J Bangladesh Agril Univ 20(3): 289–294, 2022 https://doi.org/10.5455/JBAU.34785

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Research Article

Design and Development of a Power Operated Sunflower Thresher

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ARTICLE INFO

Article history
Received: 09 May 2022
Accepted: 07 July 2022
Published: 30 September 2022

Keywords
Sunflower thresher, Design, Capacity, Seed separation

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ABSTRACT

Sunflower production is increasing in Bangladesh, but farmers face problems separating the seeds from the sunflower heads. Sunflowers are traditionally threshed by beating the heads manually with a stick. The purpose of this study was to design and fabricate a motor-driven machine that separates the seeds from the sunflower heads. An orthographic projection was drawn using SolidWorks 2016 software. The sunflower threshing machine was fabricated according to the drawing in the FMPE Divisional workshop using locally available materials in 2017-18. The developed sunflower threshing machine was modified in 2018-19. The improved model was further modified to reduce the overall dimensions while maintaining the same capacity of the machine. The number of threshing rollers was reduced from 5 to 4. A threshing fan was added to the improved version to separate the dust from the grains. The capacity of the motorized sunflower thresher was 115 and 304% higher than that of the pedal thresher and manual threshing, respectively. The capacity of the thresher varied from 89 to 125 kg/h at the moisture content from 31 to 62% (w.b.).

Introduction

Sunflower is one of the most important oilseed crops in Bangladesh. The current total area under sunflower and other minor oilseeds in Bangladesh is 1290 ha with a production of 1975 tons in 2018-19 (BBS, 2020). The area under oilseeds has been declining over the years due to various technical reasons such as lack of proper machinery (Miah et al., 2014). Agricultural machinery is an important and fundamental element for agricultural development and crop production in Bangladesh. The use of farm machinery in agriculture significantly reduces the time farmers need to complete agricultural tasks. Sunflower is one of the most important oilseed crops in Bangladesh. The cultivation area of sunflower in Bangladesh is increasing especially in the southern region (Khatun et al., 2016). Production is expected to increase over the next decade to meet the growing demand for vegetable oil in the country. The problems faced by farmers in removing sunflower seeds need to be addressed in a research paper. Removing the seeds is very time consuming and requires a lot of human labour. Either farmers remove the kernels manually or they rely on the industry to provide them with large machines to remove the kernels (Kazi et al., 2016). In the manual method, the kernels are removed by beating on the sunflower head, which is very problematic and involves a lot of labour, thus wasting time and energy. The yield of traditional manual threshing is very low and depends on the efficiency and experience of the workers. The mechanized sunflower thresher is needed to replace the reduced manual labour, thresh sunflower in the fields, shorten the threshing time, improve the quality of threshed seed and increase the threshing efficiency. Productivity, threshing efficiency, broken grains, grain loss, power consumption, cleaning efficiency, and specific energy are the indicators of thresher performance (Kibria, 1995). Ali et al. (2020) found that the threshing process of sunflower is directly dependent on feed rate, roller speed, concave clearance, and thresher type. The effectiveness of breaking the seed-head junction depends on the mode of action of the threshing equipment (El-Morsy et al., 2019). Peeneejdangang (1997) reported that threshers designed for paddy and

Cite This Article
Hoque, M.A., Hossain, M.A., Miah, M.S., Karim, M.R. and Ali, M.M. 2022. Design and Development of a Power Operated Sunflower Thresher. *Journal of Bangladesh Agricultural University*, 20(3): 289–294. https://doi.org/10.5455/JBAU.34785

soybean were tested for sunflower threshing and found that these threshers were not suitable for sunflower threshing because grain damage can be as high as 4-10%, cleaning efficiency as low as 87-92%, and grain loss as high as 20-35%. The output of the power sunflower threshing and manual hand rubbing method was 10 kg/h/man and 1.5 kg/h, respectively (Goel et al., 2009). Azharuddin et al. (2016) developed a sunflower seed extraction machine with threshing efficiency of 99.76%, seed damage of almost zero and seed loss of 0.238%. Kakhandaki et al. (2012) evaluated a sunflower thresher whose average output and percent breakage of the machine were 879 kg/h and 1.84%, respectively. Previously, BARI Farm Machinery Division (1993) developed a manual single-head sunflower thresher, which was also laborious to operate. Since there is no suitable sunflower threshing machine, farmers work with the traditional methods. Considering the above facts and the socio-economic situation of farmers in the country, a program was developed to design and manufacture a motor-driven sunflower thresher and test the performance of the sunflower thresher.

