600 mm. The dimensions of each slot were 45×9 mm with approximately 24–25 slots per 100 cm^2 of area. There are two pulleys of different sizes on the machine. A 64 mm diameter pulley is mounted on the motor. The 228 mm diameter pulley is mounted on the transmission shaft. The required maximum tool shaft speed was 400 rpm, so to achieve 400 rpm speed from a 1440 rpm electric motor over the size of the required pulleys.

Fig. 1 Front view of groundnut decorticator Mk-I

Fig. 2 Side view of groundnut decorticator Mk-I

Fig. 3 Groundnut decorticator Mk-II

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Fig. 4 Groundnut decorticator Mk-II

A transmission shaft size 25.4 mm in diameter and 850 mm in length is placed on the machine. The size of the shaft is selected according to the size, weight of the driven pulley. These were respectively 228 mm, 6.3617 N. Another criterion of selection was the tension of the belt coming from the IS (T1 = 77.784 N, T2 = 6.858N). The yield stress was 550 N/mm2 and the safety factor was considered to be 2, so the working stress was 270 N/mm^2 and the permissible shear stress was 151.21 N/mm^2. Two ball bearings were fixed on the machine.

The inner diameter of the ball bearing is 25.4 mm according to the shaft diameter. Wet lubrication is used to lubricate the bearings for smooth operation. A 0.50 hp single phase and 1440 rpm electric motor was used to operate the machine. The total power required by the machine was mainly considered during the selection of motor for Power Operated Groundnut Decorticator. Calculated speed of tool shaft and torque required on tool shaft for power consumption. According to the literature, a 227.54 W, 1.0 hp motor was selected for the total power. But 0.5 HP motor was selected in Modified Power Operated groundnut decorticator as the weight of the tool shaft was comparatively high and the blower unit operated through a separate motor. An electric blower was used to separate the groundnut kernels and husks. Blower size is 406 mm and speed are 1440 rpm. Casing was provided to prevent groundnut splatter.

Table 1: Specifications of Modified Groundnut Decorticator Mk-II

Sl. No.	Particulars	Specifications
1.	Type of machine	Power operated groundnut decorticator
2.	Overall dimension	
	Length	762 mm
	Width	686 mm
	Height	762 mm
	Weight	96 kg
3.	Power Unit	
	Power Unit	Electric motor
	Horse power	0.50 hp
	Revolution per minute	1440 rpm
4.	Pulley	
	Number of Pulley	2
	Diameter of Driving pulley	64 mm
	Diameter of Driven pulley	228 mm
5.	Semi-circular sieve or Net	
	Length	600 mm
	Width	600 mm
	Slots size	45×9 mm
6.	Bearing	
	Type of bearing	Ball Bearing
	Number of bearings	2
	Diameter of bearings	60/60 mm
7.	Shaft	
	Number of shafts	1 (main transmission shaft)
	Diameter of main shaft	25.4 mm
8.	Electric blower	
	Blades size	406 mm
	Speed	1440 rpm
9.	Belt	
	Size	A70 (length – 1778mm)
10.	Hopper	
	Capacity	7 kg
11.	Decorticating Tool	
	Type	Cylindrical having six bars
	Length	559 mm
	Diameter	330 mm
12.	Collecting kernels tray	
	Length	720 mm
	Width	530 mm

III. RESULTS AND DISCUSSION

The power operated groundnut decorticator Mk-I and Mk-II was tested for its performance observing Indian standard power thresher safety requirement (IS9020:2002) and following Indian Standard Groundnut decorticator - Test code (IS 11473:2002). The data obtained for decorticators (Mk-I & II) are tabulated at tables 2 & 3.

The observation of Table-2 about groundnut decorticator Mk-I reveals the breakage varying from 4.19 to 4.95 % with an average value of 4.63%, while the decorticating efficiency varies from 92 to 94.15 % with an average value of 92.63%. The data is obtained with specified ambient condition and specific moisture content as per Indian Standard Groundnut decorticator –Test code (IS-11473:202). The decorticating tool speed is maintained maximum to 400 rpm. The average capacity of power operated decorticator Mk-I is found to be 247.27kg/h.

The performance of groundnut Decorticator Mk-II is tabulated at Table 3 reveals the breakage varies from 3.65 to 4.40 % with an average value of 4.02% while average decorticating efficiency and capacity of decorticator is found to be 95.06% and 334.63kg/h respectively with varying speed of drum from 250 to 400rpm while the moisture content of the pods is between 10.5 and 22.5%. The energy consumption analysis is done for with-load and without load of both the machines for its decorticating capacities and is shown at table 4 & 5.

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Table 2: Data obtained by power operated Groundnut Decorticator (Mk-I)

Sl. No.	Qty. of groundnut, g	Time taken, s	Decorticated Kernel, g	Undecorticated Kernel, g	Broken Kernel, g	Breakage, %	Decorticating Efficiency, %	Capacity of decorticator, kg/h
1	350	5	160	35	7	4.19	90.00	252.00
2	450	7	288	33	15	4.95	92.67	231.42
3	550	8	360	40	17	4.51	92.72	247.50
4	650	9	393	38	20	4.84	94.15	260.00
5	750	11	450	48	22	4.66	93.60	245.45
					Average value	4.63	92.63	247.27

Table 3: Data obtained by power operated Groundnut Decorticator (Mk-II)

