

Design and Development of Automatic Vertical Flow Pulse Thresher Suitable for Different Pulses

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ABSTRACT--- *Semi-automatic and power operated vertical flow pulse thresher-cum-winnower was developed by the author¹ for efficient threshing and winnowing of matured crops of a variety of pulses having diverse physical characteristics, wherein threshing and winnowing operations were carried out separately. Therefore it was upgraded to a compact, hybrid and fully automatic pulse thresher-cum-winnower by the author¹ to overcome power constraints in villages as well as to obtain combined operations of threshing, crushing and winnowing together. Feeding of dry crop into thresher is manual, while rest of operations are automatic without human touch. Significant features are >99% threshing and winnowing efficiency, almost nil seed loss and seed breakage, crushing all crop residues into powdery animal fodder, dust free cleaning of seeds, and by 3 hp prime mover; either oil engine with simplest clutch arrangement and/or with single phase electric motor. Threshing and crushing actions are executed by multiple progressive shears and impacts through a set of radial rotary beater and stationary beater inside a vertical hopper, like in semi-automatic pulse thresher. The crops flow vertically downwards into shear zones by scissoring actions of the beaters and gravity. Seeds are separated and cleaned by an improved winnower-cum-grader, and the crushed crop residues are disposed from the machine by a combined mechanism of walker and flat air jet. Configuration and performance of this fully automated vertical flow thresher for threshing of different types of pulses are presented and discussed.*

Keywords--- Combined mechanism of threshing, crushing & winnowing, variety of pulses of diverse physical characteristics, vertical flow, high efficiency without seed breakage

1. INTRODUCTION

Existing axial flow multi-crop threshers or any other versatile threshers were not efficient for threshing matured crops of a variety of pulses having different physical characteristics [2, 3, 5]. General pulses like black gram, green gram (Moong), horse gram (Kulthi), red gram, arhar, lentil, etc are consumed every day along with cereals to supplement proteins in households of India. Production of these pulses are comparatively very less when compared to production of cereals by an individual farmer. Therefore traditional threshing methods are commonly practiced by the farmers. These are stamping (treading) by heavy animals, rolling the roller/ tractor or by beating the dry crops by heavy stick. Due to such improper threshing, 10% to 15% seeds are lost in the crop residues, and maximum 85% seeds are recovered and 50 to 60% crop residues are crushed into small sizes. Animals also eat away 3-5% seeds during threshing. Loss of seeds in crop residues is estimated to nearly 1-2 million ton pulses per year in India [6, 8]. Moreover cleaning of seeds is not very good, which leads to damage of pulse due to pest infection during storage. As the crop residue, called as 'Bhusa' is mixture of dried green leafy biomass & un-threshed pods with seeds and has nutritious value, most of the farmers feed Bhusa to their bullocks and cows. The traditional threshing & winnowing methods are highly labour intensive and non-economical [1, 4].

Physical characteristics of these pulses such as shape, size & type of seeds, pods and plants are quite different from each other. Plants of these pulses, except arhar, are leafy and short height within 8 inch. These are grown in less rain fed areas. In few places of coastal Orissa, India the black gram plants are creeper in nature and 1 to 2 meters long [13]. The dry plant of horse gram and lentil are soft & strong but not brittle and its stem does not break easily, whereas the dry plant of black gram and its pods are brittle which break easily. The pods of green gram are brittle but its stem & root are thick and strong which take more time for mutilating. The dry plant of red gram is short and strong, not brittle and not breaks easily. The beans or pods of these pulses are thin. The seeds or grains of the pulses are also different from each

other. The seeds of black gram and green gram (Moong) are partly spherical and partly cylindrical, whereas the seeds of horse gram are flat and circular. The seeds of red gram are not completely spherical but somewhat irregular [4, 6]. The Bulk density of the grains of black gram and green gram varies from 1251 to 1305 kg/m³ [10].

