Cylinder Indent Machine

W. Sorensen

Follow this and additional works at: https://scholarsjunction.msstate.edu/seedsmen-short-course

Recommended Citation

This Article is brought to you for free and open access by the MAFES (Mississippi Agricultural and Forestry Experiment Station) at Scholars Junction. It has been accepted for inclusion in Proceedings of the Short Course for Seedsmen by an authorized administrator of Scholars Junction. For more information, please contact scholcomm@msstate.libanswers.com.
CYLINDER INDENT MACHINE
Wayne Sorensen

1. Operational Principle.

The cylinder indent machine is designed to separate basically by length, as is the disc-type indent machine. As we progress further we will see that there are other physical characteristics that enter into the separation also.

The indent cylinder machine utilizes the forces of gravity and centrifugal force in its operation. The particles to be removed from the mass are loaded into the indents by a combination of gravity and centrifugal force. After locating themselves in the indent, they are retained by centrifugal force to a point of the rotation where the resultant force of centrifugal and gravitational forces falls within the circle of the cylinder. This theory will be more fully explained later.

At this point of discharge, they are dropped and fall into a receiving trough where they are conveyed to a discharge spout. The smaller particles are placed in the trough and the longer particles are discharged as "thru," or in other words, they pass out the far end of the cylinder from the feed without being lifted by the indents. For a particle to be lifted, its center of gravity must fall within the indent itself, otherwise, it will tumble out. For some seeds the center of gravity is at, or near, its geometric center - on others it is displaced greatly from this geometric point. (Figure 1).

Therefore, it may depend which way a seed orients itself in the indent whether or not it is lifted, and seeds must have the opportunity to enter the indent properly before being discharged as a "thru" as shown in Figure 2.

---

1/Mr. Sorensen is Product Planning Engineer, Superior Separator Company, Hopkins, Minnesota, manufacturers of graders, aspirators, cylinder separators, and miscellaneous other seed processing equipment.
II. Machine Sections.

No matter what cylinder machine we choose, there are about five main sections or functional areas of the machine. Each performs a definite part of the separational process.


The cylinder is, of course, the main element in that it is the actual "divider" of the machine and all other parts simply aid the cylinder in accomplishing its purpose. As stated earlier, the cylinders' function is to lift the smaller particles out of the grain mass the correct distance to most accurately and easily make the desired separation. This cylinder is simply a thinwall tube with indents formed from the inside to a shape approximating a hemisphere. The indents may vary in shape from one cylinder to another and these variations will be covered later.

It has been stated that the first cylinder was fashioned out of a hollow log by drilling from the inside a series of shallow holes. We feel that we have progressed a little way from this first attempt, but the principle remains the same.

2. Receiving Trough.

In different machines the configuration of the receiving trough varies somewhat, but the purpose remains the same - to accumulate the lifter particles and convey them to a discharge spout. This trough is adjustable in order to make the "cut" at the exact point of particle size variation desired. This "cut" is usually made within an area of about $60^\circ$ ahead of top dead center of the cylinder. By the proper adjustment of this trough, very good flexibility of operation is possible.

3. Leveler or Conveyor.

It is necessary in a cylinder to have some method of conveying grain through the machine, and to discharge the particles too large for the indent.
There are actually several methods of accomplishing this, each with their advantages and disadvantages. When grain or seed is placed in the rotating cylinder, it rotates in a mass and therefore it is feasible that the small particles at the center of this rotating mass could pass through the machine without ever being exposed to the indented surface. The leveling mechanism should break up this rotation as well as slowly conveying the material through the cylinder. Probably the first effort was the use of a screw conveyor in the cylinder to break up the rotation of the core and also convey the material. Another more recent method has been the use of the grain line blades which both break up the mass and also convey. Some operators are now tilting their machines a variable amount from the feed end toward the discharge end. This method is very good for even feeding and also for cleaning out the machine between batches of grain or seed, but the core of steadily rotating material (similar to a whirlwind) is still there. For most accurate separation, this rotating mass must be constantly agitated as material progresses through the cylinder.

