Iowa State University
Digital Repository

Agricultural and Biosystems Engineering Publications

Agricultural and Biosystems Engineering

1991

Conveyors for Bulk Handling of Seed Soybeans

Manjit K. Misra
Iowa State University, mkmisra@iastate.edu

Yuh-Yuan Shyy
Iowa State University, yshyy@iastate.edu

Leopoldo Baudet
Iowa State University

Stephen J. Marley
Iowa State University

Follow this and additional works at: http://lib.dr.iastate.edu/abe_eng_pubs

Part of the Agriculture Commons, and the Bioresource and Agricultural Engineering Commons

The complete bibliographic information for this item can be found at http://lib.dr.iastate.edu/abe_eng_pubs/546. For information on how to cite this item, please visit http://lib.dr.iastate.edu/howtocite.html.

This Article is brought to you for free and open access by the Agricultural and Biosystems Engineering at Iowa State University Digital Repository. It has been accepted for inclusion in Agricultural and Biosystems Engineering Publications by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.

Conveyors for Bulk Handling of Seed Soybeans

Abstract

Six soybean-seed conveyors were evaluated for capacity and seed damage. The belt conveyor, the flight conveyor, and the nylon-brush auger did not cause significant damage to soybean seed during conveying. The capacity of the belt conveyor declined significantly at 30° angle of inclination. The steel-flighting auger caused the most amount of damage, followed by the auger with rubber intake, and the pneumatic conveyor.

Keywords

Conveyors, Grain, Handling, Soybeans

Disciplines

Agriculture | Bioresource and Agricultural Engineering

Comments

This article is from *Applied Engineering in Agriculture* 7 (1991): 735–740, doi:10.13031/2013.26295. Posted with permission.

This article is available at Iowa State University Digital Repository: http://lib.dr.iastate.edu/abe_eng_pubs/546

CONVEYORS FOR BULK HANDLING OF SEED SOYBEANS

M. K. Misra, Y. Shyy, L. Baudet, S. J. Marley
MEMBER ASAE   MEMBER ASAE

ABSTRACT

Six soybean-seed conveyors were evaluated for capacity and seed damage. The belt conveyor, the flight conveyor, and the nylon-brush auger did not cause significant damage to soybean seed during conveying. The capacity of the belt conveyor declined significantly at 30° angle of inclination. The steel-flighting auger caused the most amount of damage, followed by the auger with rubber intake, and the pneumatic conveyor. **KEYWORDS.** Conveyors, Grain, Handling, Soybeans.

INTRODUCTION

Improper handling of soybean seed can substantially reduce seed quality. Many commercial conveyors are available for bulk handling of soybeans. These conveyors are generally designed for grain. Information is limited on the damage caused by these conveyors to seed intended for planting purposes.

OBJECTIVE

The objective of this research was to compare several soybean handling systems with respect to their effect on soybean seed quality. The ultimate goal was to provide the soybean seed conditioners (processors) with information on which to base the purchase of a new conveying system and optimize the operation of those already in hand.

A survey was conducted to determine the types of conveyors being used by soybean seed conditioners in Iowa. A total of 74 questionnaires were sent and 66 conditioners responded. The survey indicated that 25.8% of the respondents use steel-flighting augers, 24.2% use belt conveyors, 19.7% use augers with rubber-flighting intakes, 15.2% use pneumatic conveyors, 10.6% use flight conveyors, 3% use other conveyors, and 1.5% do not use any conveyors for bulk handling of soybean seed. A brief description for each of the six conveyors used by soybean seed conditioners follows.