In order to overcome the above mentioned shortfalls in traditional threshing methods and axial flow multi-crop threshers, a semi-automatic & power operated vertical flow pulse thresher-cum- winnower was developed by the author¹[6, 8, 13]. Its design was optimised after undergoing rigorous tests in laboratory with different pulses such as green gram, black gram, horse gram and red gram. This machine had achieved >99% threshing efficiency, <1% seed loss in crop residues, almost nil damage of seeds, >90% germination of seeds, crushing of entire crop residues into powdery animal fodder, 10% increase in yield of seeds over traditional methods during threshing above mentioned pulses[9, 13]. It was operated successfully with 2 hp single phase electric motor without changing any parts or operating parameter unlike axial flow threshers. Threshing and winnowing operations were carried out separately. 14 sets of semi-automatic pulse thresher & winnower were also extensively tested and demonstrated for a period of one year among the farmers in different villages of 14 districts of Odisha, India in different geographical conditions. The extensive field trials were carried out under direct supervision of Agriculture department, Government of Odisha as a third party to assess its efficacy & acceptability by the farmers. The semi-automatic pulse thresher & winnower was commercialized and propagated in Odisha by Govt of Odisha under National Food Production programme to enhance production of pulses and reduce seed loss & drudgery of farmers [8, 9, 13]. But main hurdle observed during field trails was poor voltage of electricity power supply in many villages. The electric motor could not operate in rated speed. Therefore voltage step-up transformer (Inverter) was needed to operate the pulse thresher. Many farmers had suggested replacing electric motor by oil engine for poor quality power supply. Some had also suggested for combined operations of threshing and winnowing at a time by a common prime mover. Some rich farmers had suggested for development of a fully automatic pulse thresher with built-in winnower operated by oil engine [9, 13].

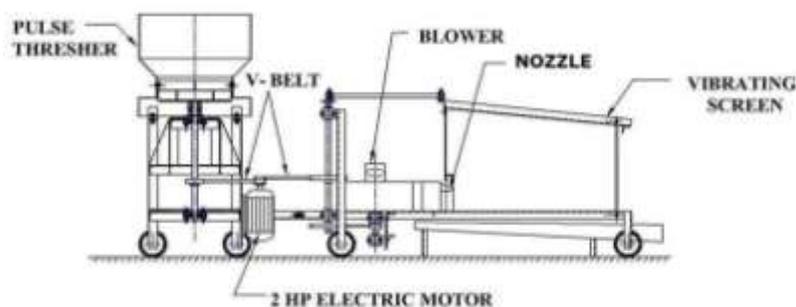


Figure 1: Semi-automatic vertical flow pulse thresher & winnower

A fully automatic, compact and engine/ power operated pulse thresher with built-in winnower-cum-walker was designed and developed by the author¹ to overcome above mentioned shortcomings and also to make the vertical flow pulse thresher more acceptable & useful by the farmers. Configurations & performance of Automatic pulse thresher with winnower are described below.

2. MATERIALS AND METHODS

The principle and design of the fully automatic compact type vertical flow Pulse Thresher is completely new at present. The semi-automatic mechanism of the pulse thresher was upgraded to fully automatic by incorporating threshing and winnowing operations in a single unit. All operations of the automatic thresher, except feeding of crop into the machine, such as threshing of dry crop, crushing of crop residues into small pieces, separation of grains from the crop residues, winnowing and cleaning of grains, removal of sand, mud and foreign particles from the grains and flow of all materials inside the machine are carried out simultaneously without human touch. During operation of the thresher, dry crops of pulses are fed into the hopper manually at the top end of the machine, while clean grains are collected through a chute at bottom of the machine and the crushed crop residues are removed from the machine through another chute automatically. Major components of the machine are vertical flow thresher, winnower, walker, reciprocating sieve & tray, rectangular air nozzle and various power trains. These components are designed and developed separately to obtain maximum efficiency. Then the optimised components are coupled together to form the final prototype of fully automatic pulse thresher-cum-winnower. The prototype was tested in laboratory & field to evaluate its performance with various types of pulses. The schematic diagram and picture of the automatic pulse thresher-cum-winnower are shown in figure 2.

