Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7140

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (6):** 838-852 (2018)

International Journal of Pure & Applied Bioscience

Research Article

OPEN ACCESS

Performance Enhancement of Pre-cleaner and Gravity Separator

Patil Pawankumar[1*], T. K. Goswami[2], Lad Priti[3] and Pachpor Nitesh[3]

[1,3]Department of Process and Food Engineering,

College of Agricultural Engineering and Technology, Saralgaon, Thane, India

[2]Agricultural and Food Engineering Department (AgFE), Indian Institute of Technology (IIT) , Kharagpur, India

*Corresponding Author E-mail: pawanpatil1815@gmail.com

Received: 9.11.2018 | Revised: 13.12.2018 | Accepted: 19.12.2018

ABSTRACT

Cleaning and grading are the first and most important post harvest operations undertaken to remove foreign and undesirable materials from the threshed crops/grains and to separate the grains/products into various fractions. The pre-cleaner cleaner is the basic machine in almost all seed processing plants. The air screen cleaner uses three cleaning principles viz aspiration, scalping, grading. A common air screen cleaner processing seed uses two air blasts and two screens. The first air system removes dust and light chaff before the seed reaches the first screen .The first screen allows the good seed to drop into the second screen. The large foreign material rides over the first screen and is discarded. The second screen is a grading screen.The specific gravity separator makes the separation according to difference in density or specific gravity of the materials. This separator works on two principles,1) the characteristics of grains to flow down over an inclined surface, 2) the flotation of the particle due to upward movement of air. Mechanical cleaning with vibratory as well as rotary screen grain pre-cleaner is mostly adopted in grain markets nowadays, but these machines can give desired results if the important factors affecting, performance are selected, calibrated and operated. However, a rational approach to the design, selection and operation of the mechanical cleaning system does not exist. It is understood in a general that factors like the screen area, screen slope, feed rate and air velocity influence the cleaning efficiency and cleaned grain output per unit time of these systems. Screen effective surface area of 2.29 m^2, screen slope of 6°, air velocity of 9.08 m/s and feed rate of 1.75 kg/s were optimum values of the independent variables for flat screen grain pre-cleaner. Air velocity of 2.4 m/s (70% flap opening), deck angle of 2.05° and deck oscillation of 500 rpm were optimum values of independent variables for gravity separator.

Key words: *Cleaning, Grading, Screens, Pre-cleaner, Specific gravity separator, Screen slope, Screen area, Feed rate and Air velocity.*

Cite this article: Patil, P., Goswami, T. K., Priti, L. and Pachpor. N., Performance Enhancement of Pre-cleaner and Gravity Separator, *Int. J. Pure App. Biosci.* **6(6):** 838-852 (2018). doi: http://dx.doi.org/10.18782/2320-7051.7140

INTRODUCTION

India is the second largest producer of food grains after china. India has produced highest ever food grains of 241 million tonnes in 2010-2011. In previous year, country produced 218.11 million tonnes. In 2010-11, production of wheat and pulses production is also estimated to be an all time record at 85.93 million tonnes and 17.3 million tonnes respectively (The Economic Times).

Agricultural processing which perform to maintain or improve the quality or change the form or characteristics of an agricultural product. Processing operations are undertaken to add value to agricultural materials after their production. The main purpose of agricultural processing is to minimize the qualitative and quantitative deterioration of the material after harvest. Some of agricultural processing includes cleaning, grading, sorting etc.

Cleaning and grading are the first and most important post harvest operations undertaken to remove foreign and undesirable materials from the threshed grains and to separate the grains into various fractions. The operations of cleaning, grading and separation of the products are performed by exploiting the difference in engineering properties of the materials. Various types of cleaning, grading and separation equipment have been designed and developed on the basis of properties of product to be handled.

Chaff like materials were removed from cereals like wheat, rye and soybeans at air velocities of 3.05 m/s which is less than their terminal velocities[24]. Grains on handling after harvest contains various proportions of materials other than grains such as stem, pod, stone and dirt. Separation of material other than grain is essential to upgrade the quality of food materials. Some of the methods employed for separating materials other than grain winnowing, aspiration, sieving and use of vertical air stream or horizontal air stream[19]. The effect of introduction an air stream over the front of upper sieve of a combine on the separation of wheat grain from straw and chaff[15] The winnowing of paddy rice crop particles in a horizontal air stream and air speeds of between 4 and 6.6 m/s were required to separate grain from material other than grain and their results indicated that the horizontal displacement between two dissimilar particles decreased the height of the free fall above the air stream increased[14].

Both efficiency and capacity were higher at lower screen speed for all the four mixtures used in study. The effect of design parameters such as screen surface area, screen drum rotational speed and feed rate on cleaning efficiency and capacity of a rotary screen grain pre-cleaner. It was observed that cleaning efficiency as well as capacity increased with the increase in screen surface area and decrease with the increase of screen drum rotational speed. The cleaning efficiency decreased with the increased in feed rate.

The test on a cereal cleaner to determine optimum tilt angle of sieve to be between 4° and 5° when operating between 300 and 350 rpm[13]. The table slope of 38 percent and the oscillation frequency of 238 rpm, tray type separator gave the best performance[17]. The performance of a schule type paddy separator with selected parameter when run at a table slope between 1 to 2 degrees, gave the best performance[9]. The gravity separator provided more efficient separation and increased germination percentage of fraction one compared to corresponding lot from the fractioning aspirator. i.e. 24 to 48 %[5].

MATERIAL AND METHODS

1. Studies on Performance of Flat Screen Grain Pre-cleaner:

The following variables were considered with the levels indicated as in the brackets:

a) Feed Rate (3)

b) Air velocity (3)

c) Screen slope (2)

d) Screen effective surface area (3)

a) Feed rate:

The level of feed rate was controlled by controlling the feed-hopper gate. The hopper opening was pre-calibrated and following feed rates were obtained:

$F_1 = 0.3$ kg/s

$F_2 = 1.75$ kg/s

$F_3 = 2.77$ kg/s

b) Air velocity:

The following three levels of air velocities were chosen for the study:

$V_1 = 7.28$ m/s

$V_2 = 8.41$ m/s

$V_3 = 9.08$ m/s

c) Screen effective area:

The following three levels of screen effective surface areas were chosen for study. Circular holes screens were used.

