International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 15, 2018, pp.-6793-6795.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Review Article

POWER THRESHERS FOR EFFECTIVE THRESHING OF CROPS SINCE GREEN REVOLUTION - A REVIEW

TIWARI R.K.*, DIN M. AND KUMAR MANISH
ICAR- Central Institute of Agricultural Engineering, Nabibagh, Berasia Road, Bhopal, 462038, India
*Corresponding Author: Email - rk96tiwari@gmail.com

Received: July 25, 2018; Revised: August 10, 2018; Accepted: August 11, 2018; Published: August 15, 2018

Abstract: This paper focuses on review of development of proven designs for threshing of cereals, oilseeds, pulses for savings of labour, time and cost of operations. The development of power threshers started in India in mid 1950's.The use of mechanical power for threshing started with the use of chaff cutters in Punjab. It was used to chop up the wheat crop, which also partially threshed the heads. Mechanical threshers of varying power range (3.7-15 kW) are commercially being manufactured which not only thresh the grain but also provide good quality bhusa for cattle feed. It is estimated that there are nearly 30 million threshers of various designs in operation in the country. The annual addition to this number is 2,00,000 units. Multi-crop threshers in 3.7 kW capacity have been developed at CIAE, Bhopal, ANGRAU Hyderabad and PAU Ludhiana centres of AICRP on FIM and these have been commercialized through industrial liaisoning. These designs proved successful in reducing total losses, power consumption, straw/stalk size, human drudgery ensuring quality produce. The main parameters which affected the performance of the threshers, were speed of the threshing cylinder, feed rate and moisture content of the harvested crop. The intensity of the impact of the pegs of the cylinder on the crop was dependent on the rotating speed of threshing cylinder which affected the threshing efficiency, grain damage and power requirement. For higher threshing efficiency, fine straw quality and minimum specific power consumption, rectangular spiked threshing cylinder of 600 mm tip diameter and spike thickness of 6 mm have given best performance results with total grain loss within permissible limit. The spike thickness of 6 mm gave minimum broken grain loss with fine straw quality. The round spiked (plain spike) threshing cylinder with same configuration of threshing cylinder showed best results. But from mass manufacturing point of view, tip diameter of 600 mm and 8 mm round spike thickness will be appropriate for manufacturers. It also delivered good output capacity and threshing efficiency and fine straw quality.

Keywords: Fine straw, power consumption, spike thickness, output capacity, threshing efficiency

Citation: Tiwari R.K., *et al*., (2018) Power Threshers for Effective Threshing of Crops Since Green Revolution - A Review. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 15, pp.- 6793-6795.

Introduction

The principle of rotary threshing is not new, having been invented nearly 200 years ago. Peg drums which originated in North America, were discontinued in Europe mainly because of excessive breaking of dry straw, which added to grain separation problems. It was only after 1950s that Japan, South Korea, Taiwan, China, and other Asian countries began to adopt small power threshers. In Japan, threshers progressed from hand-feed to mechanical head-feed, and from stationary to self-mobile machines. In Philippines, ninety percent of the rice crop is mechanically threshed. Many thresher designs have been manufactured in China, such as conical throw-in threshers, twin-drum through-flow types, vertical-shaft as well as horizontal axial-flow and fan-type power threshers. In Republic of Korea, automatic threshers (HI-5105 and HI-510) of threshing cylinder of 460 mm width and 420 mm diameter were common having 108 number of spikes. Other models JY-810, JY-880 had diameter of threshing cylinder of 510 mm. In Thailand M/s Ruang Thong Machinery Ltd., Bangkok had threshing cylinder of 355.6 to 457.2 mm diameter and 1219.2 to 1828.8 mm length delivering 1500-3000 kg/h output capacity. Animal operated Olpad threshers became very popular in mid sixties on wheat farms. Such threshers consisted of a group of 8-20 notched discs of 400-500 mm diameter mounted on 2-3 axles. A seat provided for the operator, transport wheels for easy manoeuverability and a screen cover on discs to avoid accidents were the salient features of such threshers. The output capacity of such thresher was about 75 kg/hour.The development of power threshers started in India in mid 1950's (1). In order to obtain clean grain, the threshed crop was winnowed in a separate operation. M/s Friends Own Foundry, Ludhiana under the guidance of Er SK Paul, Agricultural Engineer, Department of Agriculture, Punjab produced the first power thresher for wheat which could thresh, clean and bag the grains in a single operation. In this thresher, the threshing was carried out by hammer mill type threshing head and separation and cleaning were accomplished through the aspirating action of the air passing through the sieve by a blower which also sucked and flew away the bhusa to some distance (2). Proper selection of a power thresher is important for low operational cost and accident free operation of the unit. The selection criteria included the capacity, type, safety aspects, availability of spare parts, facilities for repair, source of prime mover and suitability for different crops. Spike tooth type threshers used a threshing drum with spikes mounted on its periphery. Cleaning and separation is accomplished by an aspirator and a set of sieves. Unlike other threshers, crop was fed through a feeding chute or a hopper for bulk feeding. The later was safer because the operator did not work in the vicinity of any of the moving parts and the crop was sucked in to the machines by the revolving cylinder.This was due to radial feeding of crop as against axial pushing in the beater type, syndicator type and drummy threshers; the resistance offered by the rotating members was quite high . Such threshers were able to handle crop which had a moisture content in the range of 8 to 10% (3). The traditional methods have gradually been replaced by power threshers operated by 3.7-11.2 kW engine or electric motor. Tractor pto driven threshers with capacity ranging from 1.5-2.0 tonnes per hour are also in use. More than 80% wheat, barley, gram, soybean, sorghum and pearl millet crops are estimated to be threshed by mechanical power thresher. Multi purpose high capacity harvesting and threshing equipment's are being developed to reduce turn around time and drudgery. Multi-crop threshers, designed on the basis of axial flow principle, are suitable for threshing wheat, paddy, oilseed and pulse crops. These threshers have provision to regulate threshing drum and blower speed independently so as to reduce grain breakage and improve cleaning.