Materials and Methods

A threshing machine for sunflower seeds was designed and fabricated at the Farm Machinery and Postharvest Process Engineering (FMPE) divisional workshop, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. A number of factors were considered in the design of the engine-powered sunflower thresher. The design parameters considered included feed rate, power requirement, shaft speed and hopper capacity, etc. The main parts of the sunflower thresher are: the engine, the press roller, the sieve, pulleys and belts, and the fan. The distance between the press roller and the sieve is an adjustable part, which changes automatically by the spring action. The press roller separates the grains from the head of the harvested sunflower. Two to three heads could be drawn in at the same time. An orthographic projection was drawn using SolidWorks 2016 software. The schematic views of the previous model and the improved model of the sunflower thresher are shown in Figure 1 and Figure 2. The sunflower thresher was then fabricated according to the drawing in the workshop of FMPE department with the available local materials in 2017-18. The developed sunflower thresher was modified in 2018-19. The modified sunflower thresher was further modified in 2019-20. The dimensions were reduced to lower the price with the same capacity. The distance between the pressing rollers (38 mm to 35 mm) was reduced. In the improved version, a threshing fan was installed to separate the dust from the grains.

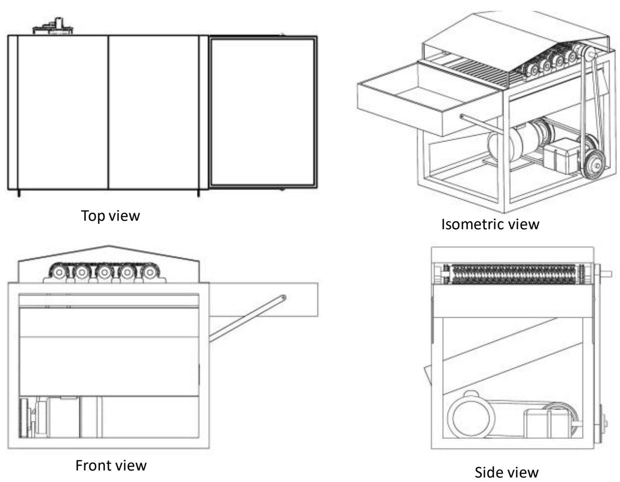

Figure 1. Schematic views of the previous model of power operated sunflower thresher developed during 2017-18.

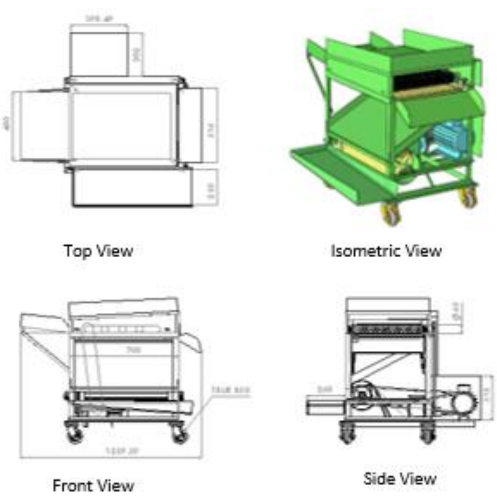

Figure 2. Schematic views of the improved model fabricated during 2018-19

Power transmission

The sunflower thresher was powered by a 0.37 kW AC single-phase electric motor. The speed of the motor was 1400 rpm. The power was divided into two parts; one was for operating the threshing roller and the other was for operating the fan. The threshing roller was operated at a speed of 220 rpm, with power transmitted through a reduction gear to reduce the speed. The blower was operated with a pulley from the motor shaft, and the best speed of the blower was found to be 1850 rpm.