$A_1 = 2.21\ m^2$

$A_2 = 2.24\ m^2$

$A_3 = 2.29\ m^2$

d) Screen slope:

The following two screen slopes were chosen for the study. Further variation in slope was not possible.

$S_1 = 6°$

$S_2 = 8°$

The other factors were kept constant to the best possible level:

Moisture content of the wheat grain = 12%

Density of wheat grain = 1300 kg/m^3

Grain-Chaff ratio = 100:4

Straw-Nodes ratio = 1:3

Size of Straw and Nodes = 8-12 mm

Upper screen sieve size = 6 mm

Lower screen sieve size = 2.25x20 mm

METHODS

1) Moisture content of particles:

An infra-red moisture meter was used to determine the moisture content of the wheat grain on wet basis. The material was first ground in a grinder. After grinding sample of approximately 5 g was placed in pan of moisture meter. The infra-red lamp was turned on to give desired temperature rating. After about 15 to 20 minutes, the moisture content of the sample was noted. This process was repeated till constant value was attained.

2) Density of grain:

Density was determined by Kerosene oil displacement method as outline by Bhattacharya et al. (1972). A known weight of sample was put into graduated jar containing kerosene oil and volume displaced by it was noted and density was calculated by following formula:

$$\text{Density } (kg/m^3) = \frac{\text{Weight of sample (kg)}}{\text{Volume Displaced } (m^3)}$$

3) Air-Velocity:

Digital Anemometer was used to measure the air velocity. Readings were taken at the blower section. In the blower section, flap arrangement was there to control air velocity. Digital anemometer gave direct readings of air velocity in m/s.

4) Feed rate:

A pointer, which was movable on a scale, was welded to the hoper gate lever. To calibrate the feed rate, the gate was opened up to a required limit and the known weight of sample was fed into the hopper. The time taken by the total grain to pass through the hopper was noted by a stopwatch and the feed rate in kg/s was calculated.

5) Screen area:

The screen area was varied by covering its sides by welding flat metal sheets. The effective length and width were measured with a scale and the effective surface area of the screen was calculated.

6) Measurement of screen slope:

A combination set was used to measure the slope of the screen surface.

Equipments:

1) Weighing Balance:

Digital type balance was used to weight the samples.

2) Aspirator column:

The samples collected from different outlets of the grain pre-cleaner were cleaned with an aspirator –column to separate the impurities completely from the wheat grain. Thus purity of the sample was determined.

3) Flat screen grain pre-cleaner:

The machine selected for this study was PC11 pre-cleaner designed to handle almost all type of cereals by changing the two sets of screens. It had an overall dimension of 287 x 215 x 299 cms (L x W x H) mounted on a frame.

The following adjustments are necessary in the machine:

a) Feed control:

The feed hopper had slanting sides which helped in the flow and distribution of the grain over the entire width of the feed roller which fed the material uniformly to the screen below. The feed was regulated by operating the lever of the feed hopper. The lever was adjusted according to the feed rate requirement for the study.

b) Slope adjustment:

Two screens one over other were bolted to the frame. The function of upper screen was to separate the coarse impurities such as nodes, stones, and large size of straw particles. The screen separates the sand and dust. Oblong semicircular type of hole was provided in the frame in vertical plane so that the slope could be varied by changing the position of the screen with respect to the frame. Only upper screen was re-positioned in this study.

c) Air velocity control:

A blower was provided to suck the light particles of the chaff. The air velocity was controlled by two gates which could be regulates by means of the operating lever which could be positioned at any one of the seven notches thus giving seven different air velocities. In position '0' the gates were closed fully, in position '7' they were fully opened. The gates were opened wide enough to ensure that the air cleaning action was as effective as possible.

d) Drive mechanism:

A 7.5 hp motor was used for this machine, which imparted drive to the blower shaft as well as screen cradle.

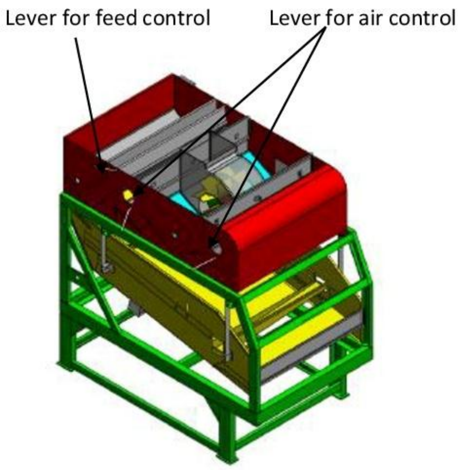

Fig1. Assembled isometric view of Pre-cleaner.

Operation of the machine:

The grain passed from the feed hopper on the upper screen. Light particles were sucked away by blower during this process. Coarse impurities such as stones, straw particles etc. were screened off by upper screen and discharged out through an outlet.

The grains fell through on to the lower screen, where sand and the dust particles were screened off. While passing through the funnel the ascending separator. During this process the remaining light impurities and shrivelled grains were sucked away and the light impurities were removed by a cyclone separator to which dust bags were attached for the collection of the impurities.

Experimental Procedure:

i. The dust bags were provided at the outlets of cyclone separator.
ii. The machine was adjusted for required combination of screen area, screen slope, feed rate and air velocity.

(Remaining factors were kept constant)

iii. 4 kg chaff (3kg nodes and 1 kg straw) were weighed and mixed with one quintal of wheat grain.

iv. The machine was switched on and after 2 minutes the mixture was fed into the feed hopper quickly.

v. The machine was switched off when the material had passed through it.

vi. The total time taken by the material to pass through the machine was noted with a stop watch.

vii. The samples from the three outlets were taken and weighed.

viii. These samples were completely cleaned with an aspirator column without any loss of grain.

ix. The cleaned grain and the straw were weighted separately.

