Study the Effects of Some Parameters on Seed Grading in Gravity Separator

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Abstract :

Higher the weight of seed more is its germination percentage, vigor and yield. The seed weight plays prominent role in increasing yield than the size of seed. Gravity separator machine plays prominent role in gradation of seed by its weight in seed processing Industry. Segregation of seeds on gravity separator machine deck for various levels of frequency of vibration, slope of deck and air fluidization was studied. In the experiment, the effects of frequency of vibration, slope of deck and air speed on segregation of wheat seeds was investigated. A quality of seed grade was defined as the density of graded seed. It was found that airflow was most influential parameter in achieving effective gradation of seed.

Key Words – Seed, gradation, germination, air speed, yield, gravity, vigor.

1.Introduction :

Quality seed denotes the seed of improved variety having high physical and genetic purity, high germination rate, and great vigor, free from seed borne disease pests, need based value addition and long shelf life and high storability.

To cope up with the increasing demand of quality seed there is need to do scientific analysis of grading machines and study the parameters responsible for effective grading of seed.

Pre-cleaner and grader are used for grading of seed as per the size of seed while gravity separator separates the seed on the basis of specific gravity of seed. Gravity separator separates the seed on the basis of sp. gravity of seed. Higher the weight of seed more is its germination percentage, vigor and yield. The seed weight plays prominent role in increasing yield than the size of seed. So gravity separator machine plays prominent role in quality gradation of seed in seed processing Industry.

In today's context one cannot think of gradation of seed without gravity separator machine.

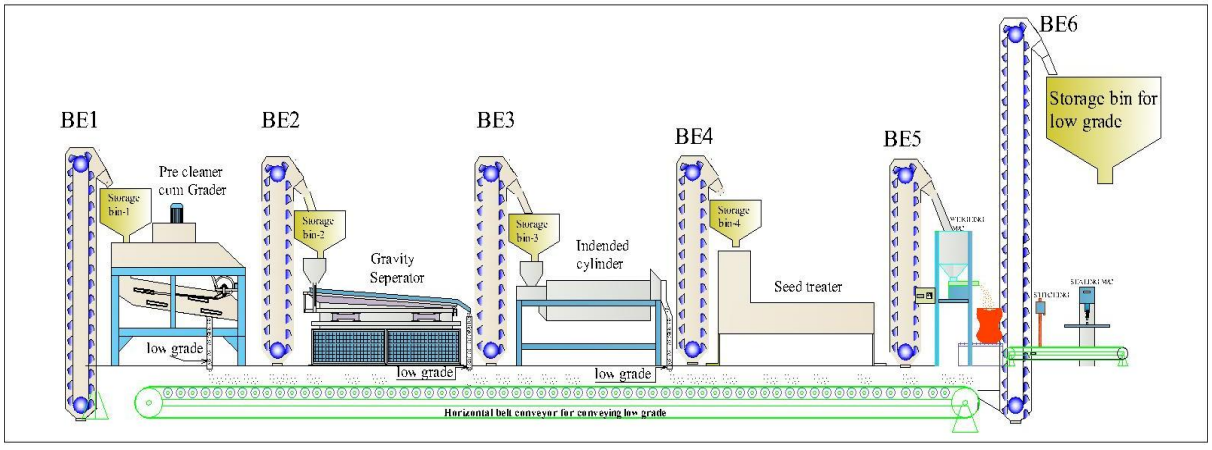

Fig-1 -Seed processing machinery set up in seed Industry

1.2 Necessity of Study –

Presently in India it is observed that the problems in quality grading on gravity separator machine is due to three important reason mentioned below-

i- Inadequate knowledge of setting of various machine parameters required for quality setting. Setting of machine parameters depends on operator skill and is completely discretionary.

ii- Non availability of mechanical arrangement to set that particular parameters precisely. Even today very few Indian manufacturers are aware of only some of the parameters responsible in grading seed on gravity separator. Hence controls provided are not adequate in getting good results.

iii – There is a need to develop mechanical systems to control some of the parameters which is not presently taken care and also some parameters that needs to be controlled more precisely.

The input machine parameters responsible for grading needs thorough study to get the knowledge of contribution of each parameter on seed grading quality on gravity separator machine as well as to know influence of each parameter on grading. This basic work will definitely help manufacturer to develop gravity separator machines with more precise controls for grading in future to come. The issue of gradation of seed has direct effect on agricultural yield of famers and ultimately our nation.

2.Literature review-

Literature review reveals that there is increasing need of improved variety seed as it is indispensable in effecting successful agriculture which is essential for a robust economy what we all dream for.

These improved variety seed and other varieties has to be graded effectively on gravity separator for enhancing physical purity , germination percentage, vigor of seed impart longer shelf life and high storability.

As per the findings of Ivashkov, [et al, 1997] from seed factory Russia studied Separator for separating seeds by weight. This demonstrated that Germination capacity of heavy seed is 93%, middle is 83% and light seed 76% respectively.This reveals that the yield can be drastically increased using heavy seed. The gradation of seed by weight can be effectively performed with Specific gravity separator. The literature review also reveals that more than hundred million tones of wheat is graded every year through the world. The share of export from India is very small and inconsistent. India achieved an all time record production of 76.47 million tones in the year 1999-2000 and became the second largest producer of wheat in the world. Since then, in spite of repeated drought, reduction in the wheat growing area and several other unforeseen reasons the production is hovering around 70.0 million tones. This shows the inherent strength and resilient nature of wheat program in the country. This could be made possible by developing high yielding, disease resistant wheat varieties and adopting matching production and grading technologies. So the quality grading of seed is very important and crucial task as it directly helps to increase yield of corps in the field.

Wu,S,[et al, 1999] in his work reveals that the effects of frequency and amplitude of vibration, and air speed on segregation of wheat seeds on gravity separator machine, it was found that airflow was critical in achieving a maximum segregation.