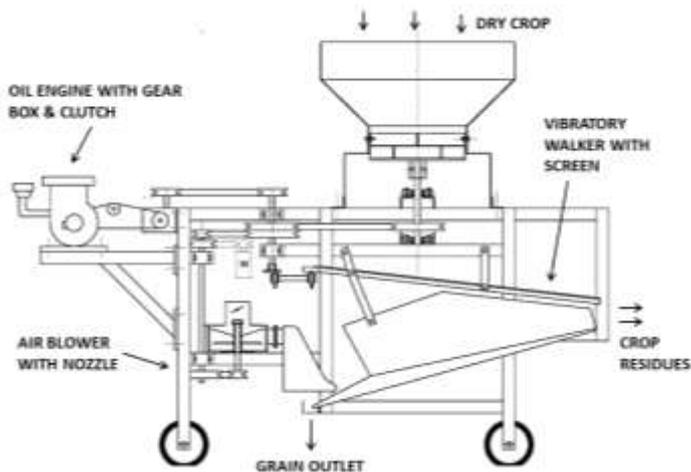


Figure 2: Automatic vertical flow pulse thresher-cum- winnower

2.1. Pulse Thresher

The principle of progressive shearing was adopted in development of pulse thresher. All operations of threshing such as opening of pods, removal of grains and crushing of plants are completed in a narrow shearing zone [9, 13]. The main components of the pulse thresher are fixed beater and moving beaters, which are placed inside a vertical shape hopper (cylinder). The moving beater is mounted on a shaft coaxial with the vertical hopper (cylinder). The moving beater along with the shaft rotates by a 3 hp electric motor / engine. The combination of fixed beater, moving beater and cylindrical hopper creates progressive shear actions and impacts, by which complete threshing and crushing of crops are carried out together.

During threshing, dry crops of pulses flow vertically drawn wards towards shear zone inside the hopper under influence of progressive shear actions and gravity. Then the crushed materials gain centrifugal force from the moving

beater and strike hard on annular surface of a secondary cylinder in the thresher. So that unbroken dry pods if any, break easily to complete the threshing operation. The threshed materials release through bottom opening of the cylinder. Threshing and crushing operations of the crop are carried out together inside the thresher, i.e. crushing the entire crop residues into small pieces and separation of the grains from the pods. The innovative design of the beaters creates 7000 shear actions per minute in a narrow zone. Therefore power requirement for threshing is quite less compared to the axial flow threshers [13]. It is found that the pulse thresher requires only 2 hp motive force, which can be provided by a single phase electric motor/ engine to obtain threshing capacity of 500 to 600 kg dry crops hour. However 3 hp motive forces are provided to avoid overload and jamming.

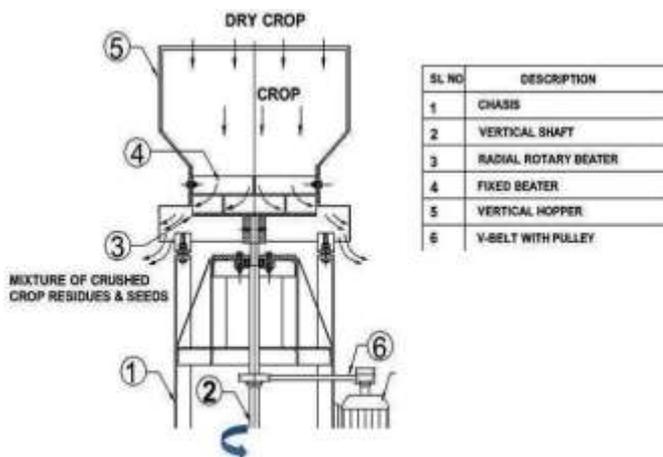


Figure 3: Threshing mechanism of vertical flow pulse thresher

2.2. Winnower

A set of winnower is placed below the pulse thresher for separating and cleaning the grains from the crop residues. The winnower comprises of air blower, air nozzle, reciprocating sieve, reciprocating tray and product chute [9]. Both the thresher and winnower are operated by a common prime mover through pulley & belt drive power train. All these components are placed one above another in different vertical layers. Thresher, Reciprocating sieve, Reciprocating tray, Air blower with nozzle and product chute are placed in an order from top to bottom as shown in figure 4. The reciprocating sieve is inclined suitably down wards so that the mixture of small size crop residues and grains are screened and passed through the sieve. Large size crop residues are separated over the sieve and thrown out of the machine by the

combined mechanism of the air jet, ridges of the walker and inclination of the sieve. The air blower along with rectangular nozzle is placed below the reciprocating sieve in the same direction of flow as the inclination. The reciprocating tray is placed below the sieve in reverse inclination, while the air nozzle is positioned in between the sieve and tray. The flat air jet always flows below the reciprocating sieve and glides over top surface of the reciprocating tray.

