Proceedings of the Short Course for Seedsmen

4-1-1988

Mechanical Damage - Causes and Solutions

S. Beckham

MECHANICAL DAMAGE - CAUSES AND SOLUTIONS

Steve Beckham[1]

After a seed reaches physiological maturity, essentially everything that we do lowers quality. The best that we can hope to do is maintain quality. Since damage is cumulative, we cannot improve the quality of an individual kernel. However, we can prevent further damage and there are several tools that we can use to remove those seed that are cracked, broken or deteriorated. The purpose of this paper is to examine the causes of mechanical damage and suggest solutions for damage prevention.

For seedsmen, a major concern with regard to mechanical damage is that germination is lowered. Often germination will be lowered before an obvious crack develops. Unfortunately, most of the research on mechanical damage has been done on grain. Since many of the causes of damage to seed and grain are the same, the results from research on grain are directly transferable to seed. It is hoped that a review of mechanical damage on seed will be of benefit both to the seedsmen and the elevator operator.

Types of Mechanical Damage

There are two basic types of mechanical damage - abrasion and impact. Abrasion is caused by friction of the seed or grain sliding over a surface. For the most part, abrasion results in very little actual damage. The major problem resulting from abrasion is dust. As we will later see, many times in designing a grain handling system we will try to convert an impact situation to abrasion.

Abrasion is somewhat affected by the coefficient of friction of the grain. However, most research in this area has been to minimize the effect of the sliding grain on the equipment. Our concern is to minimize the effect of the equipment on the grain.

Impact is the major cause of mechanical damage. In physics we learned that Force = Mass x Acceleration (acceleration equals velocity squared) or F=MxV. Grain is a fragile commodity that we are continually impinging against hard, immovable objects. The force caused by impact has the most immediate effect on the grain. When we

---

[1]President, Amos, Inc., Lafayette, IN.

impact grain, we lower its capacity to germinate or we break it, or both.

From the force equation, it can be seen that in order to decrease force we must either lower the mass or slow down the seed. Obviously, in the case of seed or grain our only hope of decreasing force is to slow the velocity of the grain as it goes through a handling system. Our other strategy for decreasing mechanical damage is to temper the seed or grain so that it is less susceptible to impact. Research data will be shown on how changes in moisture content and temperature affects susceptibility to damage.

Sources of Damage

Mechanical damage begins with the harvest of the grain. This is especially obvious with soybeans. Soybeans combined at a moisture content less than 12% are very susceptible to mechanical damage. In order to minimize this damage, it is critical that the seedsman starts harvest as early as possible. Soybeans can be combined at 16% moisture if facilities are available to safely dry the beans. Research at the University of Kentucky showed that air with a relative humidity less than 40% contributes to cracked seed coats. Caution is required to be sure that the drying air doesn't cause internal stresses that result in mechanical damage.

Since all seed cannot be harvested at ideal moisture levels, steps must be taken to reduce harvest damage. Combines can be adjusted to minimize impact. First, reduce cylinder speed, then increase concave clearance. What we are trying to do is cause the seed to be threshed by rubbing plant material together instead of beating the seed out of the pods.

A device is available that allows a combine operator to directly measure splits on the combine. This insures that proper adjustments are made before too much damage is done. This dockage tester has a screen for sifting out splits. The percentage splits are then directly read from the tester.

Drying any grain at high temperatures will cause stress cracks that predispose the grain to breakage. Drying processes and techniques are beyond the scope of this paper. However, it is much easier to prevent broken kernels if the kernels do not contain stress cracks.

Most mechanical damage occurs when the grain is either dropped or thrown against a hard surface. Foster and Holman did a series of studies on the effect of dropping grain (Table 1). They also measured some of the effects of bucket elevators on mechanical damage. Traditionally, most people felt that the best way to minimize

Table 1. Breakage in grain from free-fall.

