Note on a Method for Measuring Breakage Susceptibility of Shelled Corn During Handling[1]

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Because foreign buyers and others who process corn want whole kernels with no damage, a method is needed to measure potential breakage under simulated elevator conditions. The method should have flexibility for use as a reference method, to duplicate conditions in a grain elevator, and to test samples under defined conditions. Such a system also would be useful in determining breakage of samples from plant breeding programs.

Several methods have been proposed. Keller et al (1972) described a pneumatic system to accelerate the grain toward an impact surface. Sharda and Herum (1977), who used a centrifugal impeller to impinge corn kernels randomly against a steel surface, reported that it was more sensitive to measurement of damage susceptibility than the commonly used Stein breakage tester (McGinty 1970) sold by Fred Stein Laboratories, Inc., Atchison, KS 66002.

To approach a normal grain handling operation, we built a grain acceleration device that impacts corn against corn at velocities both above and below that attained by corn falling vertically 30.5 m (100 ft).

MATERIALS

We obtained a set of five commercial corn samples from The Andersons, Maumee, OH (Table I). All samples were graded U.S. No. 2 yellow (Official U.S. Standards for Grain 1978).

METHODS

Analytical Methods

Whole kernels were analyzed for moisture by the ASAE method (Agricultural Engineers Yearbook 1978). Thousand-kernel weight was determined after hand counting. The grade was determined at the Kansas State Grain Inspection Department, Topeka.

Determination of Breakage

We built an apparatus (Figs. 1 and 2) capable of accelerating kernels at velocities from 19.5 to 42.8 m/sec (64.0–140.4 ft/sec) and impacting them against corn from the same sample. The device consists of two steel wheels 203 mm (8 in.) in diameter by 102 mm (4 in.) in width covered with 16 mm (5/8 in.) of soft durometer (35-40) natural rubber vulcanized on the roller by Kansas City Rubber and Belting Co., Kansas City, MO 64108. The wheels, which are 3.18 mm (1/8 in.) apart at the closest point, are driven in opposite directions to accelerate the corn down through a Plexiglas chute with inside dimensions of 95.3 × 120.7 mm (3.75 × 4.75 in.). The bottom of the chute consists of a drawer (impact box), the floor of which is 1,067 mm (42 in.) below the axis of the steel wheels.

We first removed the throughs of a 4.8-mm (12/64-in.) round hole, grain dockage sieve from a 500-g sample on a Gamet shaker (Dean Gamet Mfg. Co., Minneapolis, MN) operated for 30 sec; then we put 200 g of the sieved corn in the Plexiglas impact box and passed 200 g of corn through the rolls of the grain accelerator during 30 sec with a Model 10A vibratory feeder (Eriez Mfg., Co., Erie, PA). The entire 400-g sample was sieved for 30 sec on a Gamet