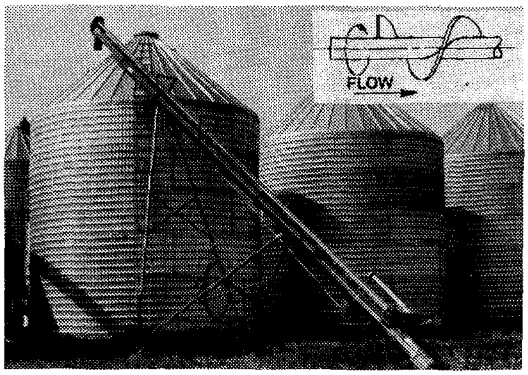

Figure 1–Steel-flighting auger (flighting is shown in the upper right corner of the figure).

Steel-flighting auger. A steel-flighting auger (fig. 1) is the most common device on the farm for bulk handling of seed. A rotating steel helix mounted inside a steel tube moves the seed in this device.

Auger with rubber intake. The main feature of this auger is a two-foot rubber intake section connected to the steel-flighting section with stub shafts (fig. 2).

Pneumatic Conveyor. Seeds in this device are conveyed by a moving air stream. The seeds are conveyed through the suction intake pipe (fig. 3) to the separator cyclone and into an airlock. From the airlock, the seeds drop into the discharge pipe and are conveyed to the discharge cyclone or a truck.

Belt Conveyor. In this conveyor, a rubber belt travelling through a steel tube carries the seeds (fig. 4). The belt is wider than the tube diameter providing a concave shape to carry the seeds.

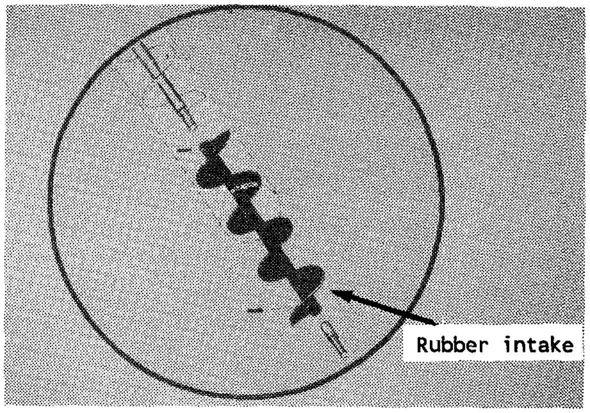

Figure 2–Auger with rubber intake.

Article was submitted for publication in September 1990; reviewed and approved for publication by the Food and Process Engineering Inst. of ASAE in July 1991.

Journal Paper No. J-14176 of the Iowa Agriculture and Home Economics Experiment Station, Ames. Project No. 2813. Funding for this research was provided by Iowa Crop Improvement Association.

The authors are **Manjit K. Misra**, Professor, **Yuh-Yuan Shyy**, Research Associate, **Leopoldo Baudet**, Graduate Student, **Stephen J. Marley**, Professor, Agricultural Engineering/Seed Science Center, Iowa State University, Ames.

© 1991 American Society of Agricultural Engineers 0883-8542 / 91 / 0706-0735

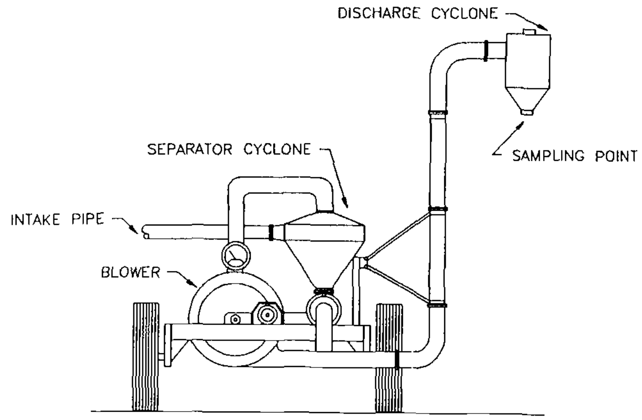

Figure 3–Pneumatic conveyor.