Brenchley, W. E. [et al, 2008] in has work reveals that better crops are usually obtained by the use of heavy seed in preference to light, whether equal numbers of bushels or equal numbers of seeds are sown per acre. Water culture experiments with peas and barley have shown that there is a steady and considerable rise in the dry weight of the plants as the initial weight of the seed increases. This occurs both with a limited and abundant food supply. The increasing need of improved variety seed as it is indispensable in effecting successful agriculture which is essential for a robust economy what we all dream for. These improved variety seed and other varieties has to be graded effectively on gravity separator for enhancing physical purity , germination percentage, vigor of seed impart longer shelf life and high storability. The relative development of shoot and root is to some extent influenced by the initial weight of the seed, but may vary with the species and with the amount of available food. The results lend support to the growing agricultural practice of advocating the use of large heavy seed, especially with annual crops. The advantage in the case of perennials would appear to be less, if any, but this has not been determined by laboratory experiments.

G. Belay, [et al, 2009] reveals most interesting fact that seed sizes do not have significant effect on yield it is the specific gravity of seed that has positive effect on yield. This fact shows that in seed processing Grading machines separates the seed as per size. The size has less influence on yield. But gravity separate separates the seed on the basis of weight i.e. specific gravity which is most important factor as far as final yield in the field is concerned.

3. principle of gravity separator-

It works on principle of sp. gravity (weight) difference in particle. It separates grains or seeds of similar in size and shape, but having difference in specific weight.

3.1 The Separating Action -

If seed which differ in specific gravity (relative weight per unit of volume) are placed on a substrate of intermediate density, seed of higher specific gravity will fall down through the substrate, while seed of lower specific gravity will be buoyed up the substrate. This is basically the separation made by the gravity separator, which uses air as a separation substrate.

As seed flow onto the deck of the gravity separator, they enter a volume of air coming up through the porous surface of the deck. The terminal velocity of the air rising through the deck can be controlled very closely. To separate two kinds of seed differing in specific gravity, the air is adjusted so that only the lighter seed are filled up of the deck surface. These lighter seed are held up by air pressure and tend to float on the air column without coming in contact with the desk surface. The heavier seed possess a terminal velocity creator than that of the air column, so they are not lifted and so will lie on the deck surface. The air column thus stratifies the seed mixture into vertical zones of relative weight with the heavier seed lying on the deck, and the lighter seed lifted up to the top of the seed mass.

Once the seed have been stratified, these vertical zones must be invaded to different parts of the deck so that they can be discharged through different spouts. The accomplish this, the inclined deck is connected on inclined toggles and is shaken back and forth by an eccentric drive system. The deck shakes rapidly moving back and forth from the low end toward the high end. As it moves toward the high end, the deck rises slightly under the heavy seed and carries them forward. As its backward movement begins, the deck drops slightly downward so that the heavy seed are not held as firmly against the deck surface; they thus do not move back toward the low end with the motion of the deck. Thus, the rapid motion of the deck is (1) up and forward, and then (2) down and back toward the low end. This motion pitches the heavy seed uphill each time the deck moves forward, until they finally reach the banking rail at the high end of the deck and are forced off into a discharge spout.

Light seed floating on the air column are not affected by the motion of the deck. However, the deck is tilted so that one end is lower than the other. The cushion of air offers no resistance to hold back the light seed, so they slide over the top of the heavy seed to the lower end of the deck. Here they move off the deck into a separate discharge spout.

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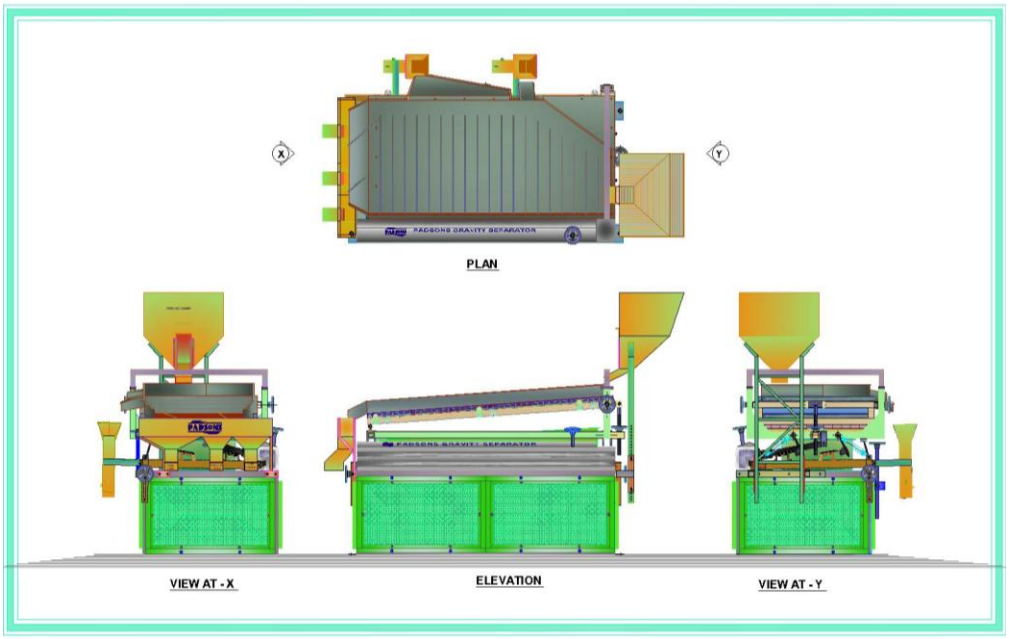

