PRINCIPLES OF SEED SEPARATION

Howard C. Potts

The emphasis of this discussion will be on the seed and other materials encountered in seed lots because the specific machines used for cleaning seed are discussed in a wide range of publications. Often we get so involved in thinking about machines that we ignore or at least neglect the seed to be processed.

The removal of undesired materials from a seed lot is an act based upon the application of scientific principles. Because of the inherent variability of all biological materials, such as a seed lot or an individual seed, no one formula or recipe can be applied to processing all seed lots of a species, or even the various seed lots of the same variety. The anatomy of every seed lot is different. It is the seed processor's responsibility to use his knowledge of seed and the available machines to prepare the seed in a manner acceptable to the consumer.

Two seed can be separated mechanically only when there is a mechanically detectable difference in one or more of their physical characteristics. If either a sufficient physical difference doesn't exist or you don't have the machine capable of making the desired separation, the separation can't be made as far as you are concerned. A lot of time and money has been wasted trying to make separations that can not be effectively made with the machines available, although to the naked eye, there was an obvious physical difference.

There must be a significant difference between the good seed and its contaminants to make a mechanical separation. This is the most basic fact of mechanical seed cleaning.

Physical Characteristics of Seed

Consider the physical characteristics of the seed on which various machines act to make a separation. There are five physical characteristics of seed materials by which machines can make economical separations. These are: size, weight, surface texture, shape and color. The use of differences in electrical charge, buoyancy and resiliency have some promise, but these are not important at present.

SIZE

The most common difference between seed and their contaminants is that of gross size. Most of the material cleaned from every lot of seed is simply larger or smaller than the seed you are cleaning. Differences in gross size are the principle reason that air-screen cleaner is the basic machine in a processing plant.

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Consider the components of any lot; the pure seed, inert matter, weed seed, other crop seed, damaged seed, some of these materials will be either larger or smaller than the seed we want to clean. This is the difference in gross size. It is the screens of an air-screen cleaner that are used to make this separation (Figure 1.). Recall that all components of seed lot are three dimensional, that is they have length, width and thickness. If there is a large difference in any one of these physical characteristics between the seed and the contaminants, screens are available which can make the separation. Gross size can be subdivided into three components; length, width and thickness.

Length

Differences in length are very common among seed. The length of a seed is its longest dimension. For most length separations there must be a difference of at least 4/64-inch, although, if you have the time, separations are possible among particles of less difference in length. Two machines which separate primarily on the basis of length are the indented-cylinder and the disc separator.

As shown in Figure 2, a cross section of the indented-cylinder, the shorter seed fit into the indentations, are subsequently lifted out of the longer seed and deposited in a collecting through. The weight of the seed influences separations made with the indent-cylinder. The disc separator also separates on the basis of differences in length. This separation is shown in the longissection of a single disc given in (Figure 3.). This length separation is not weight dependent.

Width

For many years separating seed on the basis of width was restricted to corn and this is still the primary use of width separators. Figure 4 shows the shell of a width grader and clearly demonstrates how the width separation is made. Any seed or particle whose width is smaller than the round perforation will pass through. With this machine differences in width as small as 1/64-inch are sufficient to make a separation. Because of its accuracy in classifying seed, separations can be made between long and short grain rice varieties. The noxious weed, red rice, is a short grain rice and wider than long grained varieties.

Thickness

Separations made on the basis of differences in thickness are not common except for corn. Although, in a true sense the removal of split or damaged seed, such as soybean splits, are made on the basis of a difference in thickness. When the size grader is used to make thickness separations a shell having oblong slot perforations is used (Figure 5.).

Shape

Shape varies widely among seed of different species. The separations made by the screens of an air-screen cleaner are often related to differences in shape, especially when screens having triangular perforations are used. Of course the indented-cylinder, disc separator and width-thickness
Figure 1. Screen and lower air systems of an air-screen cleaner (gross size).

Figure 2. Cross-section of an indented cylinder separator (length).

Figure 3. Cross section of an individual disc from a disc separator (length).
Figure 4. Schematic view of a shell used to make width separations (width).

Figure 5. Schematic view of a shell used to make thickness separations (thickness).
grader separate seed on the basis of shape.

However, there are some contaminants which can not be separated from the good seed except for the fact that some seed are round and others flat on at least one side. The spiral separator was developed to take advantage of the fact that round seed, such as winter peas or vetch, will roll more readily than wheat, oats or rye (Figure 6.). However, today this same principle, a difference in shape, is most widely used to separate split and flattened soybeans, despined cockle burr and giant morning glory from essentially round soybeans.