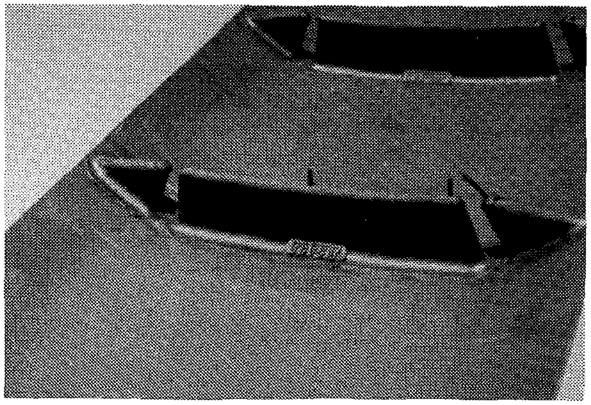

Figure 5–Rubber-flight conveyor.

Rubber-flight Conveyor. This conveyor has rubber flights molded on a rubber belt (fig. 5) to prevent the roll back of seeds during handling. The flight conveyor can therefore be operated at higher angles of inclination than the belt conveyor without increasing the belt speed.

Steel-core Bristle Auger. This auger uses nylon bristles at the outer periphery of metal flightings to move the seed (fig. 6). The nylon bristles are attached to a steel core. The steel core provides strength to keep the material moving and the bristles provide a sweeping action to move the seeds.

LITERATURE REVIEW

Coppock (1955) found that the clearance between the flighting and tube affected the amount of seed damaged by an auger. Bouse et al. (1964) investigated various intake designs in an attempt to reduce the mechanical damage in an auger operation. Sands and Hall (1971) determined breakage to shelled corn during transport by an auger and recommended that the auger be operated at full capacity to minimize mechanical damage. Hall (1974) reported breakage data for handling soybeans by various equipment, including an auger. Rademacher (1981) made theoretical derivations to reduce the damage to grain due to jamming at the tube wall and shearing at the inlet in an auger operation. Husak (1984) reported that specific power and grain damage were significantly reduced when a screw conveyor tube is rotated at a speed of about 10% of the flighting speed in a direction opposite flighting rotation. The capacity was increased when the tube was revolved in either direction. Misra and Bern (1982) concluded that a nylon-bristle auger damaged soybean seeds less than a comparable steel-flighting auger.

Magee et al. (1983) found that the grain damage increased exponentially as air velocity increased above 20 m/s. Baker et al. (1985) reported that the kernel velocities in a pneumatic conveyor were less than 2000 fpm (10 m/s) when the conveyor was operated at airflow of 4000 fpm (20 m/s). An evaluation of a

