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Abstract

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Disciplines

Agriculture | Bioresource and Agricultural Engineering

Comments

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Technical Notes:

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ABSTRACT

TESTS were conducted on corn with a Wisconsin Breakage Tester to determine how two tester modifications changed operating time and breakage results. The Weber valve, which seals the bottom opening of the tester, reduced sample testing time from 120 s to 45 s per sample and did not change breakage susceptibility values. The Fritsch Laboratory Vibratory Feeder significantly reduced breakage susceptibility values at the standard feed rate and did not reduce testing time or improve data precision.

INTRODUCTION

The Wisconsin Breakage Tester (WBT) is a centrifugal impact breakage susceptibility testing instrument developed by S. S. Singh and M. F. Finner at the University of Wisconsin for rapid testing of grain samples. See Singh and Finner (1983) and Pomeranz et al. (1986) for further information about tester design and use.

Operation of the WBT

Grain is introduced one kernel at a time into the center of the motor-driven impeller and spun outward through a slot, causing the kernel to impact the inside of a smooth cylindrical surface. The impact cylinder is made of steel tubing with a wall thickness of 6.35 mm. After each grain kernel is impacted, grain and generated fines are funneled to a user-supplied collection box at the base of the WBT. The 200-g sample is then screened with a 4.76-mm round-hole screen. Percentage breakage is calculated:

$$B = \frac{(W_t - W_f)}{W_t} (100) \dots\dots\dots [1]$$

where

- B = percent breakage
- W_t = total sample weight, g
- W_f = weight remaining on top of screen, g

WBT Modification

Some problems were encountered during use of the WBT in the Iowa State University Grain Quality Laboratory. The standard WBT comes equipped with a John Deere double-run feeder powered by an electric motor. It requires approximately 120 s to process a sample even though feeding time is only 25 to 30 s. Turbulence in the chamber (which comes open at the bottom) slows particle settling. Other researchers were also concerned that the standard feeder mechanism may be damaging or losing (tossing out on the work table) some of the kernels.

A valve was developed to speed up processing of a sample. The Weber valve (named for its developer, ISU lab worker Dennis Weber) is a sliding gate valve mounted on the bottom of the WBT (Fig. 1). The gate is 5-mm plexiglass, made to move into a slot cut in a 30-mm section of 76-mm (3-in.) PVC pipe.

The manufacturer has tried to make WBT results more reproducible by offering a new feeder, the Fritsch Laboratory Vibratory Feeder (Fig. 1), for retrofit. This feeder was claimed to give better results by not damaging the sample as it enters the WBT and by not losing kernels during feeding.

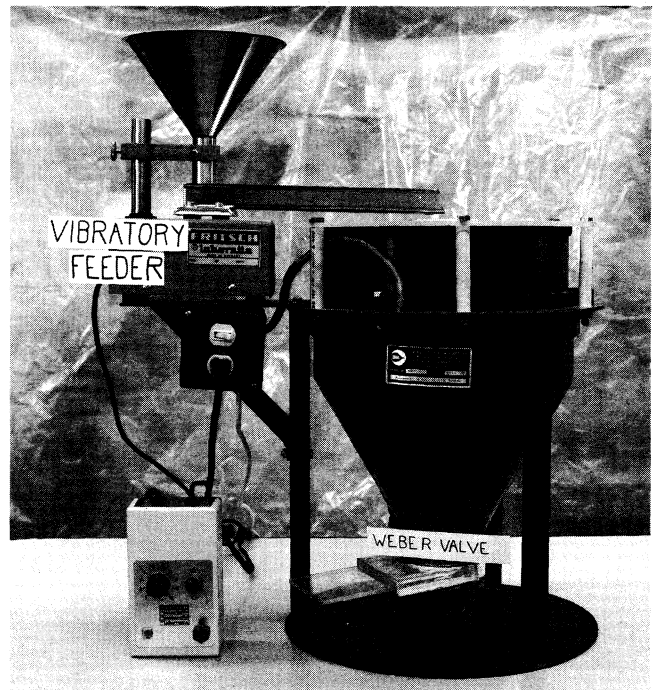


Fig. 1—Wisconsin breakage tester with Fritsch vibratory feeder and Weber valve.

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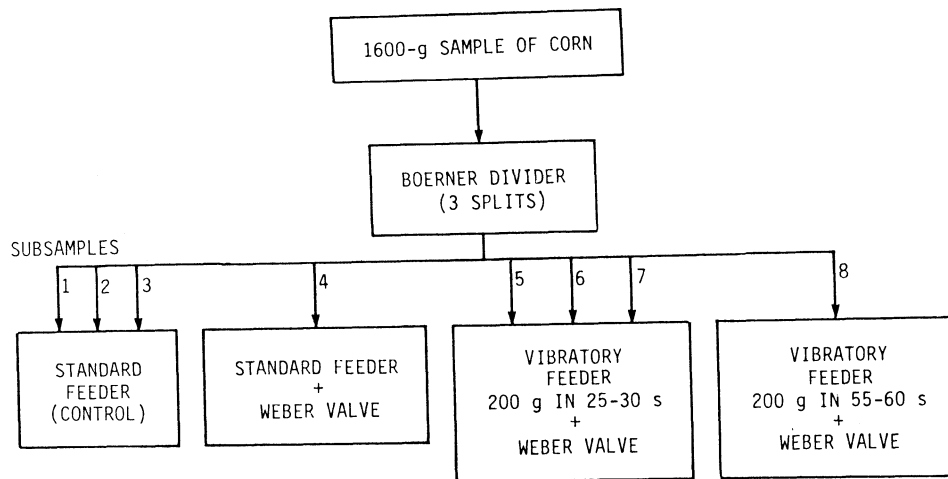


Fig. 2—Experimental design.

