SPECIAL PURPOSE SEED SEPARATORS

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Introduction

In seed conditioning we are interested in more than basic cleaning of seeds. The physiological quality of a seed lot can, in many cases, be upgraded and specific contaminants removed. The air screen cleaner is a basic conditioning machine which removes undesirable material from seeds by means of the screens or sieves and air systems of the air screen cleaner. Frequently, however, certain contaminants or other undesirable materials remain in the lot after basic cleaning with the airscreen cleaner and other machines have to be used eliminate them. In some instances the contaminants can be removed by dimensional sizing equipment (disc separator, indent cylinder separator, width and thickness grader) while in other instances machines categorized as "special purpose seed conditioning equipment" have to be used.

A seed lot can be physically upgraded by removing inert material, weeds, and off-type seeds, while its physiological quality can be upgraded by removing diseased, insect damaged and immature seeds that do not germinate.

All seed conditioning equipment make use of differences in the physical properties or characteristics of seeds and undesirable materials to effect separations. For any two seed kinds or a kind of seed and a contaminant to be separated, they must differ in at least one physical property.

Special purpose separations are effected by taking advantage of differences in the following physical characteristics of seeds:

- Shape (degree of roundness)
- Weight (specific gravity)
- Seed coat texture

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• Affinity for liquids
• Electric conductivity
• Color

**Spiral Separator (Shape or Degree of Roundness)**

In some instances the dimensions of a contaminant are so close to those of the seeds being conditioned that a separation with the air screen cleaner or sizing equipment is not possible. This is the case of soybean seeds contaminated with giant morning glory or purple moonflower (*Ipomoea turbinata*) seeds. Soybean seeds do differ from purple moonflower seeds in degree of roundness (or shape) - moonflower seeds have two flat sides. This difference permits their separation with the spiral separator.

The spiral separator basically consists of a series of sheet metal flights spirally wound around a central tube. In the older style (Krussow style) separator the flights are surrounded by a separate outer spiral which receives the "round" seeds for discharge separately from the "less-rounded seeds" (Figure 1). The new models such as the AMOS no longer use the outer spiral. The spiral flights are placed inside a metal box which contains the "roundest" seeds and has appropriate discharge openings (Figure 2).

Seeds fed into the hopper fall onto the spiral flights and begin to roll or slide down the flights. Those seeds which are round roll faster and attain a velocity which causes them to roll over the edge of the flight under the influence of centrifugal force. They are collected by the outer spiral (in the Krussow type) or at the bottom of the box (as in the AMOS) and spouted out of the machine. Seeds or particles that have a lesser degree of roundness do not roll over the edge of the spiral flight but continue to slide down the flight toward the bottom where they are discharged.

The only significant adjustment that can be made for the spiral separator is the rate of feed which consists of moving a disc that contains various size holes until the desired size is directly in the bottom of the hopper in the Krussow type, or by placing the plate with the appropriate diameter hole in it at the feed end of the enclosed type spiral. Another adjustment is the use of "fingers" to retard the movement of the seeds and direct them toward the central axis.

**Gravity Table (Density or Specific Gravity)**

Seeds of similar dimensions but differing in specific gravity or density can be separated with the gravity table. A density separation is essentially an air
Figure 1. Krussow Spiral Separator.
Figure 2. AMOS-type Spiral Separator
flotation process by which the seeds are first vertically stratified in a rising air column according to density (Figures 3 and 4). The layers are then separated horizontally on the deck of the gravity separator by vibrating action.

The gravity table makes use of fans and "vibration" to accomplish a density separation. Air is either pulled or forced up through the deck to stratify the seed layer. The deck is slightly inclined toward one side and vibrates in a semi-elliptical motion toward the high side. Once the air is adjusted properly, the light material is lifted and suspended on an air cushion, while the heaviest material remains in contact with the deck. Because of the inclination to one side, the light material flows "down hill" to accumulate across the lower side. The heavier seed overcomes the air pressure and remains in contact with the deck surface and moves toward the higher side and end as it is pitched uphill by the deck motion. The deck is also inclined perpendicularly to the direction of vibration leading toward the discharge end of the machine, thus allowing the seeds to move down hill and eventually discharge at the front high edge of the deck. The use of gravity tables in the seed industry has increased as seedsmen have become more aware of the importance of selling higher quality seeds. For example, acid delinted cottonseed is substantially upgraded by removing most immature seeds which are low in density and quality. Despined cockleburs can also be eliminated since they have a lower specific gravity than fully developed cottonseed. The gravity separator is also used (along with the aspirator) as the finishing machine for corn seeds. And, it is now widely used in conditioning soybean seeds, those of the small grains, e.g., sorghum, wheat, some kinds of pasture seeds such as Bahiagrass seeds, sunflower seeds, many kinds of vegetable seeds and so on.

The gravity table is the most effective machine for upgrading the germination and vigor of seed lots because it separates seeds on the basis of differences in density which is the physical property of seeds most closely and consistently correlated with physiological quality.