4. Retarder.

The retarder is most easily described as a "dam" at the discharge end of the machine. It is adjustable, due to necessity. In order to be most accurate, the grain bank in a cylinder should be relatively uniform, and if so, action will be quite uniform. Without the retarder, the grain mass would be less at the discharge end of the machine due to depletion of the smaller particles and surging may result. By that I mean that the material will not roll as it should, but the entire mass will move with the cylinder to a point where friction no longer will support it and then it all slides back in a single mass. By retarding the discharge of the machine, the grain depth can be built up to the desired level and maintained at that point, where best operation occurs. The adjustment of the retarder will
depend on the type of seed being processed, etc. If grain level is allowed to drop near the discharge end of the machine inaccurate separation will result. As grain passes through the cylinder we can readily see the following procedure taking place. The smallest particles are lifted out near the feed end of the machine, sometimes with more than one particle located in a single indent. As material progresses through the cylinder, slightly longer particles are lifted into the receiving trough. The toughest division always takes place nearest the discharge end, after the small particles are depleted. If the cylinder is allowed to "starve" at that end, larger particles will be lifted than if grain bank is maintained at a constant level. The indent size cannot accurately perform a length separation unless sufficient depth of material bed is present. This same retarder must also be designed so that it can be removed or displaced so that the cylinder can be quickly and completely cleaned out. If retarder is removed and cylinder rotated, grain will be emptied from the machine quite thoroughly and rapidly.

5. Feeder.

An accurate feeder is a very important requirement on a cylinder machine; the metering must be consistent if separation accomplished is to be consistent. If feed varies, all particles will not have the same length of time to be separated as did other particles. One other consideration besides accuracy is that the metering device does not damage the seeds. Seed processors are becoming more and more concerned about mechanical damage to seeds, as they rightfully should be.

III. Indent Sizes, etc.

Indent sizes are listed in 64ths of an inch, similar to screens used in screen machines. There are no other figures or letters used to describe the indents other than this diametrical nomenclature. There is no way to determine the shape
or depth of the indent from the number.

The two basic types of indents are made with either conical punches or hemispherical punches. The hemispherical punch makes an indent with straight side walls and a circular bottom or root. The conical punch makes a tapered indent with a larger diameter at the top than at the bottom. On some seeds one will hold definite advantages and on other seeds the other holds an advantage. As I stated earlier, the center of gravity of a seed must fall within the indent if it is to be lifted. In a seed that is basically round, the depth of an indent is not so critical as with seeds having a large length to diameter ratio. However, with some seeds, trouble may be encountered with wedging if a hemispherical indent is used with a radius less than the depth of the indent. Wedging will lower the number of effective indents and capacity will be lowered. When a conical indent is employed, this trouble is eliminated to a large extent. Spherical indents do hold some advantages, however, over the conical indents on certain separations and are widely used in shallower depths where wedging is not a problem. Rounded shoulders tend to alleviate the wedging possibility (Figure 3).

We also know that the ratio of depth to diameter. Sharpness of indent shoulders, the angle of the sides, etc. will effect the operation of an indent cylinder. It would be impossible for us to produce, or for you to justify purchase of all the different possible variations of cylinder indents that might be designed for specific seeds. Instead we must standardize our designs to those that will do the most good on the most products.

IV. Speed.

It may be interesting to you to know just how we determine the speed of a cylinder machine. The speed of the machine can be determined by a formula and then altered slightly to overcome variable conditions encountered. First of all, let's establish the conditions for our calculations. The most important deviation from actual conditions is that friction, both air and mechanical, are considered
Figure 1

Figure 2

Figure 3

Sufficient clearance to rotate about this point.

Seed tends to rotate around this point, but sufficient clearance is lacking and seed may wedge.
non-existent. Also, calculation for speed assumes that particles are emptied at top dead center, where centrifugal force is totally in a vertical direction, directly opposing gravitational force.