Drop Height (feet)	Discharge Orifice Diameter	Impact Surface	Corn 12.6 at 25	Corn 15.2 at 31
100	12	Concrete	12.01	6.87
70	12	Concrete	7.07	2.54
40	12	Concrete	3.59	0.27
100	8	Concrete	13.82	9.55
70	8	Concrete	10.83	5.03
40	8	Concrete	5.86	0.86
100	8	Grain	12.53	7.11
70	8	Grain	7.74	4.00
40	8	Grain	4.35	0.25

*From Foster and Holman

mechanical damage was to drop grain on grain. However, Foster and Holman found that at drop heights greater than 40 feet, the damage was essentially the same whether corn was dropped on corn or concrete.

They also documented the effect of grain moisture and temperature on mechanical damage. Corn at 12.6% to 13% resulted in a three-fold increase in damage; decreasing temperature from about 80F to near 40F doubled breakage.

Mechanical damage to grain is cumulative. What this means is that if a certain process results in "X" amount of damage, the same "X" amount of damage will occur each time the same lot of grain is handled in that same process.

Martin and Stephens found a continuous and relatively constant increase in corn breakage with repeated handlings (Figure 1). They moved corn from one bin to another 21 times. Each handling produced a 0.6% increase in breakage. Similar results were reported by Foster and Holman.

The bucket elevator is a common source of mechanical damage. Foster and Holman examined two aspects of bucket elevator use, percent bucket fill and down-leg verses up-leg filling. Their results (Table 2) shows that damage is reduced when the buckets are full and the bucket elevator is fed on the down leg. Both of these methods reduce the force of impact on the individual kernel. The fuller a cup is filled the less is the likelihood that an individual kernel touches the cup. Likewise, impact is reduced when grain is introduced with the bucket (down leg) versus against the bucket (up leg).

Bucket speed is a factor in damage. Slower belt and bucket speeds will reduce both the impact during filling and discharge. However, it is critical that the head be designed for a given bucket speed. Ideal head pulley diameter and discharge throat placement will vary with bucket speed. Slowing the belt speed of an existing leg may very well increase damage if down legging occurs.

Reducing Damage

Reducing mechanical damage from dropping corn into a bin is accomplished by installing bin ladders. A bin ladder reduces damage by not allowing the velocity of the falling grain to reach a threshold which results in damage.

Bin ladders are available which either mount on the side wall of a bin or are free standing in the bin. The free standing ladders have the advantage of being less expensive to install and come in