Capacity of sunflower thresher

The capacity of the machine was evaluated by the amount of sunflower head that could be threshed within a given time to obtain seed. In this case, 10 kg of sunflower was placed in the machine and the time to complete threshing was recorded. This was calculated using the following equation

$$C = \frac{Q}{T}$$

where,
C = Capacity of the machine
Q = Mass of processed sunflower head
T = Time taken for processed

Broken seed

The percentage broken seed was determined during the threshing process. The broken seed was separated from the whole seed by hand picking immediately after the threshing process was completed. This was computed using the equation

$$P_2 = \frac{M_2}{M_a} \times 100$$

where,
P_2 = percentage of broken seed
M_2 = mass of broken seed
Ma = actual mass of seed fed into the machine

Unshelled seeds

The percentage of unshelled seeds during the threshing process was calculated. This was computed using the following equation

$$P_3 = \frac{M_3}{M_0} \times 100$$

where,
P_3 = percentage of unshelled seeds
M_3 = mass of seed unshelled
M_o = mass of seed unshelled + mass of seed shelled

Winnowing efficiency

The percentage of winnowing during the threshing process was calculated. This was computed using the following equation

$$P_4 = \frac{M_4}{M_4 + M_5}$$

where,
P_4 = percentage of winnowing
M_4 = mass of clean seed
M_5 = mass dust mixed with clean seed

Economic analysis

Operation cost estimation of sunflower thresher

An economic analysis of the sunflower thresher was performed. The cost analysis included the operating costs of the machine. The operating costs of the machine included fixed costs and variable costs. The fixed costs of the machine included capital consumption and housing. Variable costs included labour, electricity, repair, and maintenance. Labour was required to operate the machine.

Fixed cost

Fixed cost of the machine included annual depreciation, interest on investment, and shelter. Capital consumption included depreciation and interest.

i) Capital consumption (CC)

$$CC = (P - S)CRF + S \times i$$

where,
P = purchase price, Tk
S = salvage value, Tk
CRF= capital recovery factor

$$CRF = \frac{i(1+i)^L}{(1+i)^L - 1}$$

where,
i = rate of interest
L = life of machine, yr

ii) shelter, T = 3.0% of purchase price of the machine, Tk

Total fixed cost per year

$$FC = CC + T$$

Variable Cost

In calculation of variable cost, the following relations were assumed

i) labour cost per hour, L_b=Tk man-h^{-1}

ii) electricity cost per hour, E=Lit h^{-1}

Total variable cost

$$VC = L_b + E$$

Annual cost/operating cost

$$AC = FC + VC$$

Results and Discussion

A sunflower thresher was improved according to the improved drawing of the design. Figures 4 and 5 show pictorial representations of the earlier and the improved sunflower threshers. The various parameters of the sunflower thresher are shown in Table 1. The threshing process was performed by the friction of four rotating press rollers of 330 mm length and 70 mm diameter. The friction was facilitated by a sieve placed under the rollers. The distance between the press roller and the sieve was an adjustable part, which changes automatically due to the spring action. The distance between the roller and the sieve was 20-25 mm. The thresher was operated by an electric motor of 0.37 kW. The weight of the thresher was reduced from 135 to 105 kg.

Figure 4. Pictorial view of the model-1 of power sunflower thresher

Improved model

Commercial model

Figure 5. Pictorial views of the improved power sunflower thresher

Table 1. Different parameters of the power sunflower thresher

Parameters	Model 1	Improved model	Commercial model
Overall dimension (mm)	1075 x 660 x 785	1260 x 1015 x 1150	1090 x 1030 x 760
Dimension of main frame (mm)	762 x 580 x 625	762 x 580 x 625	600 x 600 x 460
Dimension of feeding hopper (mm)	480 x 355 x 90	480 x 355 x 90	360 x 360 x 90
No of pressing roller	05	05	04
Threshing roller dimension (mm)	460 x Ø 65 dia.	460 x Ø 65dia.	330 x Ø 70 dia.
Space between roller (mm)	38	35	35
Space between roller and screen (mm)	20-25	20-25	20-25
Fan dimension (mm)	-	750 x Ø 200 dia.	490 x Ø 230 dia.
Wheel diameter (mm)	-	100	100
Motor capacity	0.75 kW	0.75 kW	0.75 kW
Weight of the machine	90 kg	135 kg	105 kg