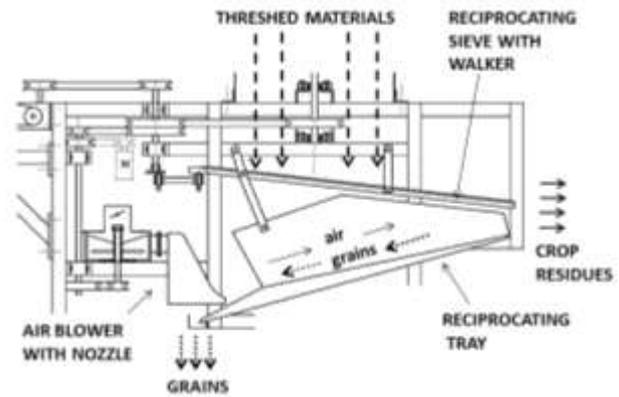


Figure 4: Winnowing mechanism of Auto- vertical flow pulse thresher

After threshing, the crushed materials are released automatically from thresher to the reciprocating sieve where the mixture of grains and small size crop residues are separated from large size crop residues. The sieved materials are further fluidised by the air jet over the tray. The light particles such as chaps, bhusa, dust etc are carried away and thrown outside the machine by the air jet leaving behind the heavy & less aerodynamic particles, such as grains, sand, pebbles on the inclined surface of the reciprocating metallic tray. As the inclination of the tray is reverse to direction of flow of air jet, only grains & heavy particles roll down from the tray to the product chute. There is a chute attached at the end of the metallic tray and a small sieve is placed along the path of the grains at the end of metallic tray, which facilitates separation of dust and sand particles from the grains. The clean grains discharge from the chute with help of vibration of the machine. In this way, the reciprocating sieve & tray and winnower carry out separation and cleaning of grains from the crop residues.

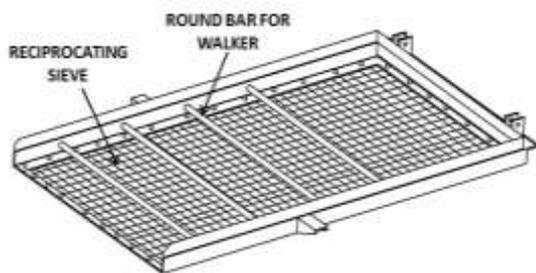


Figure 5: Reciprocating sieve-cum-walker

2.3. Operation

Basically the vertical flow pulse thresher contains three important zones to complete threshing & crushing operations, i.e. self-feeding, shear and impact zones. Both threshing & crushing operations are carried out inside the vertical hopper. Similarly winnower contains two important zones to complete winnowing operations such as sieving & cleaning of grains and disposal of crop residues without seed loss. During operation of the machine, the dry crops are drawn into the shear zone by influence of progressive scissoring actions executed by fixed & rotary beaters and also by gravity. Then the crop is trapped by the progressive shear actions of the beaters. The crops are cut into small pieces as well as sheared to open the pods in a narrow clearance between the fixed and moving beaters. The crushed material is further sheared in the annular space between vertical outer edges of the moving beater and inner surface of the cylinder. Unbroken pods (beans) present in the crushed materials are open in this shear zone.

Then the mixture of crushed crop residues and grains are discharged outside from the shear zone through the annular openings of the moving beater at bottom of the cylinder. The crushed material moves at very high tangential velocity and strikes hard on the inner surface of a secondary hopper where strong impact actions are carried out. Any remaining unbroken pods present in the crushed materials are open here due to impact actions and threshing operations get completed. In this way, threshing of matured crops of pulses; such as self-feeding of crops into the thresher, opening of pods, removal of grains and cutting of crop residues are carried out together to obtain 100 % threshing efficiency. Few vertical deflectors are provided on the inner surface of the secondary hopper to divert the radial motion of the threshed mass to vertical motion. So that the threshed mass are discharged from the thresher vertically downwards to the reciprocating sieve. The winnower and grader are placed just below the thresher which contains reciprocating sieve & tray and rectangular nozzle with air blower. All these components are operated by an auxiliary shaft which is powered by a common prime mover through v-belt drives. A flat air jet having high aspect ratio is generated by the nozzle which covers entire area below the reciprocating sieve at a uniform velocity. The air jet also always glides over the top surface of the reciprocating tray. Therefore only clean grains are collected through the chute after removing all foreign particles without seed loss in the crop residues.