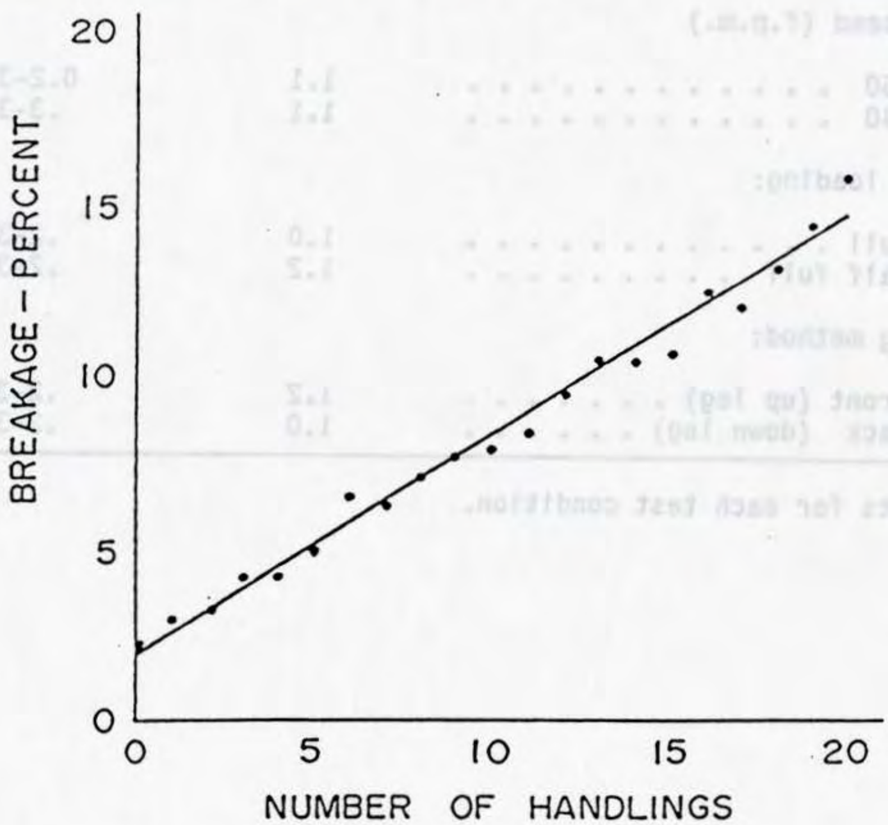

Figure 1. Breakage accumulated from repeated handling of corn.

After Martin and Stephens

Table 2. Corn breakage in bucket elevator tests.

Test Condition	Breakage: Average Percent	Breakage: Range Percent
Belt speed (f.p.m.)		
650	1.1	0.2-3.5
940	1.1	.3-3.4
Bucket loading:		
Full	1.0	.2-3.5
Half full	1.2	.2-3.4
Feeding method:		
Front (up leg)	1.2	.2-3.5
Back (down leg)	1.0	.2-3.4

32 Tests for each test condition.

larger capacities than the side mounted ladders. Both types of bin ladders have an additional advantage in that the fines are evenly distributed within a bin. Without bin ladders, more fines or broken kernels are produced plus they are concentrated in the center of a bin (Figure 2).

Mechanical damage in grain spouting may be reduced by using grain retarders or decelerators. Work by McKenzie and Foster has shown that the effectiveness of different retarders varies greatly. They found that the commonly used cushion box was no better than nothing at all. Grain retarders which were most effective were those which gradually slowed down the grain. Results are shown in Table 3 and examples are illustrated in Figure 3.

In summary, the key to minimizing mechanical damage is to handle grain using methods which eliminate impact. We must reduce the velocity of the grain so that, if and when impact occurs, it is below a threshold level for damage. The threshold level for damage is a function of temperature and moisture content of the grain.

References

1. Foster, G. H. and L. E. Holman. 1973. Grain Breakage Caused by Commercial Handling Methods. USDA. ARS Marketing Research Report #968.

2. McKenzie, B. A. and G. H. Foster. 1979. Grain Decelerators for Reducing Grain Breakage. American Society of Agricultural Engineers Paper #79-3036.

3. Martin, C. R. and L. E. Stephens. 1976. Broken Corn and Dust Generated During Repeated Handling. American Society of Agricultural Engineers. Paper #76-3026.

4. Miles, D. "Soybean Seed Storage." Unpublished Paper.

5. Thompson, R. A. and G. H. Foster. 1963. Stress Cracks and Breakage in Artificially Dried Corn. USDA Agricultural Marketing Service. Marketing Research Report #631.