**Air Separators**

Any particle that falls through the air encounters a restraining force due to the resistance of air. This restraining force increases as the air velocity increases until a certain speed is reached at which time the particle can be practically suspended on the rising column of air. This speed is known as terminal velocity. Contaminants and seeds, even within the same lot, can have different terminal velocities. Air separators take advantage of this difference to effect a separation.

Air separators can be classified as pneumatic separators and aspirators. In the pneumatic separator air is forced into a separating chamber into which the seed mixture is fed. The light materials are lifted by the uprising air column and discharged at the high or top end of the column, while the heavier seeds, with a
Figure 3. Gravity Table. (A) Fan intake closed; no stratification.  (B) Proper volume of air flow through the deck; the seed layer is stratified.  (C) Excessive volume of air flowing through the deck breaking the stratification.
Figure 4. Gravity Table. Once the seed have been stratified, the different layers can be separated.
greater terminal velocity, overcome the air current and discharge at the bottom of the column (Figure 5).

In the aspirator the air is pulled rather than pushed through the chamber as the fan is located at the air discharge. The seeds are fed from the hopper into the air column. The heaviest seeds fall "through" the air flow and out of the air stream, while the lighter seeds and contaminants are lifted by the air column which is shaped at an even widening angle causing a gradual decrease of air velocity and allowing seeds and contaminants to be discharged at one or several outlets depending on their terminal velocity (Figure 6). The fractioning aspirator has multiple discharge outlets. The use of the aspirator has greatly increased, particularly in the hybrid corn seed industry. The overall capacity of a corn seed conditioning plant can be increased by running the dimensionally graded seeds through the aspirator to separate the heaviest seeds. The light fraction can then be conveyed to a gravity table to take out the heavy seed. This procedure takes advantage of the greater precision of the gravity table while reducing the bulk of seeds sorted on the gravity.

If we were to make a summarized comparison between the gravity table and the aspirator, we could say that the gravity table performs a more precise separation but at a lower capacity. The aspirator is not as precise as the gravity table but has a considerably greater capacity and can be more easily adjusted.

**Roll Mill (Surface Texture)**

The roll mill, also known as "dodder mill," is another finishing machine useful in situations when there is a difference in the shape or surface texture between the good seeds and the contaminants. For instance, dock as well as sorrel and wild carrot seeds can be removed from several types of clovers with the roll mill. In fact, one of the machine's names - dodder mill - is derived from the separation for which it was originally designed, i.e., to remove dodder from clover and alfalfa seeds.

In the roll mill two metal rolls covered with a velvet-like material are positioned side by side slightly touching each other. When viewed from the top, they rotate outwardly in opposite directions. The paired rolls are mounted at an angle that can be adjusted between 7 and 13 degrees. A metal shield or baffle which conforms very closely to the upper shape of the rolls is positioned directly over the pair of rolls, and its distance from the rolls can be adjusted.

As the mixture of seeds is fed onto the top "trough" between the rolls, the seeds move downhill between the rolls since they are inclined. Seeds or particles with rough textures are "caught" by the velvet-like material and tangentially thrown against the baffle, which deflects the seeds back to the outwardly rotating roll. This action is repeated several times until the rough seeds are actually thrown...
Figure 5. Pneumatic Separator. Seed flow diagram.
Figure 6. Fractionating Aspirator. Seed flow diagram. (A) feed intake; (B) heaviest seed; (C) air separation area; (D) next heaviest seed; (E) third heaviest seed; (F) lightest particles.
"over" the rolls and collected in bottom bins (Figure 7). The length of the rolls varies from one machine to another and so does the number of pairs of rolls. Capacity is determined by the number of paired rolls in the machine. Usually, there are three seed collecting bins at the bottom of the machine. The rough seeds/smooth seeds ratio discharged in these bins is greatest closest to the feed end. The smoothest seeds continue to slide between the rolls until they discharge at the low end. The seeds collected in the bottom bins can be recirculated after readjusting the machine to recover some of the previously rejected smooth seeds.

Magnetic Separator (Surface Texture)

Smooth coated crop seeds contaminated with rough coated or textured weed seeds or inert material can also be separated with magnetic separator. Weed seeds with a sticky seed coat when wetted are also effectively removed with the magnetic separator.

The principle of separation lies in the fact that rough, granular or sticky surfaces (seed coverings) when carefully wetted will retain finely ground iron powder. Thus, if they are exposed to a magnetic field they can be "pulled" away from the smooth surface seeds to which the iron powder does not adhere.

Most magnetic separators consist of three basic components. The feeding unit meters a uniform amount of seeds into the mixing unit. In the mixing section a specific volume of water is applied to the seeds, mixed well and then finely ground iron powder is added and the mixture is again mixed and conveyed to the separating unit. Usually, the separating unit is made up of one or more magnetized drums. As they rotate, a uniform, one seed-thick layer of the mixture is flowed over the drums. Those seeds or particles with adhering iron powder remain attached to the surface of the drum by magnetic attraction and are brushed off or gravity removed at the underside. Seeds with a smooth surface and no adhering iron pass over the drum and are discharged as clean seeds (Figure 8).