**WEIGHT**

Frequently we encounter seed lots which after having removed contaminants different in size and shape still contain contaminants which differ in weight or specific gravity. Machines which make separations based on differences in weight involve a controlled stream of air. Thus, when the size of the particles are approximately the same, but the density differs, such as whole and weevil damaged wheat, rice or maize seed, a separation is possible. The gravity table is the machine most of us think of first when thinking of weight separations (Figure 7). However, the blast fan on an air-screen cleaner, the pneumatic and fractionating aspirators (Figure 8), and the stoner all use differences in weight among the components of a seed lot to make a separation.

**SURFACE TEXTURE**

Differences in the texture of the seed coat or outer covering of the seed or a contaminant is another physical difference among seeds by which they can be separated. For many years the roll mill, which separates seed on the basis of surface texture, was referred to as the dodder mill because of its effectiveness in removing dodder which has a pitted seed coat from smooth seeds of the same size such as red clover, alfalfa, lespedeza, etc. (Figure 9). However, surface texture separations are not limited only to seed with pitted surfaces. For example, dock can be removed from smooth seeded legumes because dock's sharp edges act in a manner similar to the pits in dodder, that is they engaged the nap on the rolls sufficiently to permit the seed to be lifted to the outside of the rolls.

More recently the magnetic separator has found favor as a separator of seed which differ in surface texture (Figure 10). However, to be effective, seed separated by any magnetic separator must have a seed coat rough enough to hold the iron powder. Thus, the magnetic separator is not effective in separating dock because the iron powder has no surface on which to lodge.

On the other hand, the magnetic separator is effective in separating buckhorn plantain from seed with smooth seed coats because when moistened buckhorn seed become sticky and will hold the iron powder. Buckhorn plantain can't be effectively removed by a roll mill.
Figure 6. Cutaway view of a spiral separator.
Figure 7. Diagramatic side view of the air separation on a gravity table (weight).

Figure 8. Cross-sections of the fractionating (L) and pneumatic (R) aspirators (weight).
Figure 9. Cross-section of a roll mill (surface texture).

Figure 10. Cross-section of a magnetic separator (surface texture).
COLOR

Separations based on differences in color are not used extensively in the seed industry, because of the cost-output ratio of the color separators. However, as this ratio has decreased use of the color sorter has increased, particularly with companies processing seed peanuts. The white, split seed are easily separated from the red, whole seed, a separation formerly practical only by hand picking. The keys to economic success of this separation are the large size of the individual peanut seed permits a relatively high volume capacity and increasing labor costs. (Figure 11).

As processors strive for greater uniformity and higher quality in seed, and the cost-output ratio becomes more favorable it is likely that increasing numbers of color sorters will be purchased for processing seed.

To summarize, the physical differences between seed and their contaminants; size, shape, weight, surface texture and color, and the machines used to make separations based on these differences are given in Table 1. Electrical charge, resiliency and buoyancy are additional physical properties possessed by seed, however, at present there are no economically practical machines capable of utilizing these characteristics to make separations.

Factors Affecting the Separation

Knowing the physical properties of seed and the machines capable of separating seed on the basis of these properties assumes practical importance only when applied to a specific lot of seed. Many persons who can recite both the physical properties and the matching machines do not fully utilize this knowledge when faced with its practical application because of the variation that exists in the components of each lot.

There are several judgement decisions which the processor must make concerning the most effective machine and its adjustments for making a particular separation or series of separations. These decisions depend upon the characteristics of the seed lot more than the machine. The only method available, on which to base these pre-processing decisions, is to examine a representative sample of the seed lot and determine the physical differences which exist between the seed to be cleaned or upgraded and the undesirable material that can be removed. Never forget: to make a mechanical separation there must be a significant physical difference between the good seed and its contaminants.

Those contaminants which have physical characteristics similar to those of the good seed are of greatest concern. When examining the seed lot particular emphasis must be placed on determining the presence of contaminants such as noxious weeds, nematode galls, etc. which could cause the seed to be unsalable even though the mechanical purity may exceed 99%. Common weed seed, seed of other crops or varieties, damaged seed and inert matter similar in physical characteristics to those of the good seed are of descending importance in most seed lots.

Contaminating materials obviously much larger, smaller or lighter
Figure 11. Schematic diagram of electrical and mechanical systems of an ESM electric sorting machine.
### Physical Property

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SIZE</td>
<td></td>
</tr>
<tr>
<td>(a) Gross</td>
<td>Air-Screen Cleaner (screen section)</td>
</tr>
<tr>
<td>(b) Length</td>
<td>Indented Cylinder, Disc Separator</td>
</tr>
<tr>
<td>(c) Width</td>
<td>Width &amp; Thickness Separator</td>
</tr>
<tr>
<td>(d) Thickness</td>
<td>Width &amp; Thickness Separator</td>
</tr>
<tr>
<td>2. WEIGHT</td>
<td>Gravity Table, Aspirator, Stoner, Air-Screen Cleaner (fan section)</td>
</tr>
<tr>
<td>3. SURFACE TEXTURE</td>
<td>Roll Mill, Magnetic Separator, Vibrating Separator</td>
</tr>
<tr>
<td>4. SHAPE</td>
<td>Spiral Separator, Roll Mill</td>
</tr>
<tr>
<td>5. COLOR</td>
<td>Color Sorter</td>
</tr>
</tbody>
</table>

Table 1. Physical properties of seed and their contaminants and the machines which utilize these differences to make separations.
than the good seed are not of great importance except when such ma-
terials affect seed flow characteristics or when they represent more
than about 20% of the seed lot. Seed lots containing a very high per-
centage of inert matter, removable crop or weed seed normally must be
cleaned at a reduced rate to permit removal of these materials and to
avoid flooding the discharge spouts.