Formula to calculate cleaning efficiency for flat screen grain pre cleaner.

$$\text{Cleaning efficiency: } \frac{E\,(E-F)\,(F-G)\,(1-G)}{F\,(E-G)^2\,(1-F)}$$

Where,

E = Fraction of cleaned grain from cleaned grain outlet.

F = Fraction of cleaned grain in feed.

G = Fraction of cleaned grain from foreign matter outlet.

Cleaned grain output(q/hr) measured directly at cleaned grain outlet of machine.

2. Studies on Performance of Grading Quality of Grain by Gravity Separator:

The machine is specifically meant for removing impurities and achieving very high grading quality in any free flowing granular material, grains all types of seed, cereals etc. It removes the impurities and upgrades the material on the principal of specific weight. For this study we measured effect of deck angle, deck oscillation and air velocity on the grading quality of grain. The following variables were considered with the levels indicated in brackets:

a) Air-velocity (3)
b) Deck angle (2)
c) Deck oscillation (3)

a) Air velocity:

The following three levels of air velocities were chosen for the study:

V_1= 2.9 m/s
V_2 = 2.4 m/s
V_3 = 2.0 m/s

b) Deck angle:

The following two levels of deck angle were chosen for the study:

d_1 = 2.05°
d_2 = 2.67°

c) Deck oscillation:

The following three levels of deck oscillation chosen for the study:

n_1 = 425 rpm
n_2 = 450 rpm
n_3 = 500 rpm

Operation of machine:

The specific gravity separator makes the separation according to difference in density or specific gravity of the materials. This separator works on two principles, 1) the characteristics of grain to flow down over an inclination surface, 2) the flotation of the particle due to upward movement of air.

The main part of device was a rectangular shaped perforated deck. The deck was properly baffled underneath to ensure uniform distribution of air over it. The pressure or terminal velocity of the air rising through the deck was controllable very closely within a wide range.

The mixture of grain was fed into the feed box. The air was blown up through the porous deck surface and bed of the grain by a fan at such a rate that the material was partially lifted from contact with the deck surface. The lightest materials were lifted to the top of the stratified mass. The heavier particles were not lifted by the air. The stratified mass moves along the direction of conveyance due to oscillating motion of the deck and was discharged at the right edge of the deck.

Adjustments in Gravity Separator:

Gravity separator had five variable adjustments that must be properly adjusted and balanced to obtain optimum separation. These were feed rate, end raise, side tilt, eccentric speed, air control.

a) Feed Rate:

The average feed rate was determined by the average capacity of the processing line of the equipment. For optimum separation on Gravity separator, the feed rate should be as low as possible without falling below the minimum feed rate at which the deck can be kept completely covered. Maximum feed rate was the maximum rate at which the deck could be fed and still obtain the necessary separation. When Gravity separator was starting, Started at the minimum feed rate. Obtain the required separation, and then increased the feed rate to the desired capacity.

b) End Raise:

End raise was the slope from the feed end of the deck to the discharge end. This slope determined the rate of flow from the feed end to the discharge end of the deck. Greater end raise means a greater rate of flow and less exposure time for the seed. Quality of separation could be related to exposure time for the seed. In general, longer a seed mass was exposed to a separating action, the cleaner it becomes.

c) Side Tilt:

Side tilt was the difference in elevation between the high side of the deck and the low side of the deck. Increasing side tilt caused the material to shift towards the low side of the deck. Decreasing side tilt caused the material to shift toward the high side of the deck. Normally, the best separation was obtained when side was set or near the maximum steepness.

d) Eccentric Speed:

Eccentric speed and side tilt were closely related. Increasing eccentric speed caused material shift towards the high side of the deck. Decreasing eccentric speed caused material shift towards the low side of deck. Generally, by increasing eccentric speed (which shifts the material toward high side) and increasing side tilt (which shifts light material back towards the low side) a more precise separation can be obtained.

e) Air Control:

Flaps were provided at the side of blowers to control the flow of air. Air regulation was one of the most important adjustments to be made on a Gravity Separator. Separation was not made by ‘blowing’ the light material from the heavy but using a controlled air flow to creates the stratified layers that were separated by the vibrating action of deck. Too much air caused a boiling or bubbling action lifting the heavier particles from the deck and mixing them with the lighter top layers. Too little air caused the material to appear sluggish and to pile at high side of the deck.

With proper air regulation, the bed of material was almost fluid in appearance. The material on the surface agitated and free flowing, with exception of stratifying zone under the feeder. Bubbling kept to minimum, allowing the vibrating deck to make the separation.

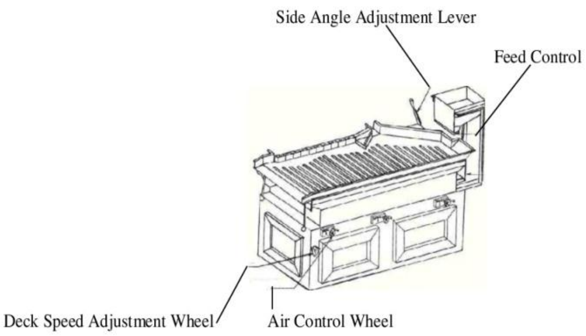

Fig. 2. Specific Gravity Separator

Experimental Procedure:

i. The bags were provided to the four outlet of Gravity Separator on the basis of grading.
ii. The machine was adjusted for required combination of Deck angle, Deck Oscillation and Air velocity for each reading.
iii. 4 kg of stone were weighted and mixed with the 46 kg of weight grain.
iv. The machine was switched on and after 2 minutes the mixture was fed into the feed-hopper quickly.
v. Feed rate kept constant for each reading and other variables changes with different set of combination.
vi. The machine was switched off when the material had passed through it.
vii. The samples from the four outlets were taken and weighted.