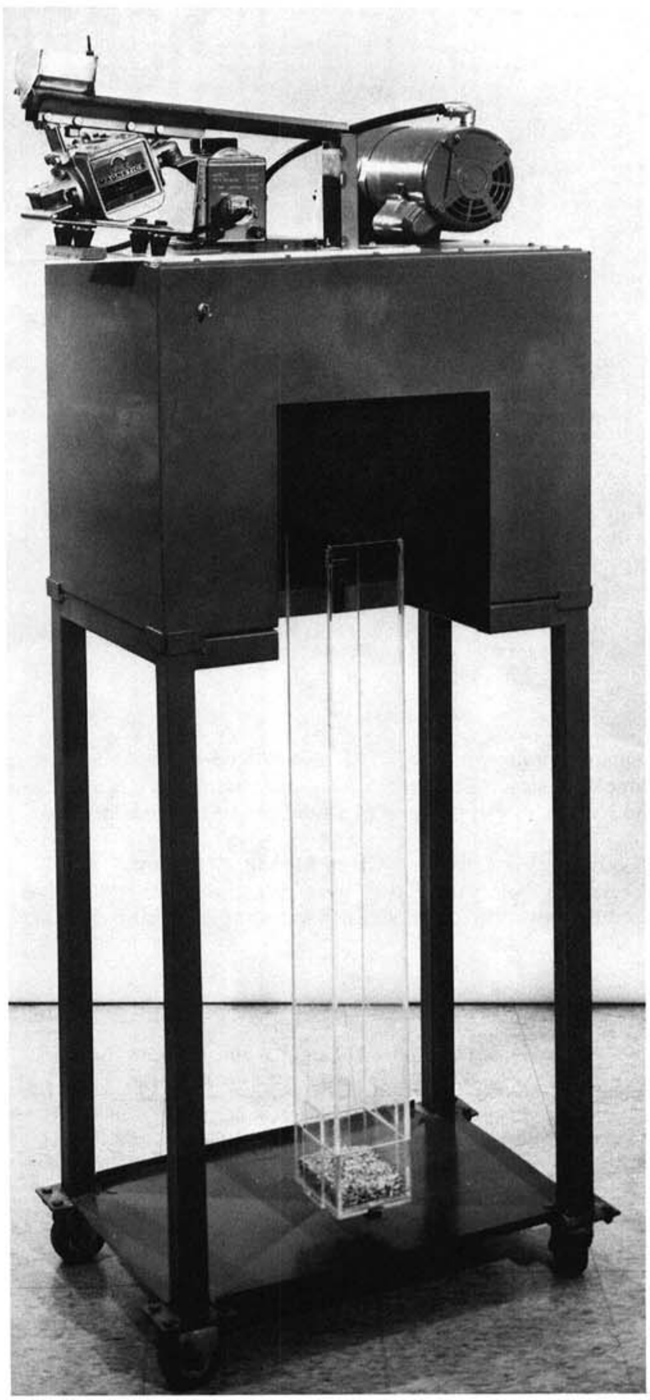

Fig. 1. Grain accelerator.

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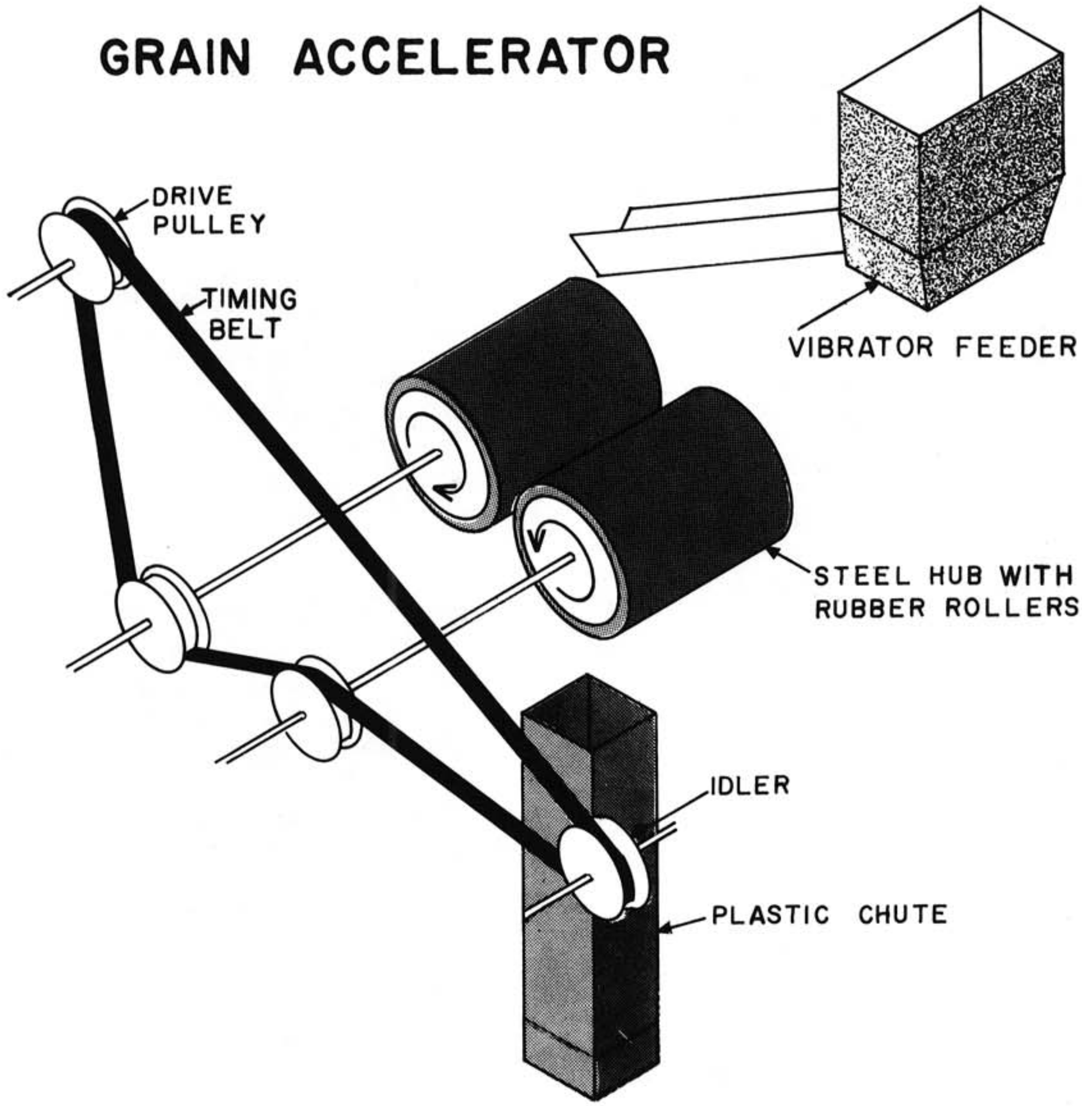