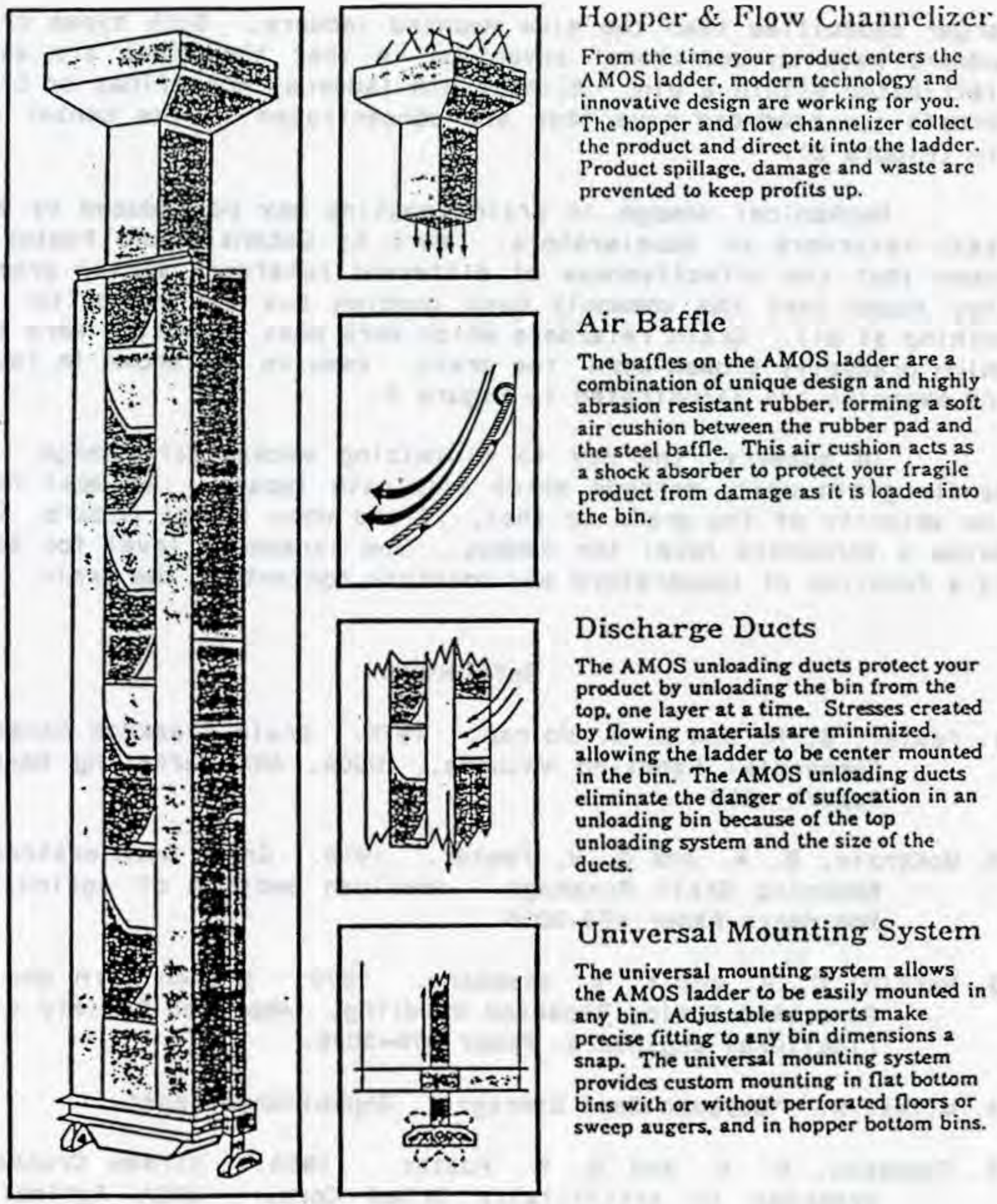

Figure 2. Center mounted bin ladder.

Table 3. Summary of corn breakage in 1977 drop tests using various spout-end decelerating devices.

Test No.	Test Date	Test Device	Breakage* Amount (lbs)	Breakage* Reduction** (%)
4	7/03/77	None-straight drop	19.3	--
7	7/21/77	None-straight drop	25.3	--
		STRAIGHT DROP AVERAGE	22.3	--
6	7/21/77	45 cushion box	22.3	0
3	7/03/77	Parallel (vertical) cushion box	19.3	13
9	8/23/77	Grain brake	13.0	42
5	7/05/77	Bucket Cascade	12.5	44
2	6/17/77	90 elbow-rubber sock	12.4	44
1	6/15/77	90 elbow-30" cyclone	10.2	54
8	8/16/77	90 involute-belt deflector	5.1	77

* Breakage separated from approximately 2000 lbs. of corn by a rotating cleaner with a 5-mesh hardware cloth screen.