The comparative capacity of sunflower threshing is shown in Table 2. The capacities of the pedal thresher and manual threshing were 47 and 25 kg/h, respectively. The capacity of the motor-driven sunflower thresher was 101 kg/h, which was 115 and 304% higher than that of the pedal thresher and manual threshing, respectively. The highest threshing capacity was found to be 212 kg/h by Ismail and Elhenaway (2009), but this was a batch thresher.

Table 2. The comparative capacity of the sunflower threshing during 2019-20

Rep	Mass of head threshed, (kg)			Time, (Sec)			Capacity of the machine, (kg/h)		
	Power Thresher	Pedal thresher	Manual	Power Thresher	Pedal thresher	Manual	Power Thresher	Pedal thresher	Manual
1	2.0	2.0	2.0	80	120	202	90	48	26
2	3.0	3.0	3.0	102	228	315	105	47	24
3	5.0	5.0	5.0	168	392	525	107	46	25
						Average	101	47	25

Performance of the power sunflower thresher at different moisture content is shown in Table 3. Capacity of the thresher was varied with moisture content. Capacity of the thresher was varied from 89 to 125 kg/h within 31 to 62% moisture content (w.b.) of the head. Unshelled sunflower seed was higher in heads having higher moisture content. Broken seed was only found in higher moist head (less than 1%). Winnowing efficiency was higher for threshing dried heads.

Table 3. Performance of the power sunflower thresher at different moisture content

Moisture Content of head, % (w.b.)	Capacity, kg/h	Unshelled seeds, %	Broken seed, %	Winnowing, %
62	115	12.96	0.25	82.30
	125	16.41	0	80.95
	117	13.35	0.50	80.25
Average	119	14.24	0.25	81.17
58	102	12.79	0	85.55
	110	13.47	0	86.50
	107	12.05	0	86.25
Average	106.33	12.77	0	86.10
31	93	9.74	0	93.80
	92	10.17	0	92.60
	89	13.67	0	91.41
Average	91.33	11.19	0	92.60

The economic analysis of the sunflower thresher for different models is shown in Table 4. The operating costs of the improved model and the commercial model were 1040 Tk/ton and 960 Tk/ton, respectively. The BCR of the improved model and the commercial model were 1.4:1 and 1.6:1, respectively.

Table 4. Economic analysis of the sunflower thresher for different models

Sl. No.	Cost Items	Improved model	Commercial model	Manual
1	Purchase Price, Tk	45000.00	35000.00	
2	Working days per year, yr	30	30	
3	Working hours per year, h	240	240	
4	Machine life, yr	7	7	
5	Salvage value, Tk	4500.00	3500.00	
6	Capital consumption cost (CC), Tk	8768.92	6820.27	
7	Shelter cost, Tk	225.00	175.00	
8	Total fixed cost, Tk/year	8993.92	6995.27	
9	Total fixed cost, Tk/h	37.47	29.15	
10	Labour cost per hour, Tk/h	62.5	62.5	62.5
11	Electric cost , Tk/h	4.27	4.27	
12	Total variable cost, Tk/h	66.77	66.77	62.5
13	Total operating cost, Tk/h	104.24	95.91	62.5
14	Capacity of the machine, kg/h	100	100	25
15	Operating cost, Tk/kg	1.04	0.96	2.5
16	Operating cost, Tk/ton	1040.00	960.00	2500.00
17	Custom hire-based income (@250 Tk/ton), Tk/yr	60000.00	60000.00	