Fig. 2. Diagram of grain accelerator.

shaker equipped with a 4.8-mm (12/64-in.) round hole, grain dockage sieve. The percent of grain passing through the 4.8-mm (12/64-in.) sieve is reported as the percent of breakage.

Equilibrating Corn to a Given Moisture Content

Samples of corn (500 g) were placed in open-ended cans with screens covering each end. Each can was placed in an enclosed glass container, stored in a room maintained at 27.8°C (82°F) and 70% RH. Each tank was partially filled with a predetermined ratio of sulfuric acid and water (15–68% sulfuric acid), which maintained humidity between 16 and 90%. Samples were left in the tanks for seven days, then moisture content was determined (Agricultural Engineers Yearbook 1978).

TABLE I

Summary of Descriptive Data of Commercial Corn Samples (U.S. No. 2 Yellow) Tested for Breakage

Sample No.	Moisture[a] (%)	Test Weight (lb/bu)	1000-Kernel Weight (g)	Total Dockage (%)	Broken Kernels and Foreign Material[b] (%)
1[c]	13.5	57.5	325	1.5	1.0
2[d]	14.8	59.5	335	3.9	0.1
3[c]	13.5	58.0	335	2.2	0.4
4[c]	14.2	57.0	332	2.0	0.1
5[c]	12.9	57.0	313	3.2	0.1

[a] Wet basis.
[b] Passing a 4.8-mm (12/64-in.) round hole, grain dockage sieve.
[c] Shelled corn.
[d] Ear corn.

RESULTS AND DISCUSSION

Calibrating the Grain Accelerator

The device illustrated in Figs. 1 and 2 was run at speeds to impell corn at 19.5–42.8 m/sec (64.0–140.4 ft/sec). A Red Lakes Laboratory Hycam model K20S4E 16-mm, high speed, motion-picture camera was used to determine the kernels' speed. The speed of the film was adjusted to 1,200 frames per second with a timing light generator (TLG-3). A 25.4-mm (1-in.) grid was placed at the same depth as the corn traveling through the grain accelerator and pictures were taken on a 122-m (400-ft) roll of Kodak 4-X reversal 7277 film. A kernel that traveled 1 in. per frame on the film actually traveled 30.5 m/sec (100 ft/sec). Any velocity deviation was determined by projecting the film and measuring the distance a single kernel moved between successive frames.

Effects of Velocity on Breakage

Amounts of breakage caused when samples of sound and damaged corn were passed through the grain accelerator are shown