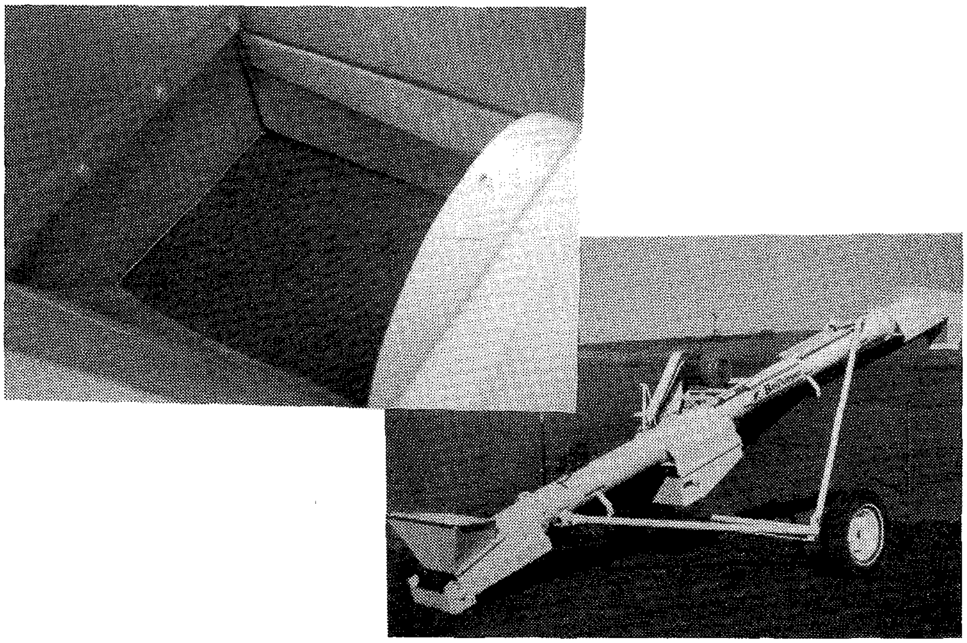

Figure 4–Belt conveyor. Inset shows the belt in the conveyor intake.

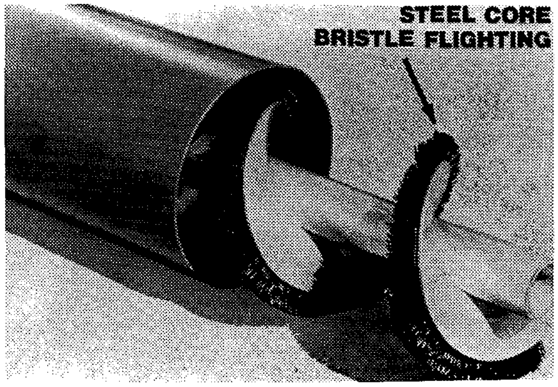

Figure 6–Steel-core bristle auger.

pneumatic conveyor by the Prairie Agricultural Machinery Institute (PAMI, 1979) in Canada indicated that each pass through the conveyor caused an average of 0.15% increase in crackage.

EXPERIMENTAL PROCEDURE

The experimental design included six conveyors as described earlier, two angles of inclination (30° and 15°), two volume controls (full capacity and half capacity), two consecutive passes through each conveyor, and two seedlots. Seedlot 1 consisted of 1200 bu (32.7 t) of Pella soybean seed grown in Madrid, Iowa, by the University Farm Service. The seeds were harvested at an average seed moisture of 14.8% and put in 20 bu plastic-lined bulk bags for the handling experiments. Seedlot 2 was a proprietary variety of soybeans and was a surplus production from a seed company. The seedlot was at 10.7% moisture, cleaned and stored in 60-lb (27.2 kg) seed bags. One thousand of these bags were transported to the warehouse for the seed handling experiments.

Two steel hopper-bottom bins, fabricated from wood and angle steel, were used for this research. One of the bins was suspended from a forklift at the height required to provide the desired angle of inclination. Each bin was equipped with a 4 in. × 16 in. (10 cm × 40 cm nominal) slide gate at the bottom. Prior to the experiments, the slide gates were calibrated to control the volume of seed flow into the conveyor.

Each conveyor transferred 500 kg (approximately 20 bu) seed from bin 1 to bin 2 (fig. 7). For the second pass, the position of bins was exchanged. After the second pass, soybeans were discarded and fresh seeds were used for experiments with the next conveyor. During conveying, samples were taken from the inlet and exit end of the conveyor. Each sample of approximately 2 kg (4.4 lbs) of soybeans was obtained by cutting across the stream of seed flow several times with a container. For the second pass, samples were taken only at the exit end of the conveyor, since the sample at the inlet for the second pass is the same sample as collected at the exit end during the first pass.

The time for conveying and the weight of soybeans were recorded by using a chronometer and a platform scale, respectively. The capacity of each conveyor was calculated by dividing the weight of seeds by the time.