Fig -2- Gravity separator sketch showing various setting arrangements

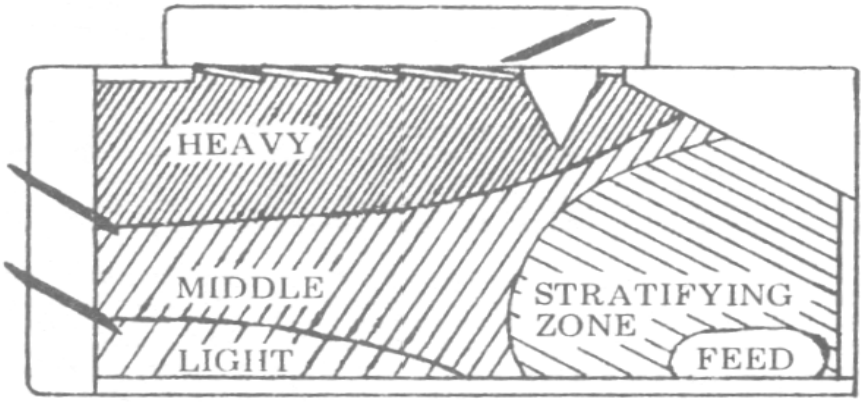

Fig-3- Grading of seed on Gravity separator machine Deck

4.Materials and methods

4.1-experimental set up

Table-1- Machine Parameters

Machine Name	Gravity separator machine
Average Capacity	2 Ton per hour on wheat basis
No. of Fans	5 nos.
Deck size	Width -1000 mm and length – 2100 mm
Motor	5 HP electrical

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4.2 Methodology -

The experimentation was carried out on wheat seed. The seed was first graded by size seed was taken as input material for gravity separator grading. Though the seed was of same size there was a difference in weight of seed. Some of the seeds were heavy and some were lighter. The lighter seeds may be insect ridden or low quality having less germination. Literature review reveals that heavy seeds have more germination and vigor. Gravity machine gives output in three seed grade i.e. good grade, middle grade which is recycled and the third is low grade which is a rejected seed. The only parameter that can judge the quality of grading is specific gravity of good seed. More the sp. Gravity of good seed means less no. of low grade seed in good seed. Specific gravity of good seed is a good measure of proper segregation of seed on gravity deck. So the reading of output was taken on the basis of specific gravity of good seed by varying the levels of different identified parameters mentioned as under. Also the quantity of good is taken as another output parameter of grading. And in analysis the most influential parameters are identified.

4.3 Important Parameters Responsible for Qualitative and quantitative grading of wheat seed identified are -

i- Oscillation speed of deck.
ii- Slope of deck.
a. Cross slope b. longitudinal slope
iii- Air flow of five fan below deck.

The levels of various parameters are recorded by the following equipment

i- Oscillation speed is measured by digital RPM meter with sensor arrangement on drive shaft.

ii- Inclination of gravity deck was measured by scale provided on machine and converted in slope for both longitudinal and cross slope.

iii- Air velocity is measured by Adlab flow meter giving digital display of air of five fans. There was a special facility to selector switch to see the air flow of any one fan at a time on display .These reading were calibrated with Anemometer (standard equipment of measuring air velocity) giving exact value of Air velocity of each fan.

4.4 Limiting parameter of gravity seed separator

Table 2 – Limits of oscillation speed of deck.

parameter	Lowest	highest
Osci. speed	300	500

Table 3- limits of Deck slope parameter

parameter	Lowest(in degree)	highest(in degree)
Longitudinal slope	2.2	4.2
Cross slope	3	5.7

Table 4 –Limits of Air velocity of each fan.

Limiting parameter	Blower Air	
	(damper Lower limit)	(Damper higher limit)
Redding on Adlab meter	325	600
Air velocity by anemometer	400 ft/min	2500 ft/min

4.5 Levels of various parameters

Table 5- Parameter 1 - Deck Oscillation

Oscillation speed	RPM
Level – 1	500
Level-2	425
Level-3	350

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Table 6- Parameter 2 – Longitudinal slope of deck in degree

End slope	Reading on scale	Slope in degree
Level - 1	150 mm	4.2
Level-2	110 mm	2.9
Level-3	80 mm	2.2

Table 7 - Parameter 3 - Cross slope of deck in degree

Cross slope	Reading on scale	Slope in degree
Level - 1	100 mm	5.71
Level-2	80 mm	4.2
Level-3	60 mm	3

Parameter 4 – Air velocity in ft/min

For 4th parameter setting combination of five number of blower is required. For each blower four different damper opening sets are decided as under and these four settings combination of five blowers will provide six levels of parameter four.

Table 8- shows four settings of all five blower dampers

For settings blowers damper to change air velocity they clubed as Blower F1, Blower F2 &F3, Blower F4 & F5.

Table 8- Annemometer readings-

Damper setting for changing Air velocity	Reading on Adlab Meter	Reading of velocity of air in ft/min. By Annometer.
setting - 1	600	2500 ft/min
setting -2	500	2040 ft/min
setting -3	400	1450 ft/min
setting -4	325	440 ft/min

Table 9- showing levels of Parameter 4 – Air velocity in ft/min

Air velocity	Fan 1	Fan 2 & 3	Fan 4 & 5
Level-1	2500 ft/min	2500 ft/min	2500 ft/min
Level-2	2500 ft/min	2040 ft/min	2040 ft/min
Level-3	2040 ft/min	2500 ft/min	2040 ft/min
Level-4	2040 ft/min	2040 ft/min	1450 ft/min
Level-5	1450 ft/min	2040 ft/min	2500 ft/min
Level-6	440 ft/min	440 ft/min	440 ft/min

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4.6 Effect on Sp. Gravity good grade seed by changing one parameter keeping other constant

Changing oscillation speed only keeping other parameters constant-

Constant Parameter	
Longitudinal slope in degree	3.5 degree
Side slope	3 degree
Air setting	Level 2