The compact type fully automatic pulse thresher can be operated either by electric motor or oil engine. A 3 hp single phase electric motor is incorporated to run the machine. As voltage of electric power is not uniform and adequate in

villages, a 3.1 hp oil engine with gear box and simple clutch arrangements are also incorporated with the thresher. So that this automatic pulse thresher can be operated at any place as per desire of the farmers and local conditions.

3. RESULT AND DISCUSSION

The optimised prototype of the automatic pulse thresher-cum-winnower was developed step by step. Individual components were tested separately to obtain maximum efficiency. The thresher was tested in the laboratory and fields for assessment of performance. Then the thresher was demonstrated at farmer's places in many villages to ensure acceptability by the farmers.

3.1. Performance evaluation

The Automatic Pulse Thresher-cum-Winnower equipped with 3 hp single phase electric motor was tested in laboratory and its overall performance is shown in the Table 1. The same prototype fitted with 3.1 hp oil engine (petrol start kerosene run engine) was tested in different villages and its average performance is shown in Table 2.

Table-1: Laboratory performance of automatic vertical flow pulse thresher-cum-winnower

Parameters	Black gram is	Green gram	Horse gram	Red gram
Average moisture in crop (%)	10.5	9.5	10.0	11.0
Threshing efficiency, (%)	99.10	99.50	99.96	99.20
Winnowing efficiency, (%)	> 99	> 99	100	> 99
Threshing capacity of dry crop, (kg/hr)	420	410	390	450
Seed loss in crop residues, (%)	< 1	< 1	Nil	< 1
Breakage of seed, (%)	< 0.30	< 0.25	Nil	< 0.2
Size of crop residues, (mm)	<80	<80	<100	<80
Quality of crop residues suitable for fodder,(%)	100	100	100	100
Loss of half-filled seeds in un-threshed pods	< 0.25	< 0.25	Nil	Nil

- Average threshing capacity in terms of seed: 100 to 175 kg/hr, depending upon growth & yield of crop.
- Average threshing capacity: 400 kg dry crops per hour with <10% moisture.

Table-2: Performance of automatic vertical flow pulse thresher-cum-winnower during field trails in villages.

Parameters	Black gram is	Green gram	Horse gram	Red gram
Average moisture in crop (%)	10 - 12	10 - 15	8-10	6-11
Threshing efficiency, (%)	99.60	99.20	100	99.75
Winnowing efficiency, (%)	> 99	> 99	100	> 99
Threshing capacity of dry crop, (kg/hr)	400	390	385	430
Seed loss in crop residues, (%)	< 1	< 1	Nil	1.0
Breakage of seed, (%)	< 0.25	< 0.20	Nil	<0.10
Size of crop residues, (mm)	<100	<100	<100	<80
Quality of crop residues suitable for fodder,(%)	100	100	100	100
Loss of half-filled seeds in un-threshed pods	< 0.25	< 0.2	Nil	< 0.2

- Average threshing capacity in terms of seed: 100 to 175 kg/hr, depending upon growth & yield of crop.
- Thresher got jammed with green gram crop having 18 to 25% moisture.

3.1.1 Comparison between Automatic Vertical flow Pulse Thresher with traditional threshing methods and Semi-automatic Vertical flow Pulse Thresher



Figure 6: Operation of Automatic Vertical Flow Pulse Thresher

Matured crop of black gram was threshed simultaneously by traditional method, Automatic Pulse Thresher fitted with 3.1 hp oil engine and Semi-automatic Pulse Thresher fitted with 2.0 hp electric motor in a village to compare performances. The traditional method comprising threshing by stamping of animals and winnowing through natural wind were conducted. A particular crop of black gram was collected from one land, dried under sun for equal period and tested in all cases. Therefore physical characteristics such as size, growth & moisture content of the crop were kept equal in all tests. The performances of different threshing methods are shown in Table 3. Germination studies of the seeds of different pulses threshed by automatic pulse thresher were carried out, and its performances were compared with germination results of the seeds threshed by semi-automatic thresher and hand threshing.

Table-3: Comparison between the performances of fully Automatic Vertical flow Pulse Thresher with semi-automatic Pulse thresher-cum-winnower with traditional threshing method.

