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MODIFIED ROTARY SIEVE FOR IMPROVED ACCURACY[1]

LEON LYLES, J. D. DICKERSON AND L. A. DISRUD

U. S. Department of Agriculture, Manhattan, Kansas[2]

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Dry clod structure has been used as an index of wind erodibility of cultivated soils for several years (1). Chepil and Bisal (4) developed or adopted the rotary-type sieve as an improvement over flat sieving by hand or by mechanical shakers. Rotary sieving has been used extensively in wind erosion research and in evaluating tillage machine action in terms of the size and distribution of aggregates produced. Chepil subsequently made two modifications to the original sieve. The first modification, reported in 1952 (2), was called an improved rotary sieve. Major changes were in the feeding device and in the number of sieves, increased from 6 to 13. Also, some sieve lengths (mesh lengths) were reduced 33 to 55 per cent.

The second modification, reported in 1962 (3), was called a compact rotary sieve. It was similar in design to the improved sieve except that the number of sieves was reduced to five and the sieve length of the two finer meshes increased.

None of the papers describing rotary sieves indicates the criteria used to establish sieve length or whether it is an important consideration. Apparently no attempts were made to determine the sieving accuracy of the three types.

Whitby (5) reported that the mechanism of nonsteady sieving can be divided into two distinctly different regions on the per cent passing-time curve: Region 1. In this region many particles much less than mesh size are still on the sieve. Region 2. As particles much less than mesh size are removed, the sieving mechanism changes and Region 2 begins. In Region 2, particles remaining that can pass the sieve are very near mesh size. The cumulative percentage passing the sieve follows the log normal law.

Although the sieving regions were established from nonsteady sieving, the principles hold for steady sieving. A certain minimum time would be required for any given material to enter Region 2 sieving. Therefore, if the sieve length in the rotary sieve was not sufficient for the material to stay on the sieves the minimum time, substantial errors in sieving would be expected.

In this study, the three versions of the rotary sieve were tested and a modified version developed.

Accuracy Tests of Existing Sieves

The testing involved three or more replications per rotary sieve and feeding rates ranging from 230 cm.^{3} added every 30 seconds to continuous feeding. Total volume per test was 900 to 1,200 cm.^{3}. The test material, a mixture of crushed limestone, river sand and gravel, was selected because it is essentially nonabrasive, and breakdown of the particles would be insignificant. Also, the same material could be used in all sieves. Material passing over each of the meshes within a rotary sieve was tested for error by placing it on a nest of standard 8-inch flat sieves which in turn was vibrated on a Cenco[3] sieve shaker for 6 to 10 minutes. The weight of material collected outside the size interval indicated by the rotary sieve was used to compute the per cent error.

RESULTS AND DISCUSSION

Feeding rate did not affect the sieving error of the improved or compact sieve; however, it did influence the error obtained with the original sieve, increasing with feeding rate.

[1] The authors are affiliated with the Southern Plains Branch, Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture, Manhattan, Kansas.

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The sieving errors are presented in table 1. Data from the subsequent sieve developed is included in this table for comparison. It is obvious that substantial errors for specific mesh sizes exist. Generally, the sieves were rated in order of decreasing accuracy: original, compact, and improved. Changes made in the compact and improved sieves evidently did not improve accuracy.

Other factors besides mesh length are involved. One source of inaccuracy for the largest mesh size is in the feeding mechanism. Although the hopper and conveyor belt in the improved and compact sieves eliminated errors due to feeding rate, the elevation is too great between conveyor belt and mouth of the sieve, requiring a feeding chute with a steep slope. Consequently, some undersize particles attain sufficient speed to bounce across the inside large mesh sieve whose mesh length is less than 4 inches. That accounts for the 100 per cent error for particles greater than 38.1 mm. for the improved rotary sieve (all particles passing over that mesh size were smaller than 38.1 mm.), and for the large error for particles greater than 19.05 mm., the largest mesh, for the compact sieve.