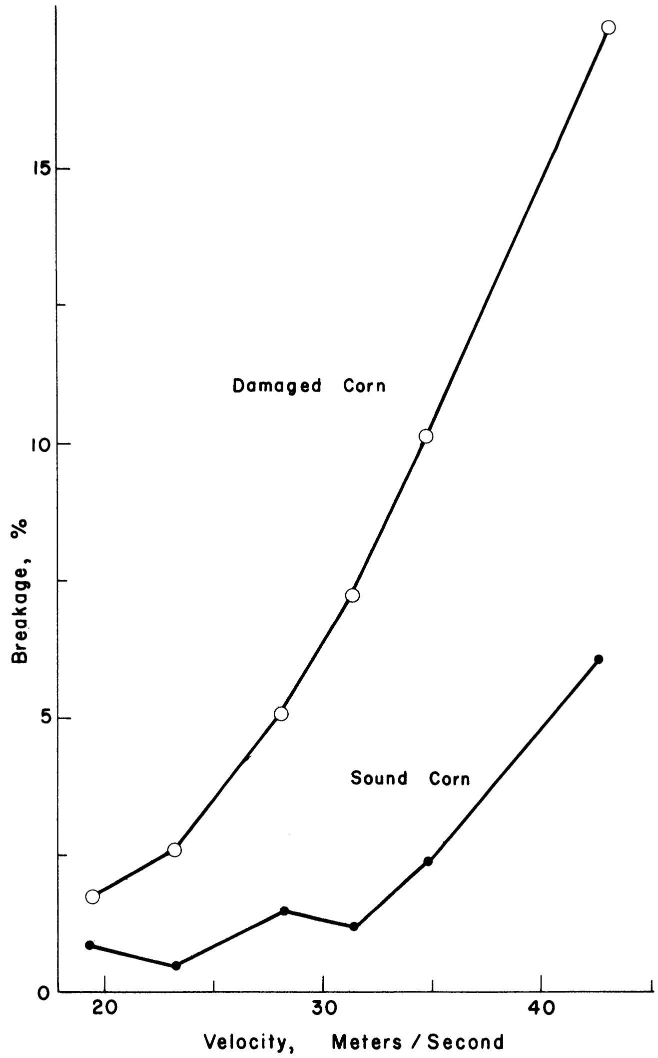

Fig. 3. Effects of velocity on breakage of sound and damaged corn samples (samples 1 and 5, respectively, Table 1). • = sound corn; o = damaged corn.

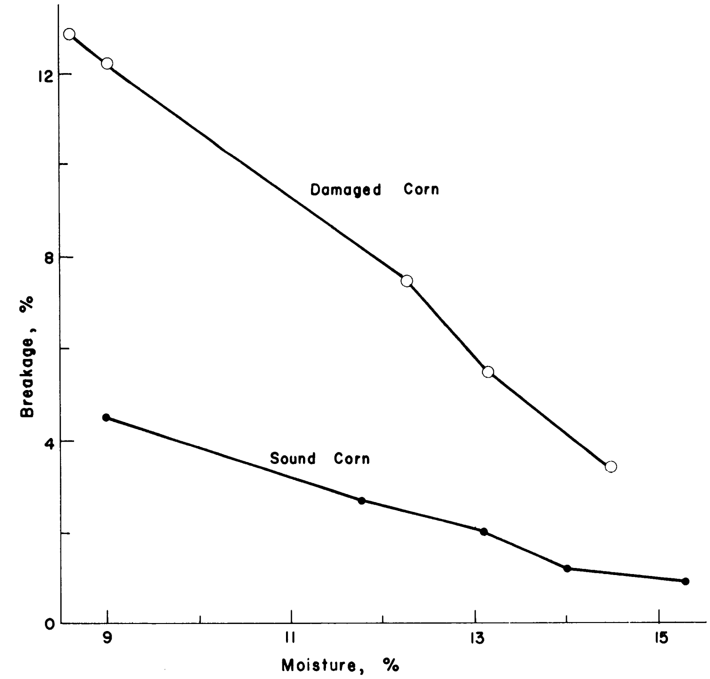

Fig. 4. Effects of moisture content on breakage of sound and damaged corn kernels (samples 1 and 5, respectively, Table 1). • = sound corn; o = damaged corn.