OBJECTIVE

The objective of this experiment was to determine if the Weber valve and the Fritsch Laboratory Vibratory Feeder affect breakage results and sample processing times compared to the normal test procedure.

PROCEDURE

Equipment Modification

The first modification consisted of installing the Weber valve on the WBT. The Weber valve seals the bottom of the WBT and reduces airflow through the machine. This decreases internal turbulence and allows lighter particles to fall to the bottom of the machine more rapidly. The valve is left closed while the sample is fed. Then the impeller motor is turned off and the operator waits for approximately 10 s to allow lighter material to drop to the base of the WBT. The valve is then quickly opened and closed to allow the sample to drop into the collection cup. The next sample can be started without waiting for the impeller to coast to a halt.

The other modification consisted of installing the Fritsch Laboratory Vibratory Feeder on the WBT. This is a variable-speed vibratory feeder which allows close regulation sample introduction rate. It replaces the standard internal double-run device.

Experimental Design

Fig. 2 shows the experimental design for this experiment. With a Carter Dockage Tester, nine corn samples of differing moisture content and of unknown variety were each cleaned with a Carter Dockage Tester and then split into eight subsamples by use of a Boerner divider. Only five samples (numbers 1, 2, 3, 6, 9) were larger enough to allow three replicate tests of standard feeder + Weber valve and Fritsch feeder (slow) tests.

Subsamples 1, 2, and 3 were tested using the standard procedure. The Weber valve was used with the standard feeder for subsample 4. The other subsamples were tested with the Weber valve and the vibratory feeder. The feeder was set at the maximum vibration rate and at a slope which would feed a 200-g sample in 25 to 30 s for subsamples 5, 6, and 7. The eighth subsample was also tested by using the Weber valve and the vibratory feeder. The feeder was set to feed a 200-g sample in 55 to 60 s.

RESULTS

Table 1 shows the breakage data obtained in this experiment. To test if percent breakage was different with modifications installed, a two-tailed t-test ($P = 0.05$) was used (SAS, 1985). The SAS procedure accounted for missing data values. All values were

TABLE 1. WISCONSIN BREAKAGE TESTER BREAKAGE VALUES, %

Sample number	Moisture %	Standard test replication number				Weber valve replication number				Fritsch (fast)*, Weber valve replication number				Fritsch (slow)†, Weber valve replication number			
		1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
1	19.3	1.0	0.8	1.0	1.0	0.5	0.7	0.9	0.7	0.8	0.7	0.9	0.8	1.0	0.9	1.2	1.0
2	13.5	8.0	5.9	7.6	7.2	8.2	6.3	7.8	7.4	6.7	7.1	7.4	6.9	7.8	6.7	6.7	7.1
3	13.7	7.2	7.1	7.3	7.2	8.0	8.7	—	8.4	6.7	6.9	6.8	6.8	7.2	8.1	7.3	7.5
4	13.0	7.6	7.9	6.8	7.4	8.0	—	—	8.0	8.1	7.8	7.3	7.7	7.3	—	—	7.3
5	12.7	8.3	7.9	8.2	8.1	8.8	—	—	8.8	8.2	7.6	8.6	8.1	8.9	—	—	8.9
6	11.6	13.1	12.9	11.7	12.6	12.9	12.6	12.7	12.7	11.8	11.9	12.4	12.0	12.0	12.9	—	12.5
7	11.9	14.1	14.7	13.0	13.9	14.0	—	—	14.0	12.3	12.1	13.6	12.7	14.5	—	—	14.5
8	11.5	14.2	12.9	13.7	13.6	14.9	—	—	14.9	—	13.7	13.1	13.4	15.1	—	—	15.1
9	12.0	15.1	15.2	14.8	15.0	14.0	14.3	14.2	14.2	15.4	13.9	14.3	14.5	—	14.9	15.5	15.2
Averages					9.5				9.9				9.2‡				9.9

*Feed time 25-30 s

†Feed time 50-60 s

‡Different from standard test ($P=0.05$)

TABLE 2. VARIABILITY AMONG REPLICATE WISCONSIN BREAKAGE TESTER BREAKAGE VALUES

Samples	Feeder	Valve	Standard deviation among replicates, % breakage	Coefficient of variation, %‡
1,2,3,6,9	standard	none	0.61	7.1
1,2,3,6,9	standard	Weber	0.52	6.0
1,2,3,6,9	Fritsch (fast)*	Weber	0.44	5.4
1,2,3,6,9	Fritsch (slow)†	Weber	0.50	5.6

*Feed time 25 to 30 s

†Feed time 55 to 60 s

‡Based on standard deviation among replicates.

compared with standard test values. Breakage results with the Weber valve were not significantly different from standard procedure breakage. Breakage with the vibratory feeder at the high feed rate was significantly lower than the standard procedure breakage. At this feed rate, there were instances when more than one kernel was introduced at a time. When the vibratory feeder was slowed down, however, breakage levels were not statistically different.

With the standard feeder (feed time = 25 to 30 s) the

time required to process a sample was approximately 120 s. When the Weber valve was added, the time dropped 75 s to approximately 45 s. Time reduction was the same regardless of feeder used.

To estimate variability among replications of each of the modifications, the standard deviation among replications for each test was calculated. Average standard deviations and coefficients of variation are listed in Table 2. Standard deviation, in percent breakage, was lowest for the vibratory feeder and highest for the standard test.

CONCLUSIONS

1. The Weber valve shortened the test procedure by about 75 s and did not significantly change breakage susceptibility values.

2. The Fritsch Laboratory Vibratory Feeder significantly reduced breakage susceptibility values at a feed time of 25 to 30 s.

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