The seed quality of the samples was evaluated in terms of breakage (splits), germination, and seed coat damage. Splits were obtained by passing the sample through a 10/64-in. (3.97 mm) slotted hand sieve. The material that fell through the sieve often contained weed seeds and small undamaged addition to splits. These materials (other than splits) were removed by hand, and the percentage of splits was calculated on the basis of weight of actual splits. The germination tests were conducted by the Iowa State University Seed Laboratory according to the "Rules for Testing Seeds" as developed by the Association of Official Seed Analysts. Four replications of 100 seeds were planted in a kimpak substrate, germinated for 7 days at 25° C (77° F), and the percentage of normal seedlings were recorded. The sodium hypochlorite soak procedure was used to determine seed coat damage. In this procedure, two replications of 100 seeds were soaked in a 1% sodium hypochlorite solution for 10 min. The seeds with seed coat damage swelled visibly and were counted. Data analysis was performed by the Statistical Analysis System using a Completely Randomized Block experimental design.

RESULTS AND DISCUSSION

Significant differences in capacity (maximum delivery rate) were found for various types of conveyors and angles of inclination (fig. 8). The capacity, averaged over the two angles, was the highest for the flight conveyor, followed in order by the belt conveyor, the steel-flighting auger, the pneumatic conveyor, steel-flighting auger with rubber intake, and the nylon-bristle auger. For all conveyors, the capacities declined as the angle of inclination increased, and the reductions in capacity were 46% and 3% for belt conveyor and the pneumatic conveyor, respectively.

The steel-flighting auger produced the largest increase in splits (0.56%), followed in order by the auger with rubber intake (0.24%), and the pneumatic conveyor (0.2%, Table 1). The nylon-brush conveyor produced only a very small increase in splits (0.02%), and the belt conveyor and the flight conveyor did not produce any increase in splits in two consecutive passes. The steel-flighting auger also produced the highest seed coat damage (4.3%) in two consecutive passes. The rubber-intake auger and the pneumatic conveyor inflicted about equal seed coat damage (2.8%) in two consecutive passes. The corresponding seed coat damage for the nylon-brush conveyor, the flight conveyor, and the belt conveyor was 1.59%, 0.66%, and 0.38%, respectively. The steel-flighting auger, the rubber-intake auger, and the pneumatic conveyor reduced the germination by very similar amounts (2.5%) in two consecutive passes. The three remaining conveyors, i.e., the nylon-brush conveyor, the belt conveyor, and the flight conveyor, induced no significant decrease in germination during conveying (Table 1).

A significant interaction of conveyor type and angle of inclination was found for splits produced during conveyance of seedlot 2 (Table 2). At the steeper angle of inclination for seedlot 2, the steel-flighting auger produced 1.49% splits in two consecutive passes. This is very undesirable and must be avoided. The rubber intake auger also produced more splits (0.66%) at the steeper angle compared with a 15° angle of inclination (0.4%). The

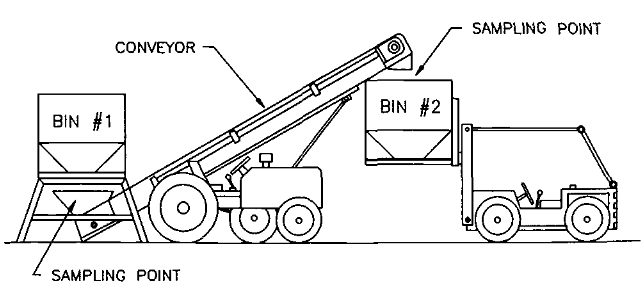

Figure 7–The experimental set-up.

pneumatic conveyor showed a reverse trend, which could be explained by the fact that the seeds were slowed down in the exit cyclone due to the additional length of pipe needed for increasing the height of discharge. The three remaining conveyors, i.e., the belt conveyor, the nylon-brush conveyor, and the flight conveyor, did not produce any appreciable amount of breakage to soybeans at either angle of inclination.