F is equal to $KWRN^2$

G is equal to weight

At the point of equilibrium gravitational force equals centrifugal force,

$(W = G = F)$ and therefore:

$W = 2.84 \times 10^{-5} \text{WRN}^2$

$N = \sqrt{\frac{1}{2.84 \times 10^{-5}R}}$

$N = \sqrt{\frac{35,200}{R}} = \text{Speed of equilibrium with perfect frictionless conditions.}$

F = Centrifugal force

G = Gravitational force

K = Constant = $2.84 \times 10^{-5}$

W = Weight

R = Radius of cylinder in inches

N = RPM of cylinder where lifted particles cease to empty

On a 23" cylinder ($R = 11.5$) for instance, a theoretical equilibrium speed of 55.5-RPM is determined. At exactly this speed, materials would cease to empty under frictionless conditions, and would carry around the cylinder. Theoretically, if we reduced our speed by 1/10 of one RPM, the indents would empty. From this formula it is evident that speed is lower for larger cylinder sizes and it also appears that the same speed should be correct for all seeds. Here is where we must alter our speed as mentioned earlier.

Several physical properties will change our frictionless conditions by introducing friction of varying magnitude. They are shape of seed, seedcoat texture, size of seed, and moisture content. The specific gravity of the seed also has an
effect on separation as air resistance will effect lighter seeds more.

These frictional forces tend to cause the particles to follow the circumferential travel further than calculated, so our speed must be reduced slightly to allow the seeds lifted to discharge without being carried over the top. In actual operation, cylinder speeds of from 42 to 53 RPM are used, depending on the accuracy of separation desired and characteristics of the material being processed.

Due to this requirement, machines are built with variable speed drives to get the exact speed needed. This speed must be determined by visual inspection of the separating job, adjusting speed and/or trough setting until desired division is accomplished.

On a theoretical, frictionless basis, indents will empty at any speed less than 55.5 RPM on a 23" cylinder. Another way to show it pictorially is that they will empty when the resultant force line falls within the cylinder circle, rather than outside. In Figure 5, the condition circled will result in indents emptying, due to resultant Force $F_R$ failing inside the circle. This force is further broken down into components $F_\parallel$ (tangent to cylinder surface) and $F_P$ (Perpendicular to cylinder surface). In actual practice, indents empty when $F_P$ becomes great enough to overcome frictional force acting on the particles. Figure 5 is based on a speed less than 55.5-RPM.

In Figures 4 and 5 -

$F_C$ = Centrifugal force
$F_g$ = Gravitational force
$F_R$ = Resultant force
$F_\parallel$ = Force tangential to cylinder surface
$F_P$ = Force perpendicular to cylinder surface

V. Accuracy and Capacity.

Two things that all of you seed processors here are vitally interested in are accuracy of separation first of all, and secondly, the capacity at which this accuracy
can be obtained. We and other manufacturers are continually striving for machines that will raise the capacity of your separating without unduly raising the cost or lowering the accuracy of the machine.

Accuracy is a function of two basic considerations - manufacturing tolerance of the indent, and constant radius of the cylinder. If indents are not uniform throughout the cylinder, accuracy is impossible, as the largest indents will be the controlling factor. Most manufacturers today have been maintaining quite close tolerances, but it cannot be exact, due to the forming characteristics of the metal.

In talking about effect of radius variation in the cylinder, let's refer back to our speed formula for a second. You can see that centrifugal force is directly proportional to the radius, and centrifugal force is our controlling force. A cylinder of varying radius at different points, the radius and centrifugal force will vary at different points on the cylinder and a sharp and accurate cut is impossible. Many times it is necessary to make very fine separations and the ability to finely adjust the machine to accomplish this is essential. If the radius of the cylinder is not constant at all points, this accurate separation will be disturbed. Centrifugal force is directly proportional to the radius, and if radius varies 10%, so will this centrifugal force. Therefore, the lifted particles will not be dropped at the same angular point of the travel of the cylinder, and the desired sharpness of cut if rendered impossible. Accuracy of separation is therefore related to the tolerance of the radius. One minor effect on accuracy of adjustment may be dependent upon cylinder diameter. If we assume that the desirable and undesirable seeds are separated by an angle of 10°, the larger the diameter of cylinder, the greater length of cylinder surface falls within this 10° arc. Trough setting will not be quite as critical, even though separation will be no more accurate than a smaller cylinder if both are adjusted accurately.