18	Net Profit, Tk/yr	34983.00	36982.00
19	BCR	1.4:1	1.6:1

Two commercial models of the sunflower threshing machine were manufactured by Mahbub Engineering Workshop, Jamalpur. One threshing machine was sent to OFRD (On Farm Research Division), Patuakhali, and the other to OFRD, Bhola, in 2019-20. The sunflower threshing machine of Patuakhali was demonstrated by the scientists of OFRD, Patuakahli (Figure 6) and used by the farmers. The capacity of the sunflower thresher was 100 kg/h, which was similar to the capacity observed in the laboratory. Detailed performance data could not be collected due to transportation constraints caused by COVID19.

Figure 6. Field use of the sunflower thresher in Patuakhali

Conclusion

The capacity of the commercial model of the motor-driven sunflower thresher was not reduced by reducing the overall dimensions. The capacity of the thresher was varied with moisture content. The sunflower thresher was evaluated in farmers' fields in Patuakhali and showed similar capacity as in the laboratory. Farmers expressed satisfaction but suggested that feeding systems should be improved.

References

Ali, K.A.M., Huang, X., Zong, W. and Abdeen, M.A.M. 2020. Mechanical structure and operating parameters of sunflower harvesting machines: *A review. International Agricultural Engineering Journal,* 29:143–153.

Azharuddin, K., Mir, S., Narasimhan, M.M. and Kumar, G.P. 2016. Design and fabrication of sunflower seed extracting machine. *International Journal of Latest Technology Engineering Management Applied Science, 5*:90–97.

BBS. 2020. Yearbook of Agricultural Statistics. Bangladesh Bureau of Statistics (BBS). Statistics and Informatics Division (SID). Ministry of Planning Government of the People's Republic of Bangladesh. www.bbs.gov.bd

El-Morsy, H.E., El-Ashr, A.S. and El-Kfrawy, A.A. 2019. Development and performance evaluation of a rubbing thresher for sunflower crop. *Journal of Soil Science and Agricultural Engineering Mansoura Univerity,* 10 (1):61- 67. https://doi.org/10.21608/jssae.2019.36668

Goel, A.K., Behera, D., Swain, S.B. and Behera, K. 2009. Performance Evaluation of a Low-Cost Manual Sunflower Thresher. Indian *Journal of Agricultural Research,* 43 (1):37-41.

Ismail, Z.E. and Elhenaway, M.N. 2009. Optimization of machine parameters for sunflowers thresher using friction drum. *Journal Agricultural Science Mansoura University,* 34(10):10293-10304.

Kakhandaki, Shivanand, H., Anantachar, M. and Madhusudhan, M.S. 2012. Performance evaluation of high-capacity sunflower thresher. *International Journal of Agricultural Engineering,* 5(2):138-141.

Kazi, A., Safiulla, M., Manohar, N.M. and Kumar, P. 2016. Design and fabrication of sunflower seed extracting machine. *International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS),* 5(5):90–97.

Khatun, M., Tanvir, M.B., Hossain, M.A., Miah, M., Khandoker, S. and Rashid, M.A. 2016. Profitability of sunflower cultivation in some selected sites of Bangladesh. *Bangladesh Journal of Agricultural Research,* 41(4):599-623. https://doi.org/10.3329/bjar.v41i4.30694

Kibria, S.A.M.S. 1995. RNAM Test codes & procedures for farm machinery in economic and social commission for Asia and the pacific regional network for agricultural machinery, Technical Series 12, 2nd ed., Publisher: Bangkok, Thailand, 6.

Miah, M.A.M., Rashid, M.A. and Shiblee, S.M.A. 2014. Assessment of socioeconomic impacts of oilseed research and development in Bangladesh. Final report submitted to PIU-BARC, NATP: Phase-1, BRAC complex, Farmgate, Dhaka 1215.

Peeneejdangang, S. 1997. Field tests of an axial flow rice thresher for sunflower threshing. A paper presented at Seminar II, Agricultural Engineering Department, Khon Kaen University, Thailand.