RESULTS AND DISCUSSIONS

The results of the study carried out on flat screen grain pre-cleaner and quality grading of grains on gravity separator are discussed in this chapter. Cleaning efficiency and cleaned grain output per unit time were taken as the performance indices of the cleaning system for flat screen grain pre- cleaner and grading quality of grains on weight basis for performance of gravity separator. The results of study have been discussed in three parts:

1. Effect of independent variables namely, screen effective surface area, screen slope, air-velocity and feed rate on dependent variable namely, cleaning efficiency and cleaned grain output per unit time of flat screen grain pre-cleaner. All other variables were kept constant.
2. Effect of independent variables namely, deck angle, deck oscillation and air velocity on grading quality of grains for performance of gravity separator.
3. Selection of optimum values of the variables for flat screen grain pre-cleaner and gravity separator.

Flat screen grain pre-cleaner

1. Effect of screen effective surface area, screen slope, air velocity and feed rate on cleaning efficiency:

a) Effect of screen effective surface area:

In general, cleaning efficiency increased or almost remained constant with the increase in screen effective surface area for all the combnations of air velocities and screen slopes at different feed rates.

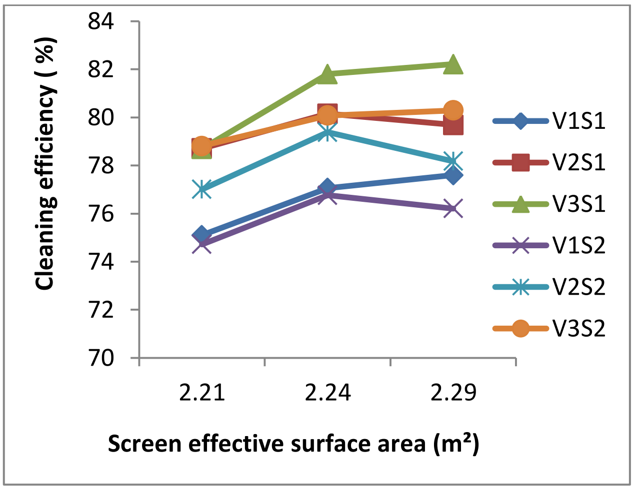

Fig. 3. Effect of screen effective surface area on cleaning efficiency as affected by air velocity, screen slope and feed rate for flat screen grain pre-cleaner.

The cleaning efficiency increased or remained almost constant with the increase in screen effective surface area from 2.24 m^2 to 2.29 m^2 for all the combinations of air velocities and screen slopes .The lower values of cleaning efficiency with lower screen area might be due to following reasons:

At lower screen area all the grain particles could not get equal opportunity to pass through the screen perforations due to fewer number of openings available thus it was carried away with the nodes on the screen surface and passed through discharge channel as overflow.

b) Effect of screen slope:

In general with increase in slope, the cleaning effency decreased or remained almost constant for the combinations of the air velocities, screen areas and feed rates except some of the combinations where cleaning efficiency increased slightly with increase in screen slope.

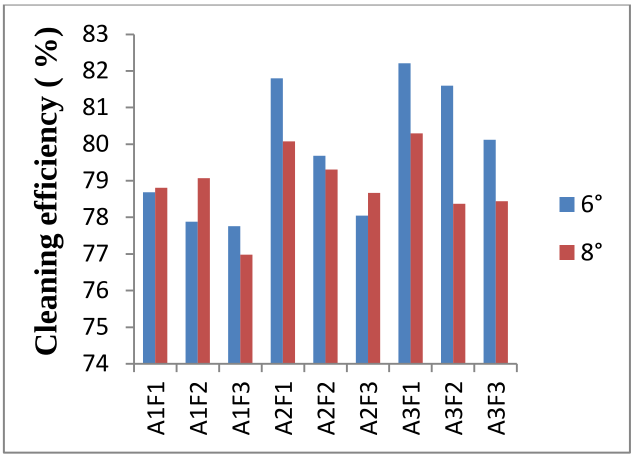

Fig. 4. Effect of screen slope on cleaning efficiency (%) for flat screen grain pre- cleaner.

One of the explanation for this phenomena could be that with the increase in screen slope the rate of travel of the material at the screen surface increased and material accumulated in the discharge channel as well as at the screen surface. Thus bed depth at the screen surface increased and some of the material was discharged through the discharge channel resulting reduction in cleaning efficiency.

In some of the combinations there was slight increase in cleaning efficiency with increase in screen slope, no possible reason could be ascertained for this.

c) Effect of air velocity:

In general, cleaning efficiency increased with the increase in air velocity almost for all the combinations of screen effective surface areaas and screen slopes at different feed rates.

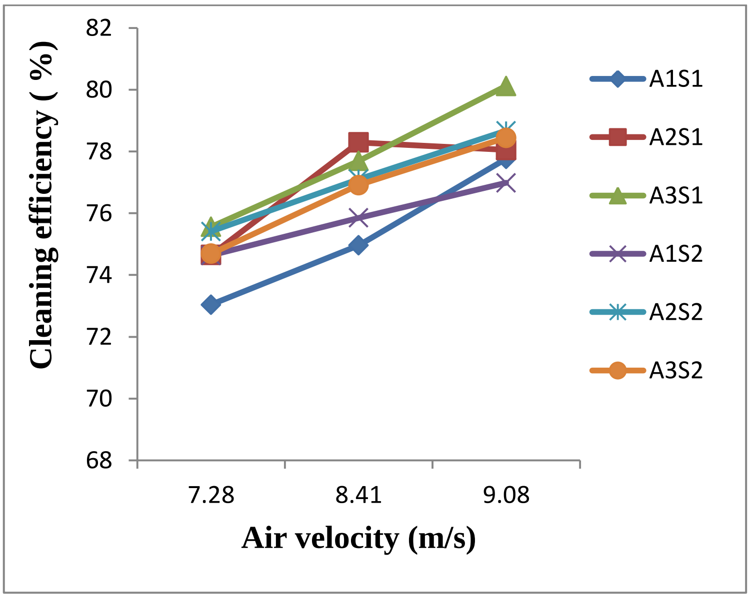

Fig. 5. Effect of air velocity on cleaning efficiency as affected by screen effective surface area, screen slope and feed rate for flat screen grain pre cleaner.