Chart -1

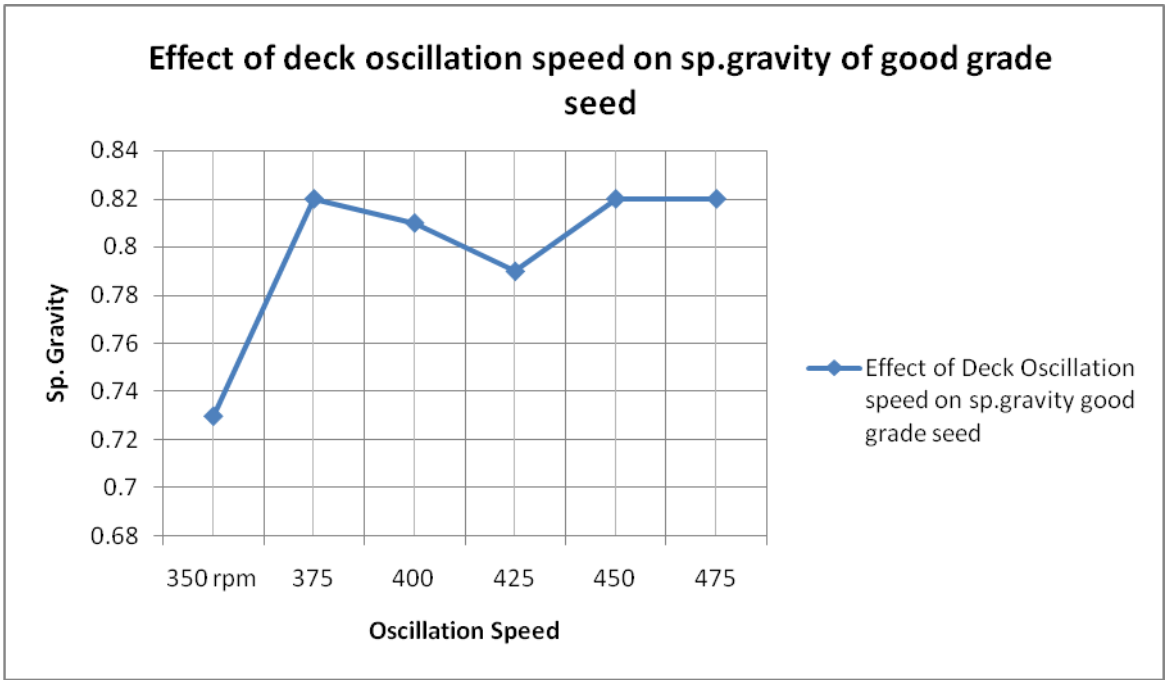
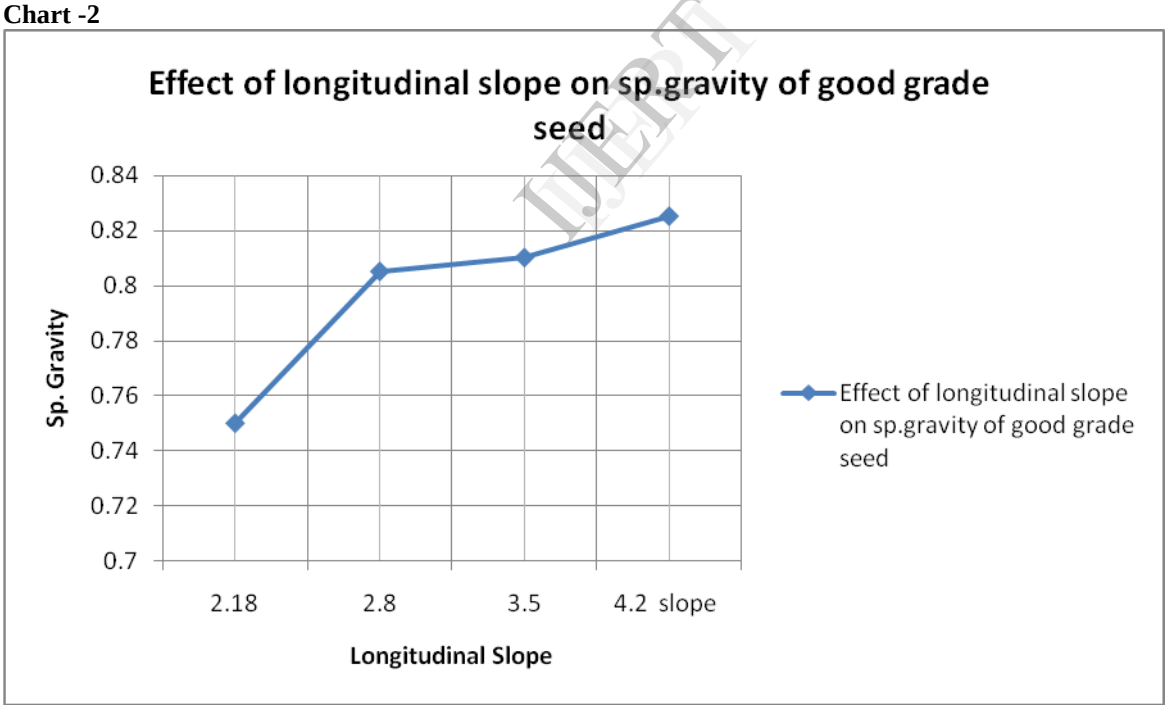


Chart -2



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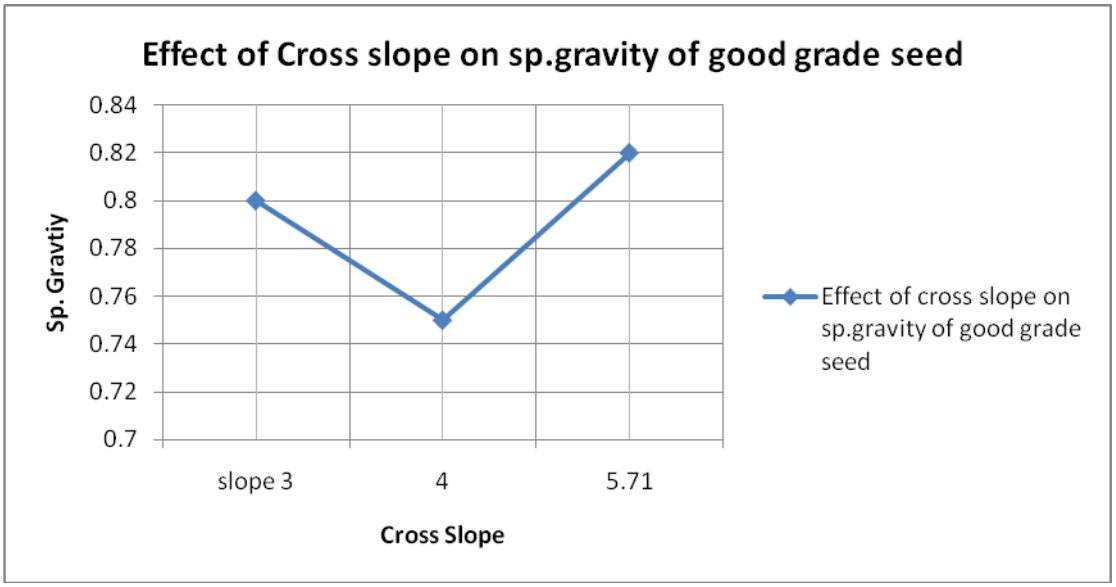