Parameters	Automatic Pulse Thresher	Semi-automatic Pulse Thresher	Traditional (By animal stamping)
Name of pulse	Black gram	Black gram	Black gram
Manpower used	02	02	02
Number of animals used	Nil	Nil	04
Threshing capacity of dry crop (kg/hr)	410	435	185
Recovery of seeds from 100 kg dry crop (kg)	39	39.5	34
Seed loss in crop residue, (%)	< 1	< 1	12
Seed breakage, (%)	< 0.28	< 0.24	Nil
Size of crop residue within 100mm length, suitable for fodder (%)	100	100	33
Increase of yield over traditional threshing methods, (%)	14.7	16.1	---

Table-4: Comparison between germination of seeds threshed by Automatic & Semi-automatic Pulse threshers and hand threshing

Name of Pulse	Average moisture content of crops (%)	Germination of seeds (threshed by Automatic Pulse thresher) (%)	Germination of seeds (threshed by Semi-automatic Pulse thresher) (%)	Germination of seeds (threshed by hand) (%)
Black Gram	9.5	90	89	92
Green Gram	11.0	91	90	93
Horse gram	10.5	91	90	91
Red Gram	9.5	92	92	94

3.2. Operating parameters controlling efficiency

3.2.1 Threshing

More than 99% threshing efficiency was achieved by automatic pulse thresher for threshing different pulses such as black gram, green gram, horse gram and red gram in laboratory tests and field trials at farmer's places. These results are almost equal to performance of semi-automatic pulse thresher. Important parameters like speed of rotary beater, shear clearance between rotary & fixed beaters and bottom opening between hopper & rotary beater plate control the performance of threshing. Like in semi-automatic pulse thresher, these parameters were also optimised to obtained highest efficiency irrespective of different type of pulse used. Therefore, adjustment or changing of any parts was not required during threshing of different pulses. It is well ascertained from test results shown in table 1 to 2.

Threshing efficiency was studied with the crops having different moisture content in a range of 10% to 25%. It was found from laboratory & field test results in table 1 to 2 that highest threshing efficiency (>99%) is obtained when moisture of all crops was less than 10%. Green gram having 15% moisture can be threshed to obtain >99% efficiency. The rotary beater of the thresher was jammed and machine was stalled when moisture content of the crops was more than 20%. Shear clearance, speed of rotary beater and moisture content of the crop determines the size of crop residues. 100% of crop residues were less than 100mm size when moisture content of the crop was less than 10%. Therefore entire crop residues were suitable for animal fodder.

Seed breakage & seed loss as un-threshed pods depend upon shear clearances between beaters & hopper and annular discharge opening area. All these parameters were optimised & fixed in the machine. It is found from table 1 to 2 that seed breakage and un-threshed pods were negligible during threshing all such crops.

3.2.1 Winnowing

Efficiency of winnowing, separation of seeds & disposal of crop residues predominantly depend upon design of three major components i.e. reciprocating sieve, reciprocating tray and air nozzle. Other operating parameters like frequency of reciprocation of sieve & tray with air jet velocity control these efficiencies. Four circular mild steel thin round bars were provided on the reciprocating sieve which serves as walker. The sieve & tray are inclined in opposite directions, but placed one above another as shown in figure 4. Degree of inclinations of sieve & tray also control winnowing efficiency. Therefore each component were designed, developed and tested separately for obtaining maximum efficiency. All optimised components then were coupled together to form the winnower of the automatic pulse thresher.

Frequency of reciprocation of sieve and tray were kept equal. The combination of frequency of reciprocation with inclination of sieve & tray were optimised to obtained >99% separation of seeds from the threshed mass and 100% disposal of crop residues without seed loss from the machine. The walker rods were provided to increase residence time of the threshed mass over the sieve in order to remove 100% seed & dust through the sieve openings. Size of sieve opening was also optimised for 100% removal of seeds of four different pulses mentioned above along with minimum quantity of crop residues & dust.

The blower and nozzle were designed to generate a flat air jet having high aspect ratio in such a manner that a uniform velocity was maintained in between sieve & tray as shown in figure 4. Top layer of the air jet spreads below the sieve to carry dusty & light materials from the winnower to outside. While bottom layer of the air jet always glides over top surface of the tray, which facilitates to roll & push the small size crop residues from tray to outside. The seeds with sand particles roll down to product chute over tray by its reciprocation actions & downwards inclination. The sand particles are removed from the seeds on a secondary sieve at rear end of the tray. Inclination, frequency of reciprocation & vibration of the tray and configuration of flat air jet control the degree of cleaning of seeds.