This increase in cleaning efficiency with increase in air velocity was due to the fact that larger quality of chaff was sucked by the blower at the higher air velocities, thus reducting the quality of the chaff for further separation.

d) Effect of feed rate:

In general with the increase in feed rate there was decrease in cleaning efficiency for all the combinations of air velocities and screen slopes.

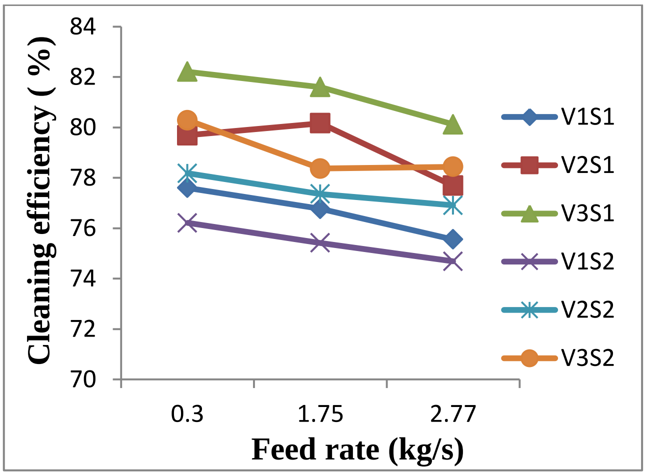

Fig. 6. Effect of feed rate on cleaning efficiency as affected by different air velocity, screen slope and screen effective surface area for flat screen pre-cleaner.

The decrease in cleaning efficiency with increase in feed rate might be due to following factors:

Comparatively lesser quantity of straw was sucked from the grain stream passing through the baffels as the grain stream was thicker.

The screen became overloaded and bed depth at the screen became deeper. Thus some of the material discharged through the discharge channel as it did not pass through the screen.

2. Effect of screen effective surface area, screen slope, air velocity and feed rate on cleaned grain output:

a) Effect of screen effective surface area:

One of the explanations for these phenomena could be that at higher screen effective surface area the grain particles got more number of perforations to pass through while at lower screen area all the grain particles could not get equal opportunity to pass through due to being fewer numbers of perforations and took much more time to pass through.

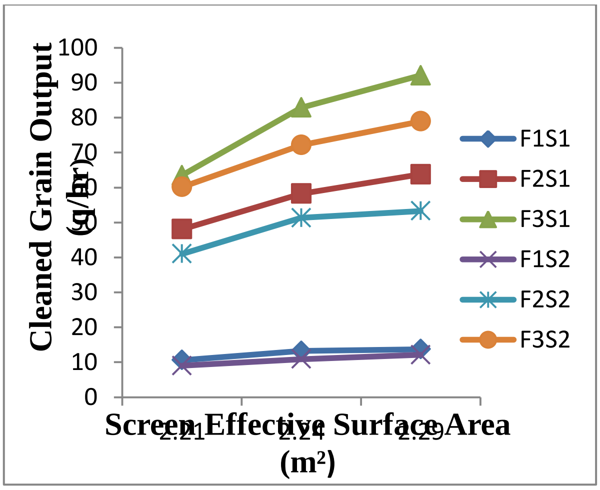

Fig. 7. Effect of screen effective surface area on cleaned grain output as affected by feed rate, screen slope and air velocity for flat screen grain pre-cleaner.

This decrease in the effect under discussion was because initially increase in screen effective surface area the material had sufficient perforations for the passage per unit time whereas further increase of screen area not significantly alters this situation.

b) Effect of screen slope:

In general cleaned grain output decreased with the increased in screen slope for all the combinations of feed rates, air velocities and screen effective surface areas.

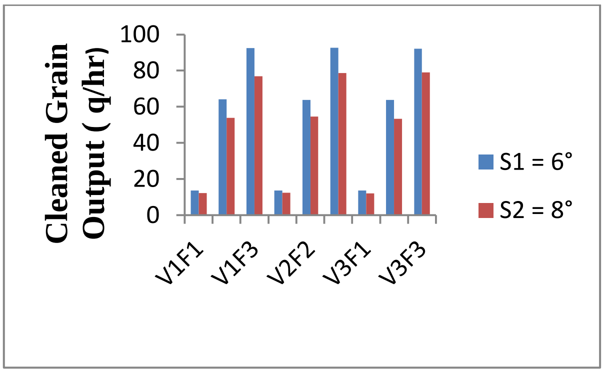

Fig. 8. Effect of screen slope on cleaned grain output for flat screen grain pre- cleaner.

One of the explanations of this phenomenon could be that with the increase in screen slope the rate of travel of material at the screen surface increased and the grain did not get enough opportunity to pass through the screen perforations and accumulated at the screen surface. The bed depth at the screen surface thus increased and discharged and some of the material flowed out through the discharge channel resulting reduction in cleaned grain output per unit time.

c) Effect of air velocity:

In general cleaned grain output remained almost constant with increase in air velocity for all the combinations of feed rate and screen slopes at different screen effective surface areas.

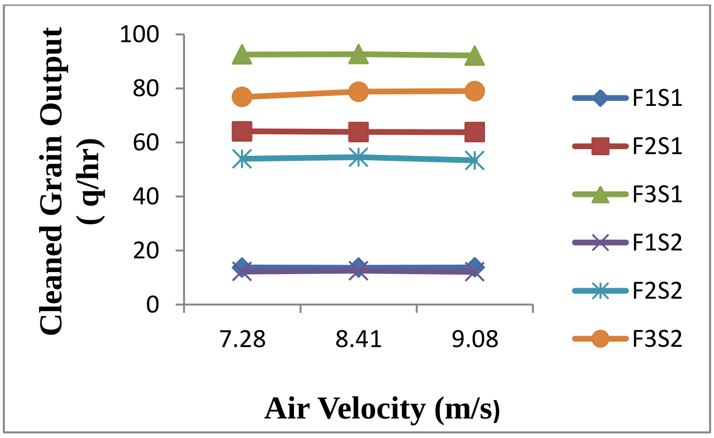

Fig. 9. Effect of air velocity on cleaned grain output as affected by different feed rate, screen slope and screen effective surface area for flat screen grain pre-cleaner.