Nearly 90% of wheat threshers are spike tooth type and majority of them are operated by a prime mover of 3-4 kW. For threshing samples of wheat, gram lentil, soybean and rice development of CIAE single earhead power thresher and multi-crop plot thresher contributed to researchers in precision agriculture projects. The handling capacity of such threshers ranged 3-4 times faster over manual method of threshing. A multi-crop thresher was developed with spike tooth cylinder and a fixed cylinder-concave clearance. This thresher resulted in wheat straw split of 25 to 30% of original length. This thresher could handle jowar, bajra, mustard, wheat and paddy (4). The threshing cylinder diameter varied from 445 to 610 mm for peg tooth type threshing cylinder (5). The threshing capacity of a given crop was dependent upon the length of threshing cylinder. For threshing cylinder diameter of 550 mm, the permissible feed rate varied 0.35-0.40 kg/s.m. Every 5% increase of moisture reduced the permissible feed rate by 15 to 25%. The results indicated that the greatest quantities of grains were sieved in the central part of the threshing cylinder.A survey of thresher manufacturers in Bhopal district was carried out. For almost all sizes of thresher (3.75 to 18.65 kW), the main shaft size was 50 mm made from bright bar. The concave was made from 6 mm square MS bar. The frame of the thresher was fabricated from the box section made from angle size 65x65x6 mm. For higher size of the thresher the angle sizes used was 65x65x8 mm. The power thresher of 3.7 kW had market share of 50% and fitted with 46 number of pegs (6). With 200 h of annual use (4 q/h grain) or 150 tonnes of grain threshing, a thresher needed peg replacement once in three years. Therefore, with life span of 12 years, thresher pegs needed replacement 3 times. The energy requirement was minimum (1.40-2.50%) for syndicator type thresher but grain crackage was minimum (0.20-0.40% for spike tooth type thresher. During late sixties AAI power thresher (3.7 kW) was designed and developed. It is a spike tooth type, which has a threshing cylinder of 456 mm diameter and 300 mm length. Forty-five spikes (bits) of 12.5 mm diameter and 75 mm length were fitted in nine rows. It delivered threshing capacity of 208 kg/h and total grain losses of 0.5%. At the feed rate of 530 kg/h, the threshing and cleaning efficiencies were 99.9 and 99.2%, respectively. Pantnagar multicrop thresher was based on IRRI axial flow threshing principle and was used mainly for paddy. It was modified for threshing of wheat. The crop was fed into the machine at one end of the cylinder and moved axially to the other end. Threshing and separation took place continuously along the length of the cylinder. In case of wheat, louvers were covered and complete material fell through the concave grate. It consisted of peg tooth type cylinder of 680 mm diameter and 1400 mm length. The spike teeth (120 no) of 18 mm diameter and 150 mm length were fitted. During field test, the thresher gave threshing capacity of 312 kg/h for wheat and the labour requirement was 1 man-h/q (7).PAU Wheat cum paddy thresher consists of a spike tooth cylinder with eight rows of staggered spikes, the cylinder had three distinct portions. The machine had a threshing cylinder with round spikes arranged in 8 rows. The spikes were arranged in two portions. The first is 375 mm long with 15 mm spikes spaced at 62.5 mm with spike projections on side of the flat of 70 mm for wheat and other side 50 mm for paddy. The second portion is 690 mm long with 12.5 mm spikes with first 11 spikes at 62.5 mm pitch and the remaining at 125 mm. The third portion is about 150 mm long having four straw throwing paddles. Full length of cylinder is useful for paddy whereas for wheat only first portion is used. First portion of the spike bars was equal to the width of the feeding chute. Different types of spikes for threshing wheat and paddy are used. The grain output of the thresher reported for wheat was 2 q/h and for paddy 2-8 q/h. It is operated by a 3.75 kW motor or 6 kW diesel engine. The CIAE multi-crop thresher, suitable for wheat and paddy, consists of spike tooth cylinder, aspirator type blower and sieve shaker. The threshing cylinder diameter and lengths were 500 and 584 mm respectively. In the thresher, ninety-two flat spikes of size 25x8x80 mm were provided. The threshing cylinder was fitted with forged spikes mounted on 8 bars in staggered fashion. Cylinder is closed with 180o concave with front clearance of 25 mm and rear clearance of 100 mm. For wheat, threshing and cleaning efficiency were respectively 99.84% and 99%, at threshing cylinder speed of 19.3 m/s. It saved 26-39% labour and operating time and 22% in cost of operation. For major crops like wheat, gram, soybean, sorghum, maize and paddy, the output capacities were 276, 348, 200, 540, 1635, 392 kg/h, respectively. A batch type, single earhead thresher was developed suitable for threshing samples of wheat in the form of single ear or a bunch of ears. The diameter and length of threshing cylinder were 210 and 160 mm, respectively. The threshing efficiency and cleaning efficiency were 99.94 and 99.97%, respectively. At threshing cylinder speed of 600 rpm, broken grain was 0.37%. It saved 50-70% labour and operating time and 60% on cost of operation compared to conventional method of manual threshing by trampling.