3.2.3 Field trials & dissemination

The automatic vertical flow pulse thresher comprising above mentioned optimised parameters and components was tested in laboratory and at farmer's places in villages. Performance results are shown in table 1 to 2. Performance of the optimised prototype in field was as good as laboratory performance. Drying of crops of pulses at farmer's places was not uniform. Free flow and automatic disposal of crop residues from the machine to outside was found little slow than in laboratory tests. Therefore the rear end of the prototype was lifted up by 100 mm, by which downward inclination of the reciprocating sieve was increased by 2.9° and upward inclination of reciprocating sieve was reduced by 2.9°. Then free flow with automatic disposal of crop residues from the machine was satisfactorily without sacrificing threshing & winnowing efficiency.

Germination tests of seeds threshed by automatic thresher and hand threshing were carried out to access quality of seeds. Its results were also compared with the germination tests carried out earlier by semi-automatic pulse thresher. All results are shown in table no 4. It is found that germinations of seeds threshed by automatic & semi-automatic pulse thresher were as good as hand threshing, and more than 90% germination was obtained in all cases.

The automatic pulse thresher attached with a 3.0 hp single phase electric motor was tested in laboratory. While in villages, it was fitted with 3.1 hp oil engine with additional attachment of a gear box, v-pulley & belt power drive and a simple clutch arrangement, figure 7. The clutch was a belt tensioner with a load to engage & disengage the gear box with the oil engine in order to reduce overall cost of the thresher. This type of simple clutch (belt tensioner) was worked well with negligible belt slippage and power loss. Starting of engine was easy without engaging the pulse thresher. The automatic pulse thresher with this simple clutch arrangement had functioned well continuously up to 8 hrs per day without any breakdown during 60 days of field trails in villages.

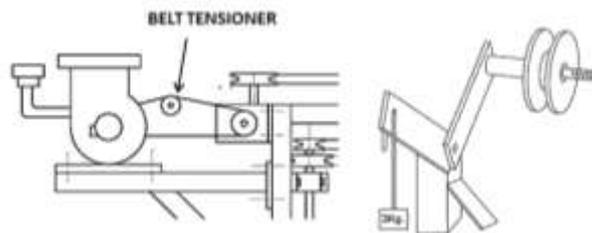


Figure 7: Clutch mechanism by belt tensioner

The automatic vertical flow pulse thresher attached with oil engine was functioned well on farm lands in villages. The oil engine was a petrol start kerosene run engine and average kerosene consumption was 1.4 litre/ hr for threshing 400 kg/hr dry crops of black gram yielding 140 kg seeds/ hr. Disadvantage of the engine operated automatic pulse thresher was bulky in size and its height was increased. So its cost was more than electric operated automatic pulse thresher. Like semi-automatic pulse thresher, this automatic prototype was able to reduce 70 to 80% energy when compared over axial flow multi-crop threshers. This machine was 2 to 3 times faster than traditional threshing methods. Grains obtained by automatic thresher were very clean and free from dust & foreign particles, for which pest infection of the grains during storage was greatly eliminated. Technology of both power/ engine operated automatic pulse thresher was transferred to few entrepreneurs in Odisha, India for mass production & marketing. It was disseminated among farmers providing subsidy under National Programme of Food Production by Government of Odisha to enhance yield of different pulses, reduce labour & drudgery of farmers and to reduce loss of pulses during harvesting. This automatic vertical flow pulse thresher can be further modified to tractor driven prototype, replacing oil engine, gear box and additional power train in order to reduce its manufacturing cost.

4. CONCLUSIONS

Power/ engine operated vertical flow automatic pulse thresher-cum-winnower was successfully developed and upgraded from semi-automatic vertical flow pulse thresher in order to obtain simultaneous & automatic operations of threshing & winnowing together. Automatic pulse thresher was found successful in threshing dry crops of a wide range of pulses having diverse physical properties with >99% threshing & winnowing efficiency, <1% grain loss, >90%

germination of seeds, converting entire crop residues into animal fodder, without damaging seeds, high degree cleaning of seeds and increasing 15% yield of grains over traditional methods through a 3.0 hp prime mover, either oil engine or single phase electric motor as per local conditions in villages. The shortfalls found in semi-automatic pulse thresher were eliminated in automatic prototype to obtain high acceptability by the farmers.

5. ACKNOWLEDGEMENT

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