One of the explanations for the constant value of cleaned grain output per unit time with increase in air velocity could be that in no way the air velocity was affecting or disturbing the flow of grain while passing through the feed hopper to screen surface. Thus output per unit time remained constant at all levels of air velocities.

d) Effect of feed rate:

In general cleaned grain output increased with the increased of feed rates for all the combinations of screen effective surface areas and screen slopes at different air velocities.

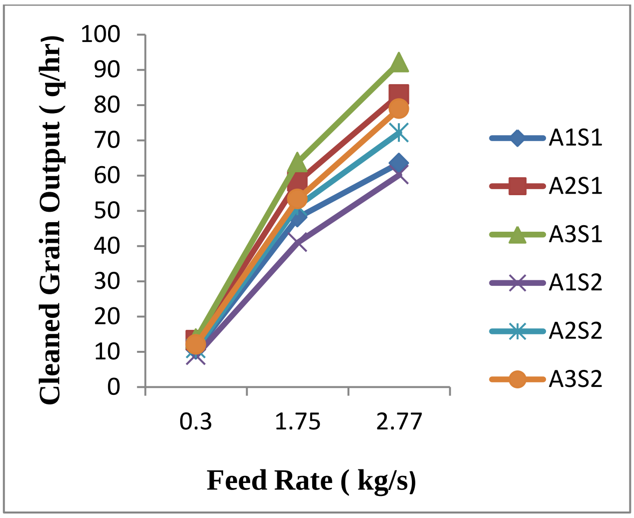

Fig. 10. Effect of feed rate on cleaned grain output as affected by different screen effective surface area, screen slope and air velocity for flat screen grain pre- cleaner.

One of the explanations for these phenomena could be that, comparatively more quantity of grain was flowing through the feed hopper and passing through the screen perforations per unit time, resulting in decreased outlet.

It was also observed that initially with the increase of feed rate from 0.3 kg/s and 1.75 kg/s there was sharper increase in cleaned grain output per unit time as compared to the effect of increase in feed rate from 1.75 kg/s to 2.77 kg/s.

One of the explanations for this phenomena could be that at initial increase of feed rate, the bed depth at screen surface was comparatively thinner yet enough to create the interparticle friction thus increasing the tumbling and gliding of the particles giving more chances for the particle passage through the screen openings. Further increase in feed rate created overloading of the screen resulting in situation where the top layer of the grain did not get adequate opportunity to pass through the perforations and some of the material passed through the discharge channel resulting in reduction of cleaned grain output per unit time.

Selection of optimum values of the variables for flat screen grain pre-cleaner:

Values of cleaning efficiency and cleaned grain output per unit time were examined to select the optimum values of the independent variables under study i.e. screen effective surface area, screen slope, air velocity and feed rate.

a) Screen effective surface area:

Cleaning efficiency and cleaned grain output per unit time were maximum at highest effective surface area i.e. 2.29 $m^{2.}$ In some of the cases cleaning efficiency decreased slightly or remained almost constant for the increase in screen effective surface area from 2.24 m^2 to 2.29 m^2 but for the same increase in screen effective surface area the cleaned grain output per unit time increased linearly, hence the highest screen effective surface area i.e. 2.29 m^2 was suggested.

b) Screen slope:

Cleaning efficiency and cleaned grain output per unit time decreased appreciable with the increase in screen with the increase in screen slope from 6° to 8°. The decrease in cleaning efficiency was approximately less than 3% but the cleaned grain output per unit time decreased appreciably in the range of 2 q/hr to 15 q/hr at different feed rates. Hence the lowest screen slope was suggested.

c) Air velocity:

Cleaning efficiency was maximum at highest air velocity i.e. 9.08 m/s and cleaned grain output per unit time was almost constant with the increase in air velocity from 7.28 to 9.08 m/s. The cleaning efficiency increased in the range of 0.3 to 3 % with the increase in velocity from 7.28 to 9.08 m/s. Hence an air velocity of 9.08 m/s was suggested for maximum cleaning efficiency.

d) Feed rate:

Cleaning efficiency was minimum though the cleaned grain output per unit time was maximum at highest feed rate of 1.75 kg/s. The range of decreased in cleaning efficiency was 0.2 to 2 % through the increase in cleaned grain output was in the range of more than 30 q/hr. Hence feed rate of 1.75 kg/s was suggested.

Grading quality of grains through gravity separator:

1. Effect of air velocity, deck oscillation and deck angle on grading quality of grains through gravity separator:

a) Effect of air velocity:

In general grade-II particles and rejection increased with increased in air velocity and grade-I and heavy particles decreased with increased in air velocity almost for all combinations of deck angle and deck oscillation at constant feed rate.

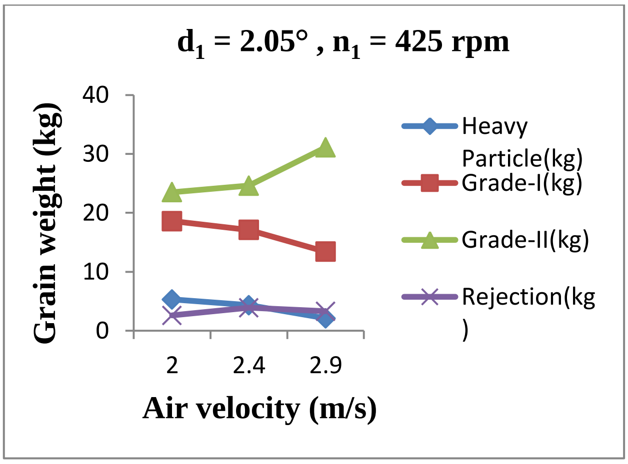

Fig. 11. Effect of Air velocity on grading quality of grain for gravity separator.