Another source of error is in the location of the various mesh sizes relative to each other. Both improved and compact sieves have overlapping concentric meshes with mesh length increasing monotonically from larger to smaller mesh sizes, i.e., from inner to outer

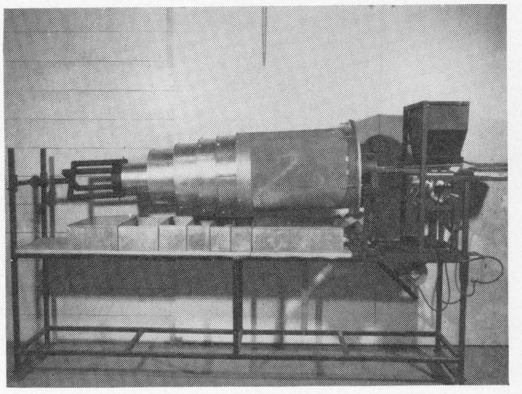

FIG 1. Modified rotary sieve, side view.

TABLE 1

Summary of average sieving errors for four rotary sieves

Size range	Sieve			
	Original	Improved	Compact	Modified
mm.	*Per cent average error*			
D > 38.1	0	100.0	—	—
D > 19.05	—	—	31.5	1.5
6.35 < D < 19.05	—	—	12.4	2.4
6.35 < D < 38.1	11.6	16.5	10.0	1.5
.84 < D < 6.35	7.5	5.8	4.2	2.8
.42 < D < .84	1.1	37.7	5.9	1.3
12.7 < D < 38.1	10.4	34.0	—	—
6.35 < D < 12.7	22.6	29.3	—	—
2.0 < D < 6.35	17.3	—	17.8	4 6
.84 < D < 2.0	3.3	—	6.8	1.8
2.38 < D < 6.35	—	28.6	—	—
1.19 < D < 2.38	—	14.5	—	—
.84 < D < 1.19	—	26.6	—	—
D > .84	10.5	33.6	15.1	2.1

TABLE 2

Dimensions of concentric cylindrical sieves of the modified rotary sieve

Mesh size	Wire diameter	Inside diameter of mesh*	Length of cylinder			
			Upper portion	Mesh portion	Lower portion	Total
mm.			*Inches*			
44.45	0.192	6	2	19¼	28⅜	49⅝
19.05	0.135	11	2	19	20⅝	41⅝
6.35	.072	13½	2	18¾	15⅜	36⅛
2.00	.032	15	2	18½	10⅝	31⅛
0.84	.017	16	2	18¼	6⅞	27⅛
0.42	.012	17	2	18	3	23⅛

* Inside diameter of lower portion of cylinder must be two wire diameters larger. Outside diameter of upper portion should be same as inside diameter of mesh.

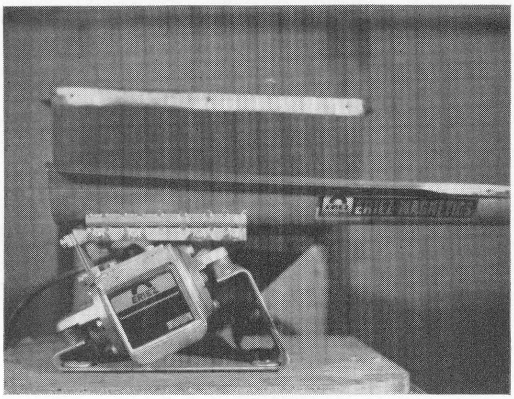

FIG. 2. Vibratory feeder with 3 by 20-inch half-round tray and a 0- to 2-ton-per-hour feeding rate. Model 20A Eriez Magnetics[3], Erie, Pennsylvania.