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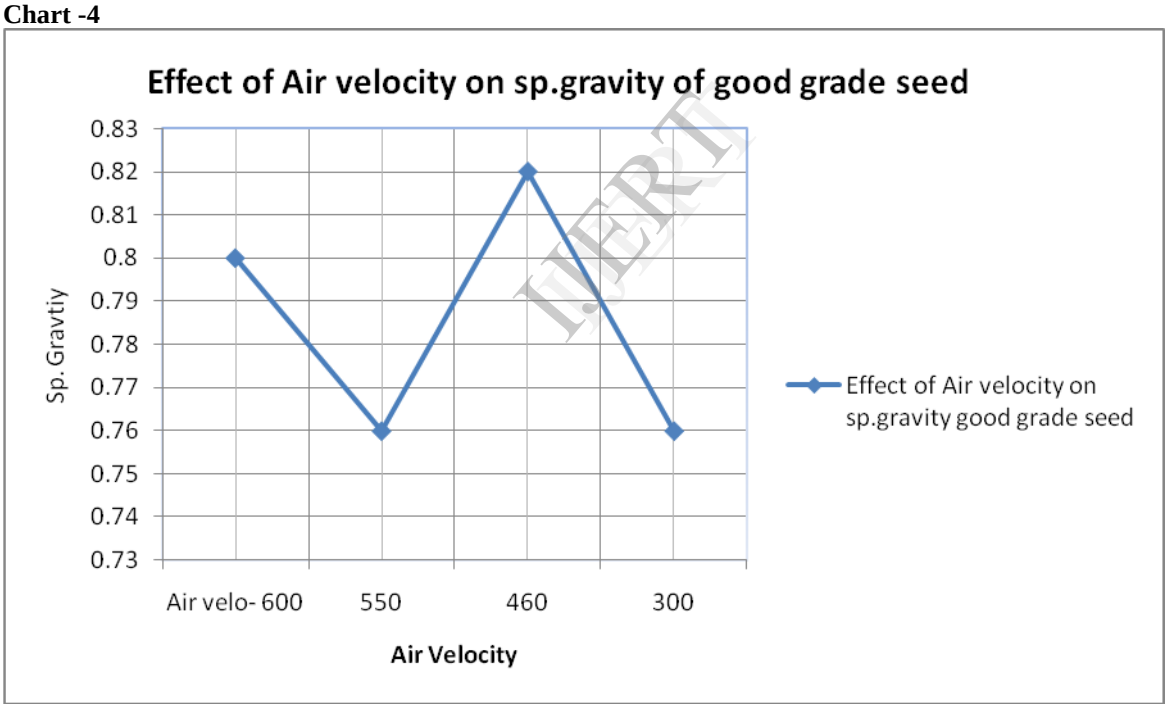

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5.Results and discussions

5.1 - Experimental design - Gravity separator machine involves a number of process variables, which contribute in a large way to the quality and quantity of good graded seed. During grading operation, various operating parameters are determined mostly based on past experience. It therefore does not provide the optimal set of parameters for a particular objective. In order to obtain the best result with regard to any specific grading characteristic, accurate identification of significant control parameters is essential. This chapter is devoted to analyze the experimentally obtained results on gravity separator made at different operational conditions. For this purpose, a statistical

technique called The Orthogonal Array Testing Strategy (OATS) for Experimental Design *based on Taguchi method* is used. Factors are identified according to their influence on the seed grading.

The Orthogonal Array Testing Strategy (OATS) for Experimental Design.

Based on Taguchi method the OATS Technique concept of mixed-level orthogonal array is a simple, efficient and systematic approach of experimental design to solve Multi-Level Example and to optimize designs for performance and cost. In the present work, this method is applied to the process of laser bending for identifying the significant process variables influencing quality of grading. The levels of these factors are also found out so that the process variables can be optimized within the test range.
Experiments are carried out to investigate the influence of the four selected control parameters. The code and levels of control parameters are shown in table. This table shows that the experimental plan has three levels of three parameters and six levels of one parameter. A Taguchi experimental plan with notation L18 OATS Technique concept of mixed-level orthogonal arrays is chosen as outlined in table. In this method, experimental results are transformed into a signal-to-noise (S/N) ratio. It uses the S/N ratio as a measure of quality characteristics deviating from or nearing to the desired values. There are three categories of quality characteristics in the analysis of the S/N ratio, i.e. the lower-the-better, the higher-the-better, and the nominal-the-better. To obtain optimal sp. Gravity of good seed as well as quantity in kilograms of good graded seed, the higher-the-better quality characteristic is taken into consideration.

5.2 – Selection of orthogonal Array -

We have three variables (parameters) in our case with three levels and one variable with six levels and Over all mean is 1,
Hence Degree of freedom= 1+3(3-1) + 1(6-1) =1+6+5=12
So minimum 12 experiments are to be conducted. In this case array that can be used is
Mixed-level L18 (3^6 6^1) orthogonal array. The naming of this array means that there are 18 runs for 7 factors, 6 of which contain 3 levels and 1 of which contains 6 levels. Our problem happens to fit inside of this array.