Grade-II particles increased from 23.5 kg to 31.1 kg and rejection increased from 2.6 kg to 3.9 kg then slightly decreased to 3.3 kg, in case of grade-I particles decreased from 18.6 kg to 13.4 kg and heavy particles decreased from 5.3 kg to 2.1 kg with increase in velocity from 2 m/s to 2.9 m/s at deck angle 2.05° and deck oscillation 425 rpm. This increased in grade-II particles, rejection particles and decreased in grade-I and heavy particles were due to process of stratification which occurred by forcing air through the particles rise or fall by their relative weight to the air.

b) Effect of deck oscillation:

In general grade-I and heavy particles increased with increased in deck oscillation and grade-II and rejection particles decreased with increased in deck oscillation almost for all combinations of air velocity and deck angle at constant feed rate.

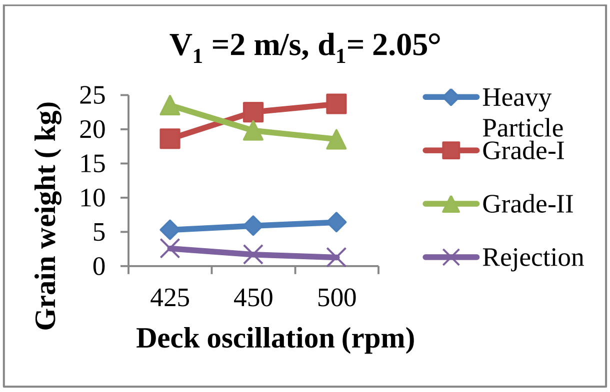

Fig. 12. Effect of deck oscillation on grading quality of grain for gravity separator.

Grade-I particles increased from 18.6 to 23.7 kg and heavy particles increased from 5.3 to 6.42 kg , in case of grade-II particles decreased from 23.5 to 18.53 kg and rejection particles decreased from 2.6 to 1.3 kg with increase in deck oscillation from 425 to 500 rpm at deck angle 2.05° and air velocity 2 m/s. This increased in grade-I, heavy particles and decreased in grade-II, rejection particles were due to vibrating action of the deck begins pushing the heavier layers in contact with the deck towards its high side. At the same time, the lighter layers, which were at the top of the bed and did not touch the vibrating deck, float downhill towards the low side of the deck. As the material flowed downhill the feed end to the discharge end of deck, the vibrating action gradually converted the layers of vertical stratification to a horizontal separation. By the time material reached the discharge end of deck, the separation completed. Heavier materials concentrated at the high side of deck and light materials were at the low side of the deck.

C) Effect of deck angle:

In general grade-I and heavy particles decreased with increased in deck angle and grade-II and rejection particles increased with increased in deck angle almost for all combinations of air velocity and deck oscillation at constant feed rate.

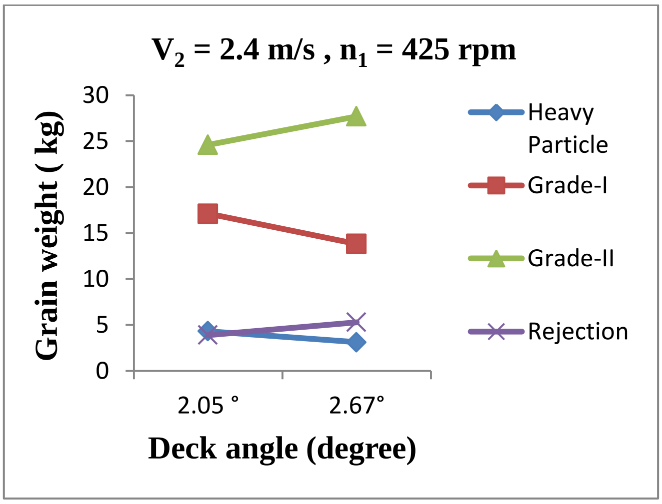

Fig. 13. Effect of deck angle on grading quality of grain for gravity separator.

Grade-I particles decreased from 17.1 to 13.82 kg and heavy particles decreased from 4.32 to 3.12 kg , in case of grade-II particles increased from 19.82 to 20.2 kg and rejection particles increased from 3.9 to 5.3 kg with increased in deck angle 2.05° to 2.67° at air velocity 2.4 m/s and deck oscillation 425 rpm. This decreased in grade-I, heavy particles and increased in grade-II, rejection particles were due to end raise was the slope from the feed end of the deck to them discharge end of the deck. This slope determined the rate of flow from the feed end to the discharge end of the deck. Greater end raise means a greater rate of flow and less exposure time for the seed. Less end raise means a slower rate of flow and more exposure time for the seed. In general, longer a seed mass was exposed to a separating action, the cleaner it becomes.

Selection of optimum values of the variables for gravity separator:

Values of grain weight for grading quality of grain were examined to select the optimum values of the independent variables under study i.e. air velocity, deck angle, deck oscillation .

a) Air velocity:

Too much air caused a bubbling action that remixes the material as fast as it was stratified. Too little air could not stratify properly. Generally, lots of air was required in feed area to obtain a good stratification. As material moved from the feed end to the discharged end, progressively less air was required to maintain proper stratification. Hence intermediate flap opening (70 % flap opening) i.e. 2.4 m/s air velocity was suggested.

b) Deck oscillation:

Decreasing deck oscillation caused material to be shifted towards the low side of the deck. Generally, by increasing eccentric speed which shifted the material towards high side of deck. Better separation occurred at higher deck oscillation. Hence higher deck oscillation i.e. 500 rpm was suggested.

c) Deck angle:

Deck angle determined the length of time a grain exposed to the separating action. Therefore, deck angle had direct effect on quality of separation. Generally, deck angle increased the quality of separation decreased and deck angle decreased the quality of separation increased. Hence lower deck angle i.e. 2.05° was suggested.

Summary and Conclusions

The effect of variables like screen effective surface area, screen slope, air velocity and feed rates on cleaning efficiency and cleaned grain output per unit time of flat screen grain pre-cleaner using wheat grain, were studied.

Cleaning efficiency and cleaned grain output per unit time increased with increase of screen area for flat screen grain pre-cleaner. Cleaning efficiency decreased and cleaned grain output per unit time increased with the increase of feed rate for flat screen grain pre-cleaner.