Capacity is dependent on three basic factors, the number of pockets or indents per unit of cylinder surface area, the number of units of cylinder surface
area that can be run under the grain bank in a given time, and the percentage of the seed mass that must be lifted into the receiving trough.

Of course, the number of indents per unit of surface area is determined by the indent size pretty largely, as the indents can be formed only so close together. The spacing of the indents is largely dependent on the type of material used to fabricate the cylinder and the method of fabrication. The more ductile or stretchable the metal, the more closely the indents can be spaced in relation to one another. The depth and shape of the indents are vitally important here. Also the percentage of the seed mass to be lifted is out of the manufacturer's hands so little can be done on capacity unless cylinder length is increased or more cylinders are used, as speed cannot be increased to get more area travel under the grain.

VI. Maintenance.

Indent cylinder machines are relatively service-free, but one thing should be made clear in order to eliminate some potential dissatisfaction on a new machine. A new machine will not operate properly until the indented surface has an opportunity to become polished. Sometimes it is necessary to clean new cylinders with a thinner or steam. Until polishing is accomplished, grain or seed mass will surge (wash back and forth in cylinder), or will carry over the top of the cylinder at normal speeds, due to increased friction. Cylinders which have not been used recently may become rusty and act the same way. Polishing can be done by running waste grain or fine chick grit in the machine until they become shiny. Cylinder should be run backward with trough turned to emptying position. When handling oily material, indents may tend to "fill" with dust imbedded in oil and effective depth of the indents is lowered. Periodical "scouring" may be needed in this case.

VII. New Developments.

In one experimental machine at Oregon State College, the receiving trough has been eliminated and lifted seeds are picked up by vacuum and collected in a
dust collector. This machine was making a very complete separation between pigweed and alfalfa — a separation which is not easy as you all know. No commercial machine is equipped with this mechanism at the present time, as certain difficult application problems still exist.

If seeds have a difference in length, they can be separated by an indent cylinder. In round seeds, the length of the seed is the diameter, so we might say that separation is by size. Separation on round or nearly round seeds is more simple than long slender seeds. This is because they will orient themselves in the cylinder more readily. As mentioned earlier, the cylinder machine is based on length, but other factors do enter in in varying magnitude.

It may be wise at this point to go rapidly through the adjustment and starting procedure for a cylinder machine.

First of all, a visual inspection should be made of the cylinder to check for rust, dirt build-up and lodged seeds, which will affect the operation of the machine.

Next, adjust cylinder speed to 51-RPM (23" Dia. Cylinder) and set the receiving trough in a level position. After these adjustments are made, the machine is ready to operate and further adjustments must be made according to visual inspection of the operation.

Following this, notice where the seed is being discharged from the cylinder. Droppage should occur between top dead center and a point roughly 45-60° prior to that point. If seeds are carried beyond that area, lower the speed and if delivered below that area, increase the speed. After speed is adjusted, trough must be adjusted according to the "cut" in particle sizes that the operator desires.

The retarder and feed rate will be determined by the amount of material to be lifted and accuracy required. The feed is adjusted so as to allow the material to remain in the cylinder long enough to separate the desired particles, and the retarder is set at a point necessary to keep the grain bank constant throughout the
machine. The greater the variation of particle sizes to be separated, the faster the feed can be. When these adjustments are made, you must answer for yourself this question, "How much good seed can I afford to lose or how much undesirable material can I tolerate in my finished product?" These questions will have a bearing on the final adjustment of the machine.

Often more than one cylinder will be required to make the separations you need. Usually more than two separations are needed.

These separations may be partially accomplished by another machine, such as a screen machine, etc. Usually cylinder sizes can be quite closely determined from charts, etc. but no chart is as good as an actual test. Your manufacturer can give recommendations for most separations.

To sum up the function of an indent cylinder in a few words, we can say that if particles have a difference in length, they can be separated (up to a reasonable point in length). If no difference in length is present, the cylinder machine is not applicable. It is a basic machine in a seed cleaning process train, but is not a "cure-all," the same as other machines are limited in their function.