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5.3 Recording of experimental results-

Table 16- Orthogonal Array for quality of good seed i.e. Sp. Gravity of good grade seed

Expt. no.	Parameters For quality				Wt.in grams of sample collected in cup of vol. 192 cu.cm.	Density	SN ratio
	Oscillation Speed in RPM	End Slope In degree	Side slope In degree	Fan Setting Level		Kg/m^3	
1	500	4.2	5.71	1	161	838	58.46
2	500	2.9	3	2	157	817	58.24
3	500	2.2	4.2	3	155	800	58.06
4	500	2.9	3	4	158	823	58.3
5	500	2.2	5.71	5	157	817	56.24
6	500	4.2	3	6	150	781	57.85
7	425	2.9	4.2	1	151	786	57.9
8	425	2.2	5.71	2	152	791	57.96
9	425	4.2	3	3	150	781	57.85
10	425	2.2	3	4	150	781	57.85
11	425	4.2	4.2	5	152	791	57.96
12	425	2.9	5.71	6	148	770	57.73
13	350	2.2	3	1	147	765	57.67
14	350	4.2	4.2	2	151	786	57.9
15	350	2.9	5.71	3	150	781	57.85
16	350	4.2	5.71	4	151	786	57.9

17	350	2.9	3	5	149	776	57.80
18	350	2.2	4.2	6	151	786	57.9

Table 17- Orthogonal Array for quantity of good seed i.e. wt. of good grade seed collected

Expt.no.	Parameters For quantity				Wt. of good seed in kgs. collected in 15 sec.	SN ratio
	Oscillation speed	End slope	Side Slope	Fan Setting combination		
1	500	4.2	5.71	1	3.455	10.768
2	500	2.9	3	2	3.912	11.479
3	500	2.2	4.2	3	4.834	13.686
4	500	2.9	3	4	5.682	15.090
5	500	2.2	5.71	5	4.789	13.604
6	500	4.2	3	6	8.649	18.393
7	425	2.9	4.2	1	5.57	14.917
8	425	2.2	5.71	2	7.329	17.300
9	425	4.2	3	3	6.347	16.051
10	425	2.2	3	4	7.603	17.619
11	425	4.2	4.2	5	5.398	14.644
12	425	2.9	5.71	6	3.165	10.004
13	350	2.2	3	1	4.377	12.823
14	350	4.2	4.2	2	4.289	12.647
15	350	2.9	5.71	3	1.944	5.773
16	350	4.2	5.71	4	5.704	15.123
17	350	2.9	3	5	7.024	16.931
18	350	2.2	4.2	6	3.511	10.908

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Table 18- For calculating SN ratio the higher-the-better quality characteristic is taken into consideration.

Levels.	parameters For quality			
	Oscillation speed	End slope	Side slope	Fan setting
1	57.858	57.98	57.69	57.99
2	57.675	57.97	58	58
3	57.83	57.61	57.87	57.92
4				58
5				57.33
6				57.62
Diff.	0.183	0.37	0.31	0.67
rank	4	2	3	1

Table 19- For calculating SN ratio the higher-the-better quantity characteristic is taken into consideration.

Level.	parameters For quantity			
	Oscillation speed	End slope	Side slope	Fan setting
1	13.8366	14.6043	12.095	12.836
2	15.0891	12.365	13.648	13.808
3	12.3675	14.323	15.549	11.836
4				15.944
5				15.059
6				13.101
Diff.	2.7216	2.2393	2.599	4.108
rank	2	4	3	1

Chart 5 -Mean of SN ratios versus factor levels for quality of good seed

Chart No. 5 . 1

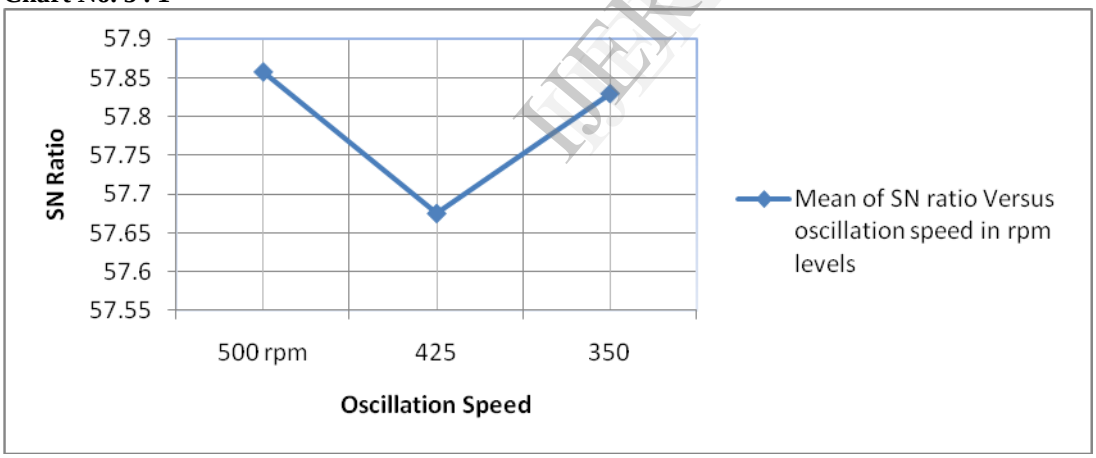

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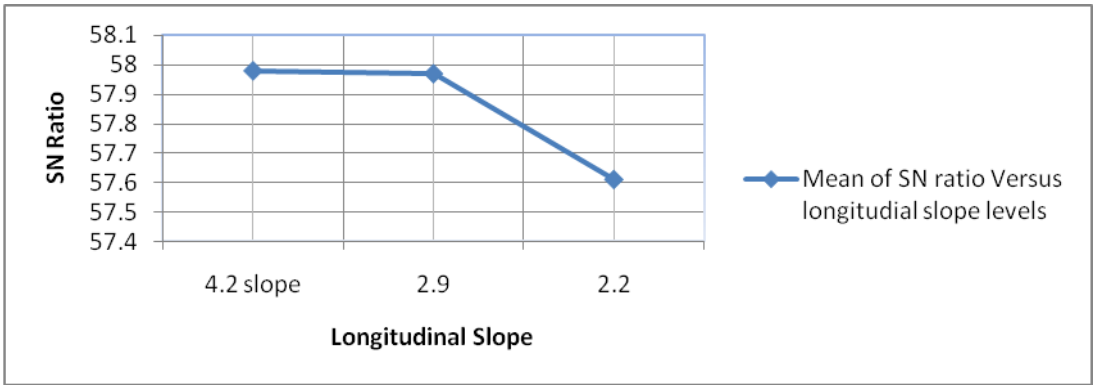
Chart No. 5 . 2