The frequency of occurrence of the contaminants also affects the
cleaning operation. Depending upon the quality standard to which the
seed must be raised, certain contaminants can be ignored. All clean
seed will contain a fractional percentage of inert matter. Many lots
of seed will contain a fractional percentage of other crop or common
weed seed because the cost of removing such seed, through additional
processing, exceeds the value added to the clean seed.

As an example, if the pre-cleaning examination revealed the pre-
sence of one oat seed per handful of wheat seed in a lot of non-certifi-
ced wheat seed, the oat might be ignored. However, if the wheat seed
is to be certified it would be necessary to remove the oat seed.
Thus, the presence of this occasional oat seed would affect the equip-
ment used, therefore, the cost of processing the certified seed, but
would have no effect in the example of the non-certified lot of wheat
seed. This same example is equally valid for common weed seed and
inert matter in that the quality standards set by management, or in
some cases laws, determines what contaminants must be removed from
each seed lot. Ideally, every lot of seed will be 100% pure seed,
realistically 100% purity is not practical, physically or economically.

Another factor which should be closely examined during the pre-
processing examination is the size variation of both the good seed and
the materials to be removed. Inexperienced processors assume that all
the good seed and/or the contaminants are the same size, shape, weight,
texture or color. This is a false assumption! Every component,
whether seed or plant part, encountered in an uncleaned seed lot will
vary in each of its physical characteristics.

The data presented in Table 2, giving the variation in diameter
and weight of the pure seed in six lots of the same variety of soy-
beans should be sufficient proof of the variability which exists in
the physical characteristics of the components of different seed lots.
This same kind of variation occurs in each contaminant of each seed
lot.

One of the saddest testimonies to the proficiency of a seed pro-
cessor is to observe machine settings or screen sizes marked with the
name of a crop. Such marking usually indicates a disregard for the
natural variation in the physical characteristics of the components
of each seed lot.

Most seed lots which have been harvested and threshed mechanically
will flow through a properly designed processing plant. However, an
occasional lot of many kinds of seed may lack the desired flow or pro-
<table>
<thead>
<tr>
<th>Lot Number</th>
<th>Seed Diameter (64th-inch)</th>
<th>Lot Average</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>(Percent of the Lot)</td>
<td></td>
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<tr>
<td>11</td>
<td>12 13 14 15 16 17 18</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.4 5.1 24.6 52.3 15.3 2.4 0.0 0.0</td>
<td>13.8</td>
</tr>
<tr>
<td>2</td>
<td>0.4 5.0 23.5 54.1 13.8 3.3 0.0 0.0</td>
<td>13.8</td>
</tr>
<tr>
<td>3</td>
<td>0.0 0.0 0.9 3.0 14.6 43.1 31.7 6.9</td>
<td>16.2</td>
</tr>
<tr>
<td>4</td>
<td>0.0 0.0 0.9 2.6 14.2 42.2 32.8 7.4</td>
<td>16.3</td>
</tr>
<tr>
<td>5</td>
<td>0.0 0.8 4.4 21.4 37.3 28.2 7.0 1.0</td>
<td>15.1</td>
</tr>
<tr>
<td>6</td>
<td>0.0 0.7 2.7 19.3 43.1 29.3 4.9 0.0</td>
<td>15.1</td>
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<table>
<thead>
<tr>
<th>Weight/100 Seed</th>
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<tbody>
<tr>
<td>(Grams)</td>
</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<td>6</td>
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Table 2. The seed size distribution and weight of 100 seeds lots of Lee 68 soybeans (Aguiar)
cessing characteristics because of natural appendages; high quantities of coarse, inert matter; high moisture content, or poor threshing. Pre-conditioning such lots to improve flowability or make other alterations in the different components often make it possible to change the physical characteristics sufficiently to make essentially perfect separations which were impossible without preconditioning.

If damaged seed are to be removed from the good seed they must be damaged sufficiently to significantly alter one of the physical characteristics discussed. Minor differences, such as soybeans with cracked seed coats, are not usually sufficient, although the surface texture is altered. There are only two basic principles for separating seed. The first is scientific knowledge and the second is common sense.