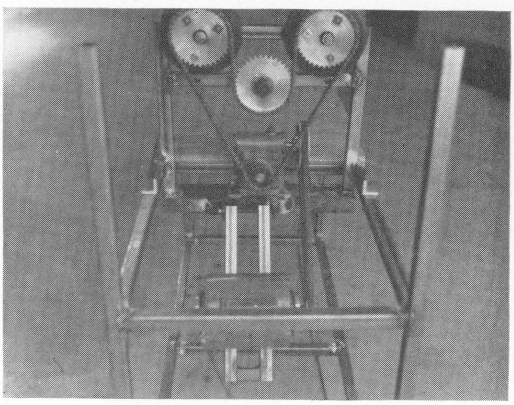

FIG. 3. Driving mechanism for modified rotary sieve. One-fourth horsepower electric motor, 24:1 speed reducer, roller chain, and drive wheels.

sieves. That permits near-mesh size particles carried towards the top of the sieve during rotation to drop downward through the larger lower meshes onto the solid cylinders of an interior sieve, then to be carried out and deposited in collection pans, though they may be much smaller than the mesh size indicated. A reversal of mesh lengths, i.e., increasing in length from outer to inner sieves, may solve this problem.

For existing sieves the relation between per cent error and mesh length was roughly logarithmic. Assuming mesh length to be the only source of error (it is not), a minimum length of about 16 inches is needed to keep the error near 2 per cent.

Modified Sieve

Because of substantial errors in the existing sieves, a modified version was developed (fig. 1).

Although the major change in the modified rotary sieve is an increase in mesh length (table 2), other changes include: better support of the nest of sieves during rotation, a variable rate vibratory feeding mechanism that can be changed or turned off independently of the power source during sieving (fig. 2); improved support of the electric motor powering the sieve, and use of a roller chain to transmit power from the speed reducer to two drive wheels rotating the sieve (fig. 3). The slope of the modified sieve is 4 degrees, the same as the existing sieves.

Accuracy Tests, Results, and Discussion

The same tests material and procedure were used for the modified sieve as for the existing sieves. The effect of rotational speed on sieving accuracy was also studied.

The slight increase in mesh length from the outer to the inner sieves in the modified version was not sufficient to eliminate the problem of particle "fall through" noted on the improved and compact rotary sieves. The fall-through particles can hit the wires of the larger meshes, bounce onto the solid cylinder downstream, and be collected in the wrong

TABLE 3

Effect of rotational speed on accuracy of modified rotary sieve

Mesh size	Speed of rotation (*rpm.*)		
	15	10	7
mm.	*Average per cent error*		
$D > 19.05$	2.0[a]*	2.0[a]	0.4[a]
$6.35 < D < 19.05$	2.6[a]	2.6[a]	2.0[a]
$2.0 < D < 6.35$	6.5[a]	5.0[b]	4.2[b]
$.84 < D < 2.0$	3.2[a]	1.5[b]	2.1[b]
$.42 < D < .84$	1.9[a]	1.5[ab]	1.2[b]

* Means followed by same letters are not different at the 95 per cent probability level by Duncan's multiple range test.

size interval. A lower rotational speed seems to reduce this error, probably because the centrifugal force is less and the particles are not carried as far towards the top before they slide or fall under gravitational forces (table 3).

The modified sieve considerably improved the sieving accuracy (table 1). Some errors still exist. Because the amount of material passing a given mesh size in region 2 sieving depends on probability considerations, no sieve can be 100 per cent accurate. The performance of the modified sieve or any rotary sieve depends on rotational speed and factors relating to the sieve material. Higher rotational speeds and materials that have a very narrow particle size distribution, especially with large numbers of particles near the mesh size of one or more of the sieves, can be expected to decrease the accuracy of the rotary sieve.

SUMMARY

Three versions of rotary sieves—called original, improved, and compact—were tested for sieving accuracy with a nonabrasive stable mixture of crushed limestone, river sand, and gravel. The three sieves are described by Chepil (2, 3, 4) and have been used extensively in wind erosion and tillage research. Substantial errors were noted for specific mesh sizes. Consequently, a modified version was developed giving major consideration to mesh length, the primary factor controlling the time the sieve material remains on the mesh area. The modified rotary sieve showed marked improvement in sieving accuracy (table 1). Additional improvements involved changes in the feeding mechanism, in power transmission, and in the location of the various mesh sizes relative to each other.

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