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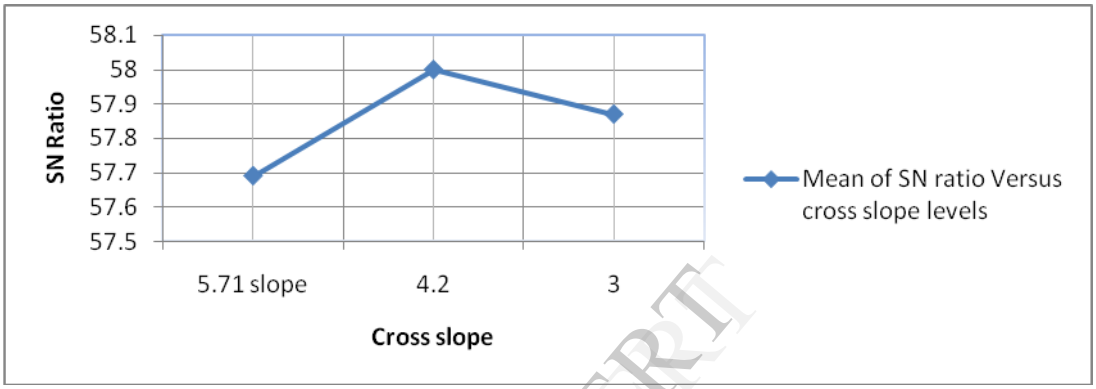

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Chart No. 5.4

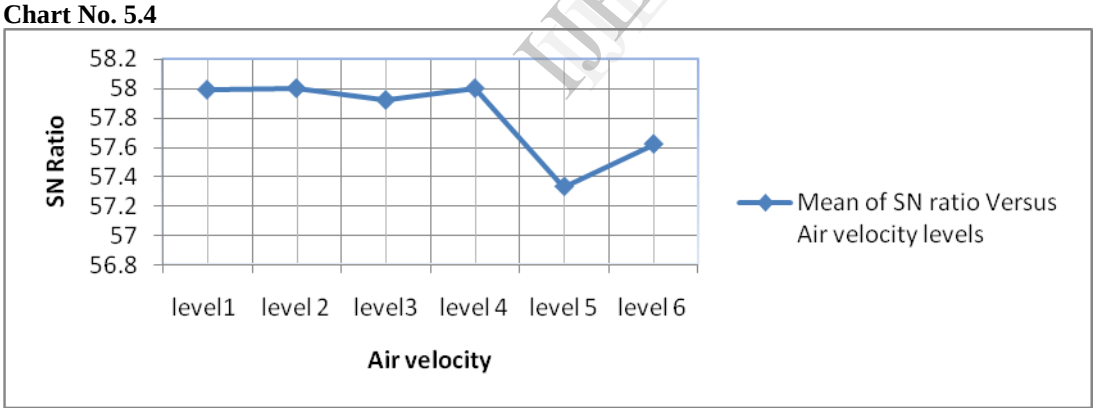
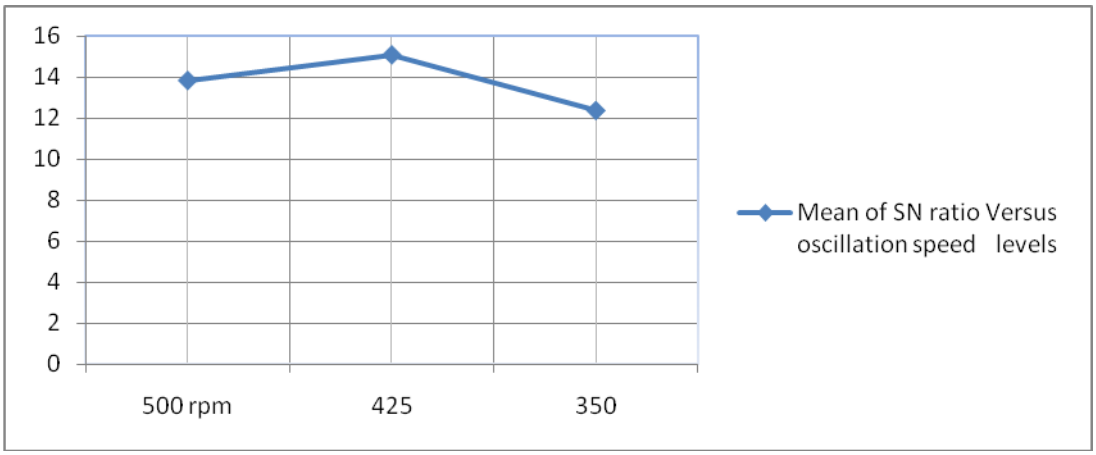