Multicrop plotthresher consisted of spike tooth cylinder of 250 mm dia and 250 mm length suitable for precision threshing of wheat. The results indicated 99.3% threshing efficiency, 93.4% cleaning efficiency and 29.5 kg/h output capacity. At 1100 rpm broken grain, grain recovery and power consumption were 0.02%, 99.83% and 0.65 kW, respectively. CIAE High capacity (15 kW) multi-crop thresher consisted of spike tooth threshing cylinder of 700 mm diameter and 1100 mm length. It was provided with 3 aspirator blowers, cleaning sieves and automatic feeding and bagging systems. ANGRAU power thresher consisted of threshing cylinder of 500 mm diameter and 610 mm length. It is suitable for threshing of wheat and other crops including paddy. The thresher gave cleaning efficiency of 98% and labour requirement of 9 man h/q. High capacity Harambha thresher consisted of threshing cylinder (combination of chaff cutter and spike tooth type), two aspirator blowers and three perforated sieves. The overall dimensions of thresher were 4100x1630x2290 mm. The threshing cylinder had diameter of 815 mm length and 520 mm length. The cylinder had beaters of 135x35x8 mm in six rows. At threshing cylinder speed of 10-13 m/min, the output capacity of thresher was 15-20 q/h. Pedal operated thresher consisted of wire-loop type threshing cylinder operated by foot pedal or motor. It is suitable for threshing rice. It saved 20 percent labour and 40 percent operating time as compared to conventional method of hand beating on a wooden platform. It costs Rs. 5500/- and its cost of operation is Rs. 28/q. The axial flow multi-crop thresher operated by single phase 1.5 kW motor/power tiller engine was designed and developed at GBPUAT, Pantnagar for threshing of cowpea, soybean, black gram, paddy and wheat crops. The output capacity of machine ranged 80-100 kg/h. Total losses varied 2.45-2.78%. A whole crop maize thresher was developed for shelling of maize cob and simultaneously converting stalk to chaff. The thresher was designed for 5.5 kW power with spike tooth cylinder having 6-7 bolts per row on periphery. The output capacity of whole crop maize thresher was 210 kg/h. The output of grain was observed as 640 kg/h with chaff size of 18 to 52 mm.