The magnetic separator is very useful in removing dodder, buckhorn plantain, and other weed seeds from crop seeds such as sericea lespedeza, alfalfa, vetch, and different kinds of clovers. Every lot requires some experimentation to come up with the optimal rate of feed, volume of water and amount of iron powder, since different proportions are required for different weed seeds/crop seeds combinations.
Figure 7. Roll Mill. Cross section of a pair of rolls illustrating the principle of separation.
Figure 8. Magnetic Separator. Rough seeds that retain a coating of iron powder are brushed off the magnetic drums and discharged through spouts 2 and 3. Smooth seeds pass over both rolls and discharge into spout 1.
**Electric Color Sorter (Color Differences)**

The electric color sorter is regarded as a very specialized finishing machine. It is utilized to sort particles that differ in color or brightness from that of the commodity being cleaned.

Color sorters are provided with a precise feeding mechanism that allows a continuous flow of singulated seeds through the sorting area. The color sorter makes use of photovoltaic cells to sense those particles of different color or brightness than the desirable seeds. A photovoltaic cell compares the color and brightness of each seed against a background color. Light is continuously being reflected from the background creating an unbroken flow of electrons to the photocell. When a seed or particle with different color or brightness passes between the electrocell and background, it reflects a different quality and/or quantity of light which the photocell senses and, in turn, activates a rejection system. Generally, the rejection system consists of an air nozzle that is activated exactly when the unwanted seed or particle passes in front of it. The unwanted seed or particle is then diverted from the product stream into the reject chute. Acceptable seeds continue their freefall into the accept chute (Figure 9).

Improvements in electronics have allowed the manufacture of compact, very reliable and easy to service machines. Higher capacities are achieved by placing many color sorters in parallel. Some particular models have front and rear photocells (viewers) for each channel conveying the stream of seeds, using either tubular or circular fluorescent lamps to provide an even lighting to the backgrounds and product surfaces.

Color sorters are used by plant breeders and foundation seed operations to purify genetic materials. They are also important in the bean industry as well as many other types of operations such as cleaning pecans, coffee, beans, peanuts, rice, sesame, and so on.

**Electrostatic Separator (Electrical Properties)**

All seeds have or can be induced to manifest certain electrical properties, namely polarity and conductivity. The electrostatic separator makes use of differences in these characteristics among seeds to effect a separation.

Basically, an electrostatic separator consists of a feeding mechanism, a separating area energized by a positively or negatively charged electrode and divided compartments for receiving the separated material.

The seeds flow from a hopper bin onto a vibrating or belt conveyor with adjustable speed. In most of the conventional units, the seeds are then discharged on a grounded rotor or belt which continues to move them forward and discharge them
Figure 9. Electric Color Sorter. Seed flow diagram.
into the electric field created by an electrode placed several inches away from the rotor. Several compartments receive the separated material.

Separation is accomplished on the basis that like charges repel and unlike charges attract. Separations can also be made when the particles acquire different strengths of charge. When material is passed through an electrostatic field, those particles charged oppositely from the electrode are attracted toward the electrode, and lifted away from the normal pattern of flow and, thus, separated from the rest by the dividers (Figure 10). This separation is performed based on differences in polarity of the charge on the individual seeds.

A separation can also be made taking advantage of the degree of insulating value of each seed. A high tension field is discharged by a very fine wire electrode toward the grounded rotor. As the seeds are exposed to the high tension field, they are "pinned" to the rotor. Some seeds which are not good insulators dissipate the charge as soon as they move away from the field and fall freely from the rotor. Those seeds that are good insulators retain the charge much longer, remaining attached or pinned to the rotor until they are brushed off, falling in a different compartment (Figure 11). "Moderate" insulators react intermediate to the other two classes and their fall pattern is largely determined by the speed of the rotor.

The same principles of separation apply to the electrostatic sorting equipment manufactured by Helmuth Incorporated. Some of the modifications include several fine wire electrodes in a rectangular frame providing the electrostatic field. A grounded metal shield is located across the electrode assembly. The distance between the grounded shield and electrode assembly can be adjusted (Figure 12).

The effectiveness of a separation performed with an electrostatic separator is highly influenced by the environmental conditions as well as the moisture content of the seeds. However, good separations have been accomplished when removing dock from red clover seeds, hulled Johnson grass from sesame seeds, and pigweed from some lots of white clover.

**Summary**

Many types of machines are available for effecting specific separations of contaminants from seeds. Analysis of the "purity" problem is necessary in order to identify the physical property difference which can be used to effect a separation.
Figure 10. Electrostatic Separator. Non-discharging field lifting effect.
Figure 11. Electrostatic Separator. Discharging high intensity field pinning effect.
Figure 12. Helmuth-type Electrostatic Separator. Seed flow diagram.