The interaction of conveyor type with volume flow is shown in Table 3. For seedlot 2, the steel-flighting auger produced a substantial increase in splits (1.23%) in the half-volume flow condition. The rubber-intake auger and the pneumatic conveyor also produced more splits when operated at half-volume capacity as compared with the full-volume flow condition. The remaining three conveyors i.e., the belt conveyor, the nylon-brush conveyor, and the flight conveyor were not influenced by the volume flow in terms of breakage. The pneumatic conveyor caused a significant decrease in germination in the half-volume condition for seedlot 2. The seedlot, after two consecutive passes, had a germination of 82.9% for half-volume flow compared to 87.3% for full-volume flow condition (Table 3). Further analysis indicated that this decrease occurred at both angles of inclination.

CONCLUSIONS

The conclusions derived from this research are as follows. The flight conveyor had the highest capacity followed, in order, by the belt conveyor, the steel-flighting auger, the pneumatic conveyor, the rubber intake auger, and the nylon-brush auger.

The capacity of each conveyor decreased at a steeper angle of inclination. This decrease was most pronounced in the belt conveyor and least noticeable for the pneumatic conveyor.

The belt conveyor, the flight conveyor, and the nylon-brush auger did not cause significant damage to soybean seed during conveying.The steel-flighting auger and the rubber-intake auger produced significant soybean seed