Power operated maize dehusker-cum-sheller consisted of threshing cylinder of 495 x 1460 mm size with peg type drum. It used centrifugal type blower. The output of machine varied from 16.9 to 20.5 q/h at moisture content of 11.8 to 24.8% with an average material capacity of 18 q/h. (8). CIAE High capacity pigeon pea thresher consisted of automatic chain conveyor type feeding mechanism, tapered spike tooth type threshing cylinder, woven wire mesh concave, two aspirator blowers, shaker assembly and transport wheels. The thresher gave output capacity of 262-281 kg/h at threshing cylinder speed of 1195 rpm. The cost of threshing was Rs 147/t and maximum broken grain was 1.52%. Groundnut pod stripper consisted of a wire loop type cylinder powered by 1.5 kW electric motor. Stripping is done by holding the pod portion of a bunch manually over spiked cylinder. Its cost of operation was Rs 43/q compared to Rs 65/q with manual stripping (9). Multi-millet thresher was developed to facilitate timely threshing of the crop and to achieve higher output with better quality. It was found suitable for cleaning and grading of millets seeds. Threshing capacity of the equipment ranged 80-150 kg/h. It saved 30 man-h/ha over traditional threshing method. Power operated axial flow sunflower thresher consisted of a feed hopper, bar type cylinder, thrower, two sieves, concave and a blower. The cylinder of length 1500 mm had two portions, the first one of 1300 mm for threshing and the second of 200 mm for straw throwing. The machine was operated by 5.6 kW motor/tractor and has a capacity of 8.0 q/h clean grains. Tractor or Electric Motor Operated Multi-crop Thresher for Seed Spices was developed at MPUAT, Udaipur in collaboration with M/s Makewell Industries, Unjha (Gujarat) and evaluated for threshing of cumin and coriander crops.The output capacity of thresher was 240-260 kg/h. A light weight paddy thresher cum cleaner operated by 0.75 kW electric motor was developed by NEH, Barapani centre of AICRP on Farm Implements and Machinery. It consisted of main frame, threshing unit, blower, sieving unit and power transmission unit including single phase 0.75 kW electric motor.

CIAE semi axial flow multicrop thresher consisted of spike tooth cylinder, aspirator blower and sieve shaker. It is suitable for threshing wheat and other crops including paddy. The threshing cylinder diameter and length were 540 mm and 740 mm. Seventy-two spikes of length 80 mm and 1.6 mm diameter were provided on threshing cylinder. At cylinder speed of 21 m/s, wheat output capacity was 350 kg/h (10). A commercial multicrop thresher (PAU design) was modified for threshing safflower crop and it was evaluated at two moisture content (10.89%, 12.05%) on wet basis, three cylinder speed (840, 735, and 630 rpm) and two feed rates (240, 180 kg/h). At fixed concave clearance (32 mm), the threshing efficiency and grain damage were 98% and 0.97%, respectively. The output capacity was 72.48 kg/h (11). A spike tooth thresher having threshing cylinder of 562 mm long and 362 mm diameter was tested at four cylinder peripheral speed (16.4, 18.2, 20.1 and 21.9 m/s) and three levels of crop feed rate (700, 850 and 1000 rpm). It gave optimum threshing and cleaning efficiency for pigeonpea at 18.2 m/s and feed rate of 1000 kg/h. The threshing and cleaning efficiencies were 99.56% and 98.63%, respectively. The seed breakage was 0.27% for pigeonpea (12). A multicrop thresher with replaceable bar type threshing drum was evaluated for maize, wheat, sorghum and barley. The mean output capacity for maize, wheat, sorghum and barley were 2526.31 kg/h, 386.98, 780.68 and 121.62 kg/h, respectively. The threshing efficiency were 99.39, 99.79, 98.63 and 98.56% and grain damage were 0.35, 2.2%, 1.12% an 0.10% during threshing for maize, wheat, sorghum and barley (13).

Results and discussion

The threshing efficiency, cleaning efficiency, output capacity and power consumption of high capacity multi-crop thresher (15 kW capacity) were 99.9, 99.1, 1380 kg/h and 12.5 kW, respectively. It saved 50% labour and operating time and 54% in cost of operation compared to conventional spike tooth thresher. NEH Barapani paddy thresher cum cleaner of 0.75 kW capacity gave threshing efficiency, grain output capacity and losses of 99.2%, 143 kg/h and 2%, respectively. The threshing efficiency of the thresher was more than 99 percent of axial flow sunflower thresher. There were saving of 85% in labour, 75% in time and 30% in cost of operation for power operated axial flow sunflower thresher. The groundnut pod stripper developed by ANGRAU Hyderabad centre of saved 66 percent labour, 80 percent operating time and 30 percent on cost of operation. It also resulted in 10 percent reduction in losses as compared to conventional method of manual stripping. The cost of operation of power operated maize dehusker cum sheller was Rs. 500/t against Rs. 1500/t by traditional method. There was a saving of about 60-70% in cost of operation and about 90% in labour for using maize dehusker cum sheller as compared to traditional method of dehusking and threshing. ANGRAU power thresher (3.7 kW capacity) saved 33% labour, 44% operating time and 89% cost of operation compared to conventional method of beating with stick manually. The total grain losses and cleaning efficiency varied 0.5-1.5% and the cleaning efficiency was 99% in threshing by high capacity Hadamba power thresher. CIAE semi axial flow multicrop thresher gave threshing efficiency, cleaning efficiency and total grain losses of 99.5, 99.3 and 1.5%, respectively. It saved 27-40% labour and operating time.