Cleaning efficiency and cleaned grain output per unit time decreased with the increase of screen slope for flat screen grain pre-cleaner. Cleaning efficiency increased significantly with the increase of air velocity but the cleaned grain output per unit time remained almost constant.

Screen effective surface area of 2.29 m^2, screen slope of 6°, air velocity of 9.08 m/s and feed rate of 1.75 kg/s were optimum values of the independent variables for flat screen grain pre-cleaner.

The flat screen grain pre-cleaner gave better results as maximum cleaning efficiency and cleaned grain output per unit time were obtained for optimum values of independent variables.

Grade-II particles and rejection increased with increased in air velocity and grade-I and heavy particles decreased with increased in air velocity almost for all combinations of deck angle and deck oscillation at constant feed rate for gravity separator.

Grade-I and heavy particles increased with increased in deck oscillation and grade-II and rejection particles decreased with increased in deck oscillation almost for all combinations of air velocity and deck angle at constant feed rate for gravity separator.

Grade-I and heavy particles decreased with increased in deck angle and grade-II and rejection particles increased with increased in deck angle almost for all combinations of air velocity and deck oscillation at constant feed rate for gravity separator.

Air velocity of 2.4 m/s (70% flap opening), deck angle of 2.05° and deck oscillation of 500 rpm were optimum values of independent variables for gravity separator.

The gravity separator gave better results of grading quality of grains were obtained for optimum values of independent variables.

REFERENCES

1. Adewumi, B.A., Aerodynamics and particle dynamics: Application in grain fractionation and classification. Paper accepted for publication in the Journal of Food Science and Technology, Nepal (May.2007).25pp. (2007).
2. Ahring, R. M. and Franks, H., Establishment of eastern gamagrass from seed and vegetative propagation. J. Range Management, **21:** 27-30 (1968).
3. Allen, G.F., Screens and pneumatic classification. Industrial and Engineering Chemistry. No.**12:** 39-47 (1962).
4. Das, H., Separation of paddy and rice on an oscillating tray type separator. *Journal of Agricultural Engineering Research*, **34:** 85-95 (1986).
5. Douglas, J. And Grabowski, J., A Comparison of Seed Cleaning Techniques for Improving Quality of Eastern Gamagrass Seed, Jamie l. Whitten Plant

Materials Centre, Coffeeville, MS, Vol.13(7) (1997).

6. Fernando, S. and Hanna, M.A., Design and development of a threshing chamber and pneumatic conveying and cleaning unit for soybean harvesting. *Transactions of the American Society of Agricultural Engineers* **48(5):** 1681-1688 (2005).
7. Gorial, B.Y. and O'Callaghan, J.R., Separation of grain from straw in a vertical air stream. *Journal Agricultural Engineering Research* **48:** 111-122 (1991a).
8. Gorial, B.Y. and O'Callaghan, J.R., Separation of grain from straw in a horizontal air stream. *Journal Agricultural Engineering Research*. **49(4):** 273-284 (1991b).
9. Gupta, R.K. and Bhole, N.G., Performance evaluation of schule type paddy separator. Indian Society of Agricultural Engineers.(1991).
10. Hall, C.W., Processing equipment for agricultural products.AVI Publishing Company Inc. Westport conneticut. (1972).
11. Harrison, H.P. & Blecha, A., Screen oscillation aperture size – Sliding Only T.A.S.A.E. **26(2):** 343-348 (1983).
12. Henderson, S.M. and Perry, R.L., 3rd Ed.AVI.Publishing Company Inc. Westport conneticut. (1976).
13. Igbeka, J.C., Agricultural mechanisation Asia, Africa and Latin America **15(2):** 67-70 (1984).
14. Kashayap, M.M. and Pandya, A.C., Air velocity requirement for winnowing operations. *Journal of Agricultural Engineering Research*, **11(1):** 24-32 (1986).
15. Macaulay, J.T. and Lee, J.H.A., Influence of oscillating frequency on separation of wheat on a sieve in an air stream. Trans. A.S.A.E. **13(1):** 648-654 (1969).
16. Martin, G., Chemical weed control in rice. *Rice Journal*. **71(20):** 22-23 (1968).
17. Modi, B. S., Factors affecting the performance of a paddy separator. Unpublished M. Tech. Thesis. *Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur*. (1972).
18. Moshenin, N.N., Physical properties of plant and animal materials. Gordon and Breach Science Publishers. pp. 20-89 (1986).
19. Ogunlowo, A.S. & Adesuyi, A.S., Design and construction of a rice destoner agricultural mechanisation. *Asia, Africa and Latin America* **30(1):** 20-24 (1999).
20. Pomeranz, Y. and Ory, R.L., Rice Processing and Utilization in CRC Handbook of Processing and Utilization in Agriculture. Vol.II, Part 1, p.139-181. Ivan A. Wolff (ed). CRC Press Inc., Baton Rouge, Florida. (1982).
21. Quick, G.R. and Barredo, I.R., A compact triple air stream, triple screen rice seed cleaner. *Philippines Journal of Crop Science*, **21(3):** 53-60 (1996).
22. Singh, A. and Singh, Y., Annual Report of Post- Harvest Technology Scheme, Processing and Agricultural Structures, *Punjab Agricultural University, Ludhiana*. (1983).
23. Suwunnamek, U., Present status of weed problems and their control in Thailand. In Proceeding of the Symposium on Weed Science, pp.31-50, Special Publication No.24, Bogor, Indonesia. (1986).
24. Uhl, J.B. & Lamp, T .A.S.A.E., **9(2):** 244-246 (1966).
25. Uichanco, V.A. and Lantin, R.M., Determination of optimum design parameters of rotary screen cleaners, using dimensional analysis. *The Philippine Agriculturist*. Vol.56, No.9-10: 291-308 (1973).
26. Wang, Q., Melaaen, M.C. De Silva, Investigation and simulation of cross flow air classifier. Powder Technology **120:** 273-280 (2001).
27. Okunola, A.A. and Igbeka, J.C., Development of reciprocating sieve and air blast cereal cleaner. African Crop Science Conference Procedding.Vol.9.pp.3-8 (2009).