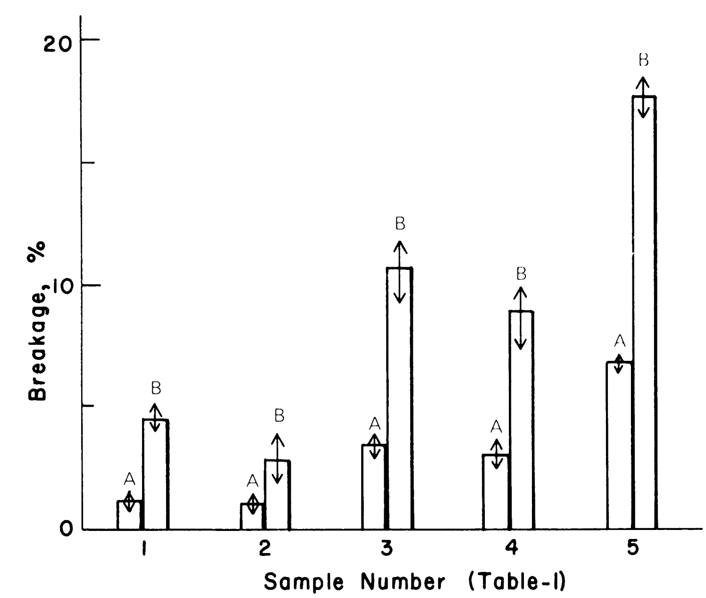

Fig. 5. Amount of breakage for samples 1–5 (Table 1). A, Throughs of 4.8-mm (12/64-in.), round hole, grain dockage sieve; 30 sec on Gamet shaker. B, Throughs of 6.4-mm (1/4-in.) Tyler sieve; 2 min on Strand shaker (Strand Shaker Co., Minneapolis, MN). Arrows represent ranges for three replicate samples.

in Fig. 3. Kernel damage increased with kernel velocity, as shown previously (Keller et al 1972). A velocity of 31.5 m/sec (103.3 ft/sec) was selected for future work because that speed gave reasonable breakage for damaged corn and did not break sound corn extensively. It exceeded the theoretical velocity of 24.4 m/sec (80 ft/sec), calculated by Foster and Holman (1973), of grain free-falling 30.5 m (100 feet).

Effects of Moisture on Breakage

Effects of moisture on breakage are shown in Fig. 4. Breakage increased as moisture content decreased in the same trend reported for grain tested in our elevator (Stephens and Foster 1976).

Breakage of Commercial Corn Samples

Amounts of breakage caused when samples 1 and 5 (Table 1) were passed through the grain accelerator at 31.5 m/sec (103.3 ft/sec) are shown in Fig. 5. The first two samples were not friable; the last three samples varied in friability. The grading (U.S. No. 2 yellow) did not indicate this difference in friability. Similarly, the breakage for U.S. No. 2 yellow corn samples in an elevator ranged from 0.2 to 14.0% depending on drop height, impact surface, and discharge stream size (Foster and Holman 1973).

Differentiation among samples was greater when a 6.4-mm (1/4-in.) Tyler sieve rather than a 4.8-mm (12/64-in.) round hole, grain dockage sieve was used to remove fines and broken kernels before a sample passed through the accelerator. This step also removed small whole kernels. The 4.8-mm (12/64-in.) round hole, grain breakage sieve removed mostly fine material and is probably the best sieve to use because it is used in grading corn (Official U.S. Standards for Grain 1978). A comparison between results for corn tested by the grain accelerator and the Stein breakage tester is being prepared.

ACKNOWLEDGMENT

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LITERATURE CITED

AGRICULTURAL ENGINEERS YEARBOOK. 1978. Moisture measurement—Grain and seeds, ASAE Standard: ASAE S352, p. 376.

FOSTER, G. H., and HOLMAN, L. E. 1973. Grain breakage caused by commercial handling methods. U.S. Agric. Res. Serv., Mktg. Res. Rep. 968.

KELLER, D. L., CONVERSE, H. H., HODGES, T. O., and CHUNG, D. S. 1972. Corn kernel damage due to high velocity impact. Trans. ASAE 15:330.

McGINTY, R. J. 1970. Development of a standard grain breakage test. U.S. Dept. of Agriculture, Agric. Res. Serv. Mimeo. Rep. 51-34.

OFFICIAL UNITED STATES STANDARDS FOR GRAIN. 1978. U.S. Department of Agriculture. Federal Grain Inspection Service, Inspection Division.

SHARDA, R., and HERUM, F. L. 1977. A mechanical damage susceptibility tester for shelled corn. Paper 77-3504, presented at the Chicago meeting of the ASAE, December 13–16.

STEPHENS, L. E., and FOSTER, G. H. 1976. Breakage tester predicts handling damage in corn. U.S. Agric. Res. Serv. ARS-NC-49.

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