Conclusion

There are different designs of power threshers (3.7-11.2 kW capacity) have been and adopted by farmers for foodgrains, oilseeds and pulses which reduced human drudgery and achieved timeliness in threshing operations. The small light weight power threshers (0.75 kW capacity) have been developed for hilly region states. The spices crops threshing could be successfully performed by MPUAT spices thresher (3.7 kW capacity) with high output capacity. The axial flow threshers for sunflower, groundnut, soybean, rice and wheat are commercialized across the country through industrial liasioning.

Application of review: Threshing of crops consumes power or fuel which can be saved by selecting appropriate critical components and better quality crop grains can be obtained ensuring good returns. The multicrops thresher which provides higher threshing efficiency with automation during peak season have ample scope for adoption. The manufacturing Industries follow these designs for different crops threshing across the country.

Review Category: First green revolution in threshing equipment

Abbreviations:
RPM: Revolution per minute
AAI: Allahabad Agricultural Institute
PAU: Punjab Agricultural University
CIAE: Central Institute of Agricultural Engineering
mm: Milli-metre, kW: Kilowatt
ANGRAU: Acharya NG Ranga Agricultural University

Acknowledgement / Funding: Author is thankful to ICAR- Central Institute of Agricultural Engineering, Nabibagh, Berasia Road, Bhopal, 462038.

***Research Guide or Chairperson of research: Dr S Ganesan**
Institute: ICAR- Central Institute of Agricultural Engineering, Bhopal, 462038
Research project name or number: Review Scenario during last 50 years

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

References

[1] Sharma V.K., Mehta M.L. and Verma S.R. (1995) *Testing and evaluation of agricultural machinery-PAU Ludhiana Publication, pp* 151-154.
[2] Anonymous (1974) *Test Report No.THR-15/70 on Spike Tooth type thresher. Farm Machinery Testing Centre, Department of Farm Power and Machinery, PAU, Ludhiana*.
[3] Bainer Roy, Barger E.L. and Kepner R.A. (1960) *Principles of Farm Machinery. III Edition, CBS Publishers, Liverpool, UK.*
[4] Harrington R.E.(1970) *J. Agril. Engg*., 7(2), 49-61.
[5] Klenin N.I., Popov I.F. and Sakun V.A. (2001) *Agricultural Machines. Kolos Publishers, Moscow*, 413.
[6] Badegaonkar U.R. and Bhardwaj K.C. (1996) *CIAE Annual report* .1995-96, 27.
[7] Pandey M.M., Majumdar K.L., Singh Gyanendra, Singh Gajendra (1997) *Farm Machinery Research Digest. Agriculture. Technical Bulletin No: CIAE/FIM/1997/69. Central Institute of Agricultural Engineering, Bhopal*. 318.
[8] Mehta C.R., Tiwari R.K. (2017) *Farm Implements and Machinery - At a Glance. Technical Bulletin No. CIAE/FIM/2017/217. Central Institute of Agricultural Engineering, Bhopal,* 30.
[9] Pandey M.M., Ganesan S., Tiwari RK. (2005) *Farm Mechanization Package for Dryland Agriculture. Technical Bulletin No: CIAE/FIM/2005/117. Central Institute of Agricultural Engineering, Bhopal.*
[10] Singh G. (1998) *Two decades of CIAE. Technical report No. CIAE/98/78. Central Institute of Agricultural Engineering, Bhopal,* 211-216.
[11] Karthik S.K., Kumar Satish, Basavaraj (2015) *International Journal of Agricultural Sciences and Research*. 5 (5), 313-321.
[12] Dora Baldev, Dogra Ritu, Singh Saravjit, Manes G.S. (2014) *Legumes Research,* 37 (6), 628-634.
[13] Abagisa Hussen, Tesfaye Teka, Befikadu Dubale (2015) *International Journal of Sciences: Basic and Applied Research,* 23 (1), 242-255.