Chart-6 Mean of SN ratios versus factor levels for quantity of good seed

Chart No. 6.1



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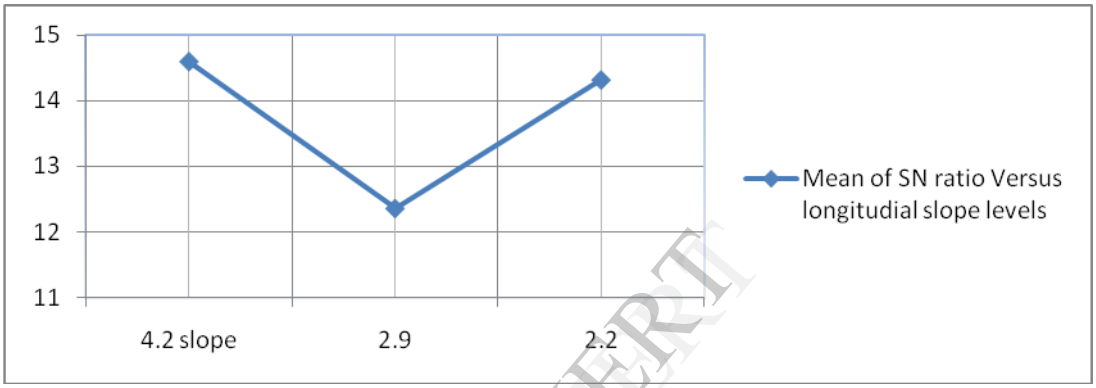

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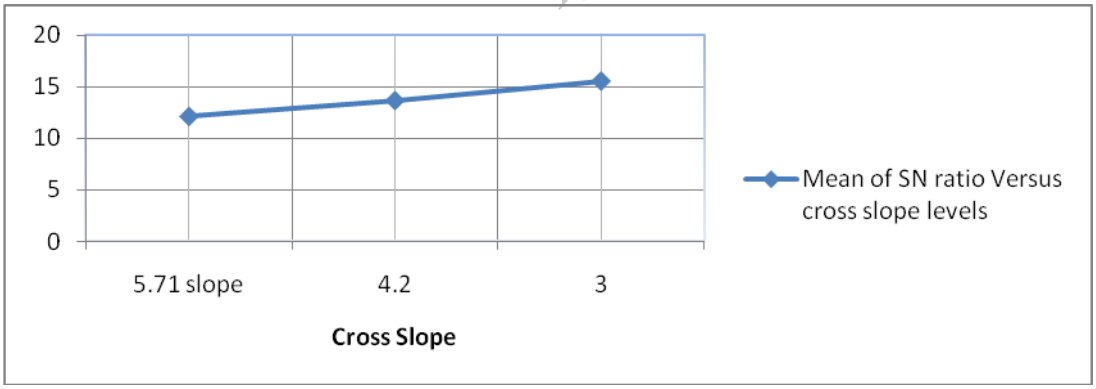

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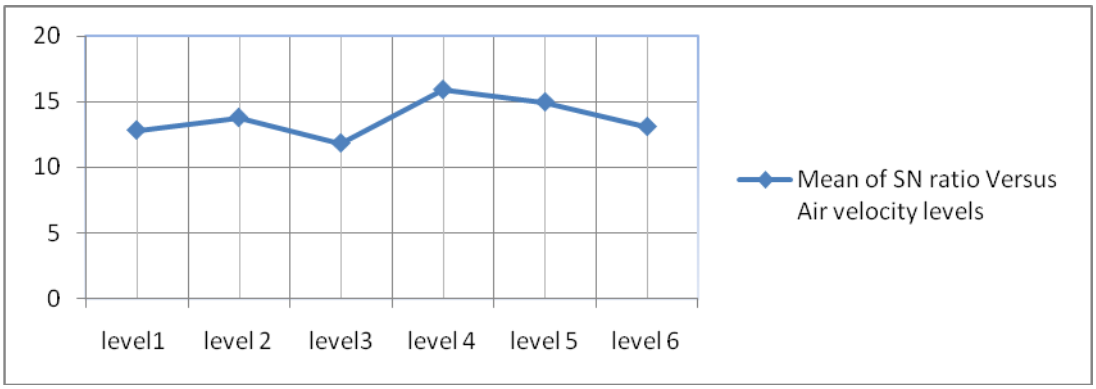

From the graphs of S/N ratio versus factor levels it is clear that the combination of Oscillation speed(level 3), longitudinal slope (level 3), Cross slope (level 3) and Air velocities (level 6) should give the maximum specific gravity good seed and maximum quantity according to Taguchi design. So to confirm, an experiment was conducted with same set of parameters and specific gravity good seed 0.838 which was the maximum.
The maximum quantity is 8.649 kgs in 15 kg i.e.2075 kg per hr.
One should understand that the setting of all the parameters should be done judiciously to have proper combination of allowable output and sp. gravity of good seed.
In the sixth expt. The graded quantity of good seed is highest i.e. 2075 kg/hr but specific gravity is comparatively less i.e.0.781. While in first experiment density is highest i.e. 0.838 while graded quantity of good seed is 3.455 kgs in 15 seconds i.e. 830 kg/hr.
So combination of settings of various parameters should be such that it should justify quality and quantities of graded good seed above acceptable level (acceptable level changes many times as per companies policy) to, say in this case experiment no.4 gives output of good seed as 5.68kgs in 15 sec. i.e. 1370kgs/hr. and sp. Gravity of good seed at this setting is 0.823, which is well above of acceptable level of sp. Gravity say 0.8.
Government has certain policy on minimum germination percentage of seed which depends on sp. gravity of seed.

7.Conclusions & scope for future work

Conclusions

This experimental investigation on the grading parameters has led to the following specific conclusions for sp. Gravity of seed:

1. Air Velocity is the most significant factor followed by longitudinal slope, cross slope and then oscillation speed.
2. There is no specific pattern of variation of sp. Gravity obtained by changing only one parameter while keeping the others constant.
3. Maximum sp. gravity predicted by Taguchi analysis for a particular set of parameters was found correct.

4. For quantity Air Velocity is the most significant factor followed by oscillation speed, cross slope, and then longitudinal slope.

Scope for future work

This work leaves a wide scope for future investigators to explore many other aspects of quality grading with increased output. Some recommendations for future research include:
Application of other optimization techniques and comparing results with Taguchi method and to study many other parameters responsible for grading. One can develop fussy logic controller for this set up.

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