Sl. No.	Moisture content, %	Qty. of groundnut, g	Speed of drum, rpm	Time taken, s	Decorticated Kernel, g	Undecorticated Kernel, g	Total husk, g	Unbroken Kernel, g	Broken Kernel, g	Breakage, %	Decorticating Efficiency, %	Capacity of decorticator, kg/h
1	10.5	1000	250	10.00	810	40	150	776	34	4.19	96.00	360.00
2	10.5	1500	200	18.75	1205	70	225	1161	44	3.65	95.33	288.00
3	10.5	2000	300	16.67	1600	110	290	1535	65	4.06	94.50	431.91
4	22.5	1000	350	13.00	775	55	170	735	40	3.84	94.50	276.92
5	22.5	2000	400	22.75	1590	100	310	1520	70	4.40	95.00	316.48
									Average value	4.02	95.06	334.63

Table 4: Energy consumption by power operated Groundnut Decorticator (Mk-I)

Trials	Without Load				With Load			
	Capacity of decorticator, kg/h	Voltage	Current in amp	Unit consumption kWh	Voltage	Current in amp	Unit consumption kWh	Energy consumption kWh/kg
T-1	252.00	170	1.18	0.2006	170	2.48	0.4216	0.0011
T-2	231.42	220	1.61	0.3542	220	3.02	0.6644	0.0018
T-3	247.50	256	2.29	0.5862	256	4.21	1.0777	0.0027
		Average unit consumption		0.38033		Average unit consumption	0.7212	0.0018

Table 5: Energy consumption by power operated Groundnut Decorticator (Mk-II)

Trials	Without Load				With Load			
	Capacity of decorticator, kg/h	Voltage	Current in amp	Unit consumption kWh	Voltage	Current in amp	Unit consumption kWh	Energy consumption kWh/kg
T-1	360.00	220	2.59	0.5698	220	4.69	1.0318	0.0017
T-2	288.00	170	1.80	0.3060	170	3.02	0.5134	0.0010
T-3	431.91	256	3.11	0.7961	256	5.98	1.5308	0.0022
		Average unit consumption		0.5573		Average unit consumption	1.0253	0.0016

Table 6: Performance comparison of power operated Groundnut Decorticator (Mk-I & II)

Power operated Groundnut Decorticator	Breakage, %	Decorticating Efficiency, %	Capacity of decorticator, kg/h	Energy consumption kWh/kg
Mk-I	4.63	92.63	247.27	0.0018
Mk-II	4.02	95.06	334.63	0.0016

The performance comparison of groundnut decorticators with energy consumptions is shown at table 6. The machine performance data shown at table 6 reveals that the breakage in decorticator Mk-II is lesser than Mk-I because of modification of Mk-II with rubber shoes glued on the periphery of decorticating tools (rotating drum). The decorticating efficiency is also better than Mk-I because the quantity of un-decorticated kernel to total weight of pods fed in the machine is also less. Similarly, the energy consumption of the groundnut decorticator Mk-II is lesser than Mk-I.

IV. CONCLUSION

The power operated groundnut decorticator Mk-I and Mk-II were tested for its performance following Indian Standard -

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Test code (IS 11473:2002) with following conclusions:

i. The performance of modified power operated groundnut decorticator (Mk-II) was better because the productivity increased and the total losses (damaged and un-decorticated kernels) decreased.
ii. The power operated groundnut decorticator Mk-II was more (334.63kg/h) than power operated groundnut decorticator Mk-I(247.27kg/h).
iii. The average breakage percentage of groundnut Decorticator Mk-II is 4.02% while average decorticating efficiency is 95.06%.
iv. The energy consumption of the groundnut decorticator Mk-II is lesser than Mk-I

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Annexure A: Important formulae and parametric relations

1.	Capacity of machine, C=W/t, kg/h where W= weight of groundnut pods fed in the machine, kg; and t= time taken for decortication, h	2.	Decorticating efficiency, percent = (1-W_u/w) x100 where W_u= weight of undecorticated pods, kg; and w = total weight of pods fed in the machine, kg
3.	Breakage, percent = $\frac{W_b x100}{W_g+W_b}$ where W_b= weight of broken kernels, kg; and W_g= weight of good kernels, kg.	4.	Specific energy requirement, E = K/W, where E = energy requirement per kg of pods, kWh/kg; K = energy meter reading, kWh; and W = weight of pods decorticated, kg.
5.	Energy consumption, $E_{sp} = \frac{1}{Q}[(P_L x\, n_L) - (P_{NL} x\, n_{NL})]$ where E_{sp}= specific energy for decortication, Wh/kg; Q = throughput of the machine, kg/h, P_L = watt meter reading(average) at load, W; n_L = efficiency of prime mover at load (assume 0.9); P_{NL} = watt meter reading (average) at no-load, W; and n_{NL}= efficiency of prime mover at no-load (assume 0.5)	6.	Volume of shelling chamber = $\pi r^2 h$ Determination of speed of driven pulley, $N_1 D_1 = N_2 D_2$ Angles of lap, $\alpha_1 = 180^0 - 2\sin^{-1}[228.6-88.9)/2560]$ Length of the belt, $L=2x+\frac{\pi}{2}(D_1+D_2)+\frac{(D_1-D_2)^2}{4x}$ Velocities of driving and driven pulley, $V_1 = \pi D_1 N_1/60,\ V_2 = \pi D_2 N_2/60$
7.	$D^3 = 16/\pi S_s[(K_b \times M_b)^2 + (K_t \times M_t)^2]^{1/2}$ Assuming, K_b, K_t as 2 and factor of safety 2	8.	Power required to drive the threshing bar, $P_D = T \times \omega$
9.	Power requirement of machine, $P_T = T \times \omega$		