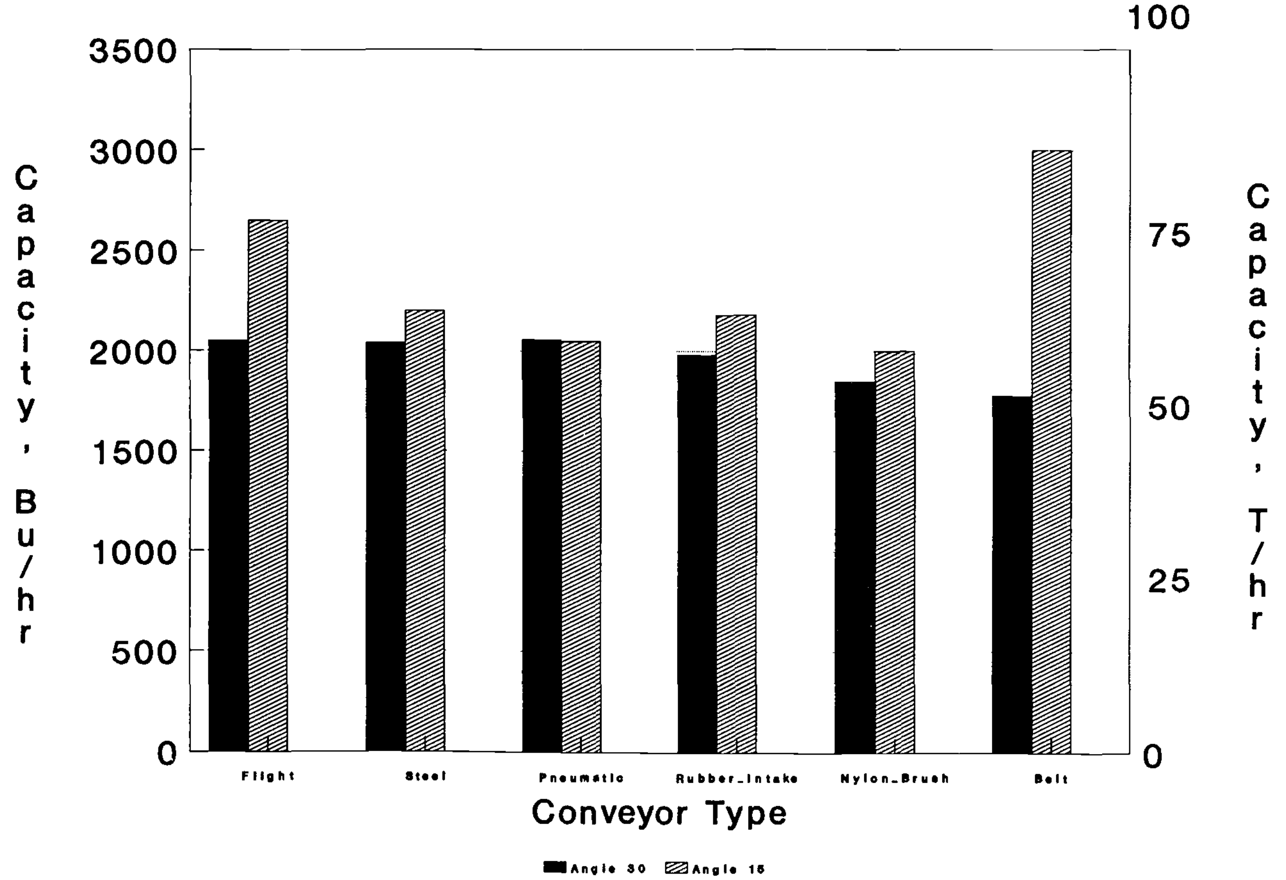

Figure 8–Effect of conveyor type and angle of inclination on capacity.

TABLE 1. Average splits, germination, and seedcoat damage for various types of conveyors; averaged across seedlots, angles of inclination, and volume flow*

	Splits			Germination			Seed Coat Damage		
Types of conveyors	Initial (%)	After 1st pass (%)	After 2nd pass (%)	Initial (%)	After 1st pass (%)	After 2nd pass (%)	Initial (%)	After 1st pass (%)	After 2nd pass (%)
Steel flighting auger	0.147a	0.418a	0.704a	93.1ab	91.9b	90.6bcd	6.53a	9.13ab	10.8
Rubber-intake auger	0.157a	0.281b	0.397b	90.9c	90.1bc	88.5d	7.28a	9.00abc	10.1ab
Pneumatic conveyor	0.140a	0.246b	0.340b	91.1cb	89.6c	88.5cd	7.84a	9.71a	10.7ab
Belt conveyor	0.117a	0.117c	0.116c	92.0cb	91.8b	91.1bc	7.50a	7.25d	7.88c
Nylon brush conveyor	0.136a	0.151c	0.159c	92.1cb	91.2bc	92.3ab	7.63a	8.19bcd	9.22bc
Flight conveyor	0.141a	0.146c	0.142c	94.7a	94.2a	94.3a	7.12a	7.78cd	8.03c

* Means with the same letters within colums do not differ significantly at the 5% level.

TABLE 2. Effect of conveyor type and angles of inclination on splits and germination

		Increase in splits (%)				Germination (%)			
		Seedlot 1		Seedlot 2		Seedlot 1		Seedlot 2	
Conveyor	Angles of inclincation	After 1st Pass	After 2nd Pass	After 1st Pass	After 2nd Pass	After 1st Pass	After 2nd Pass	After 1st Pass	After 2nd Pass
Steel-Auger	15	0.00	0.05	0.43	0.73	94.40	92.70	92.10	92.10
	30	0.01	0.10	0.78	1.49	89.30	87.80	90.80	88.70
Rubber-Intake	15	0.02	0.01	0.23	0.40	88.90	87.40	89.40	87.60
	30	0.03	0.03	0.36	0.66	93.50	92.40	89.90	89.10
Pneu. Conveyor	15	0.07	0.14	0.20	0.35	93.60	93.50	86.90	86.20
	30	0.10	0.15	0.17	0.28	91.00	91.80	88.00	84.00
Belt-Conveyor	15	-0.03	-0.01	0.06	0.06	92.60	93.50	93.00	92.30
	30	0.04	0.02	0.07	0.07	92.10	90.90	89.30	87.80
Nylon-Brush	15	0.01	-0.00	0.09	0.02	93.40	93.80	90.20	91.70
	30	0.01	0.02	0.10	0.11	91.60	93.20	89.50	90.40
Flight-Conveyor	15	0.00	0.00	0.07	0.06	96.70	94.60	90.70	91.00
	30	-0.03	-0.01	0.08	0.06	94.30	95.80	93.60	93.70