** Percentage reduction from average breakage without decelerator.

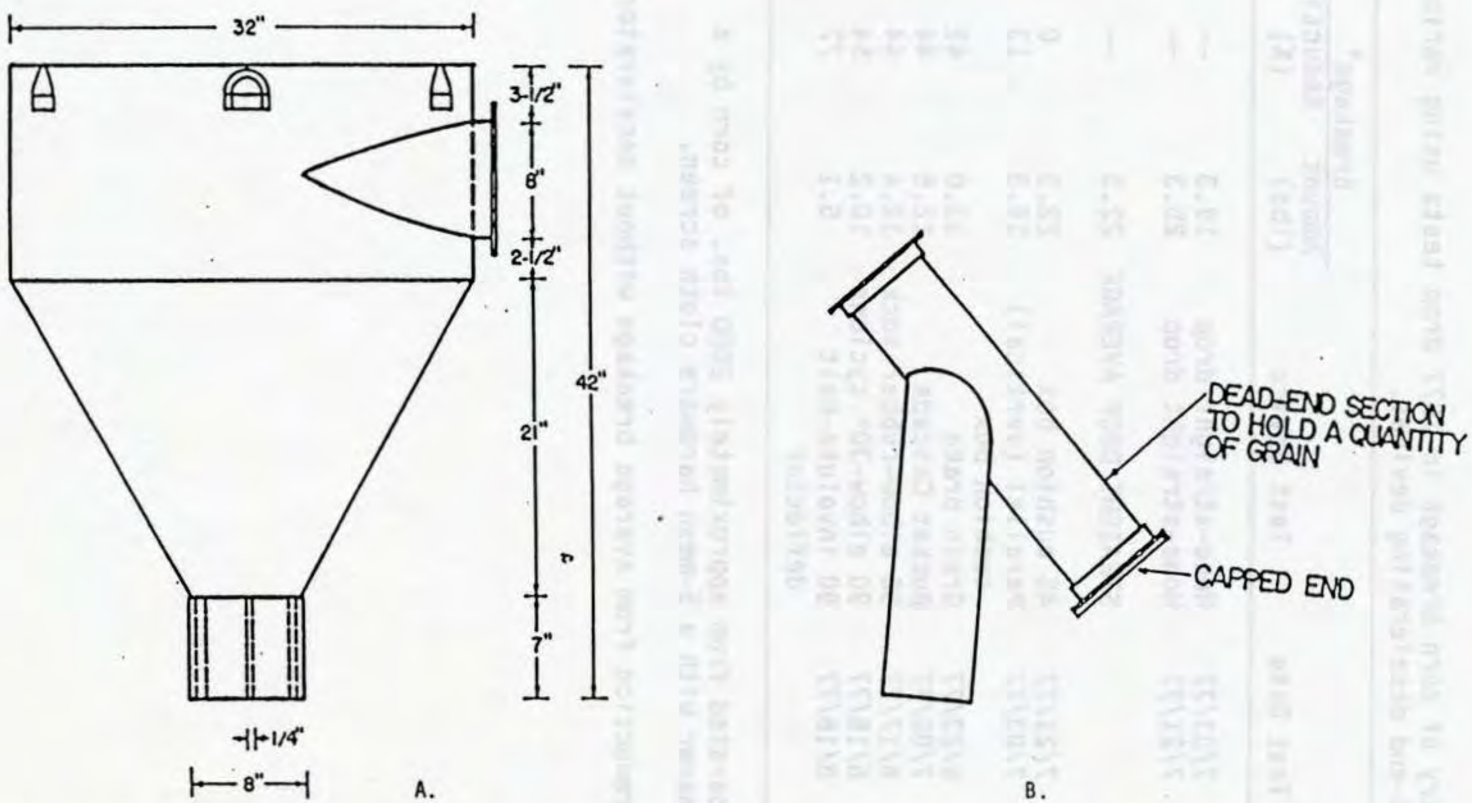

Figure 3. (A) Dimensions of cyclone grain declerator; (B) Typical 45^{o} angle "cushion box" or dead head for use on angled gravity spouts. Capped end section holds a quantity of grain for descending grain to impact onto, to reduce grain velocity and minimize tube wear.