TABLE 3. Effect of conveyor type and capacity on splits and germination

		Increase in splits (%)				Germination (%)			
		Seedlot 1		Seedlot 2		Seedlot 1		Seedlot 2	
Conveyor	Capacity (bu/h)	After 1st Pass	After 2nd Pass	After 1st Pass	After 2nd Pass	After 1st Pass	After 2nd Pass	After 1st Pass	After 2nd Pass
Steel-Auger	Full	-0.02	0.01	0.52	0.99	91.20	89.80	92.20	90.90
	Half	0.03	0.14	0.69	1.23	92.50	90.60	90.60	89.90
Rubber-Intake	Full	0.04	0.03	0.26	0.49	92.30	92.30	88.50	87.30
	Half	0.01	0.01	0.33	0.57	90.10	87.50	90.80	88.40
Pneu. Conveyor	Full	0.07	0.10	0.14	0.26	92.20	92.30	90.90	87.30
	Half	0.11	0.18	0.22	0.38	92.30	93.10	84.00	82.90
Belt-Conveyor	Full	0.02	0.02	0.08	0.08	92.60	94.10	91.20	90.40
	Half	-0.01	-0.01	0.07	0.07	92.10	90.30	91.20	89.60
Nylon-Brush	Full	0.02	0.03	0.10	0.11	91.80	94.00	89.10	90.50
	Half	-0.00	-0.01	0.09	0.11	93.30	93.00	90.60	91.50
Flight-Conveyor	Full	-0.02	-0.01	0.07	0.06	95.90	94.50	92.30	92.90
	Half	-0.00	0.00	0.08	0.07	95.10	95.80	92.00	91.90

damage during conveying if: (a) the conveyor was not kept full, (b) the angle of inclination was steep, (c) the soybean moisture was low, and (d) a combination of a, b, and c.

Also, the pneumatic conveyor produced significant seed damage during conveying when: (a) the intake was not fully covered with soybeans, (b) the soybean moisture was low, and (c) a combination of a and b.

ACKNOWLEDGMENT. The cooperation of Dr. A. Knapp and the staff of the Iowa State Seed Laboratory, and of Dr. C. Bern, Agricultural Engineering, is sincerely appreciated.

REFERENCES

Bouse, L.F., L.G. Schoenleber and J.G. Proterfield. 1964. Screw conveyor capacity and castor seed damage. *Transactions of the ASAE* 7(2):152-156, 158.

Baker, K.D., R. Stroshine, G. Foster and K. Magee. 1985. Performance of a pressure pneumatic grain conveying system. *Applied Engineering in Agriculture* 1(2):72-78.

Coppock, G.E. 1955. Performance of a screw conveyor for hulled castor beans. Unpublished M.S. thesis, Oklahoma State University, Stillwater.

Hall, G. 1974. Damage during handling of shelled corn and soybeans. *Transactions of the ASAE* 17(2):335-338.

Husak, M. 1984. Performance of a revolving-tube vertical screw conveyor. Unpublished student project report, Agricultural Engineering Dept., Iowa State University, Ames.

Magee, K.I., R. Stroshine, G. Foster and K. Baker. 1983. Nature and extent of grain damage caused by pneumatic conveying systems. ASAE Paper No. 83-3508. St. Joseph, MI: ASAE.

Misra, M.K. and C.J. Bern. 1982. Evaluation of nylon bristle auger for handling of soybean seed. ASAE Paper No. 82-3568. St. Joseph, MI: ASAE.

PAMI. 1979. Evaluation Report. Neuero 675 pneumatic grain conveyor. Lethbridge, Alberta, Canada.

Rademacher, F.J.C. 1981. On seed damage in grain augers. *J. of Ag. Eng. Research* 26:87-96.

Sands, L.D. and G.E. Hall. 1971. Damage to shelled corn during transport in a screw conveyor. *Transactions of the ASAE* 14(3):584-585, 589.