Rock Remover Design for an Amadas Combine[1]

P.D. Blankenship[2]

ABSTRACT

Peanuts are harvested with various amounts and types of foreign materials that must be removed during post-harvest processing for consumer acceptance of peanut products. To assist in rock removal during harvest, a modification to the pneumatic conveyor system used to transport peanuts from underneath a standard Amadas combine to the holding bin was designed. The design utilizes air flow patterns and cavitations following an elbow in the duct system and consists of a properly sized and spaced opening in one component of the conveyor system. A stationary pneumatic conveyor system with a controllable peanut delivery apparatus was utilized in developing the duct modification. After preliminary testing during development, the efficiency of the duct modification rock removal was evaluated with three lots of peanuts averaging 0.45 t containing an average 371 rocks (3.2% of sample mass). Peanuts were conveyed through the duct system at an average flow rate of 3.9 t/hr. An average of 30 rocks comprising 42.5% of the total rock weight was extracted from the peanuts. The weight of rocks removed averaged 153.5 g and ranged from 18.7 to 320.7 g. Rocks not removed averaged 24.2 g and ranged from 1.7 to 202.8 g. Results from the tests indicate that the design of the duct modification appears to be effective in removing larger rocks from peanuts but not effective in removing smaller rocks.

Key Words: Screening, foreign material, separation, cleaning, *Arachis hypogaea* L., loose shelled kernels, LSK.

Farmer stock (FS) peanuts are harvested and marketed by farmers with various types and amounts of foreign materials (FM) (3, 7, 8, 9). FM are any unwanted materials collected with peanuts during combining which have no value (1). FM collected with peanuts may include dirt and dirt clods; various types of rocks; plant parts such as stems (sticks), wild bur, gherkin, citron, corn cobs, horse nettle, nutsedge tubers, and wood; metal parts dislodged from equipment; and glass (7, 8). To reduce FM and increase peanut value after combining, some farmers mechanically screen FS peanuts after combining with portable, low capacity screens in the field or at buying points with high capacity stationary screeners (1, 2). Commercial cleaners at buying points are also used for post-harvest FM removal. Separation techniques used in combines and post-harvest cleaning are not completely effective in FM removal since an average of 4 to 5% of FM is marketed with peanuts at farmer marketing (8).

---

[1] This research was carried out under a Cooperative Research and Development Agreement between ARS, National Peanut Research Laboratory and Amadas Industries, Inc., Suffolk, VA. Mention of a trademark or a proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be available.

[2] Agric. Eng., USDA, ARS, Nat. Peanut Res. Lab., Dawson, GA 31742 (email: pblankenship@nprl.usda.gov).

The amount of FM collected with peanuts during harvest is dependent upon many factors such as weed control during production, soil type, environmental conditions during harvest, and harvesting equipment condition and operation technique (1, 2). Because of the wide array of factors influencing FM in FS peanuts, the effectiveness of cleaning systems, especially on combines, is variable.

Primarily, two separation techniques are utilized in combines for removing FM: mechanical screening (size-dependent) and pneumatic separation (specific gravity-dependent). In previous research an exterior trommel screen was added to Amadas combines to reduce runner peanut FM by an average of 2.15% and virginia peanut FM by 2.44% (2). The size of the FM removed by the trommel was limited by screen openings and the relative FM size in peanuts harvested during the tests. FM with maximum diameters greater than 0.95 cm in runner peanuts and 1.27 cm in virginia peanuts were not removed (2).

Two pneumatic systems are used on combines for FM removal. One system injects air along with and through the flow of FS peanuts within the combine body. Light weight FM are separated and carried out the back of the combine. The other pneumatic system is designed primarily for transporting FS peanuts separated from vines within the combine body to a holding bin or basket. In moving toward the basket through a pressurized duct, peanuts are carried across one or more screening areas with small openings. Air, along with some dirt and other small diameter FM, is forced out of the duct. The screening areas are located within turns in the duct. Both pneumatic systems used in combines make incomplete separations.

The purpose of this research was to evaluate a modification of the FS peanut transport system to improve removal of FM such as rocks, dirt clods, and dislodged metal parts currently not removed by the system. The transport system studied during these tests is used on 9000 series Amadas combines.

Materials and Methods

Stock duct components of a pneumatic conveyor system (PCS) for moving FS peanuts from underneath a 9000 series Amadas combine to the holding bin were assembled. Apparatus was provided for free-standing operation unattached to a combine. A schematic of the assembly is shown in Figure 1. The fan for the PCS was powered by a 25 horsepower electric motor (Fig. 1). A variable flow vibrating trough was positioned to supply FS peanuts into the PCS through the opening ordinarily receiving FS peanuts underneath the combine for transporting to the holding bin. Prior to the tests, the vibrating trough was adjusted to provide a flowrate to estimate flow from high yielding peanuts. During the experiment, sample flowrate through the PCS was maintained as a constant. Peanuts moving through the PCS emptied into a catch bin. For visual examination of the flow of materials through the PCS during operation, plexiglass view ports were installed on vertical sides of Elbow A, Elbow B, and Component C (Fig. 1).

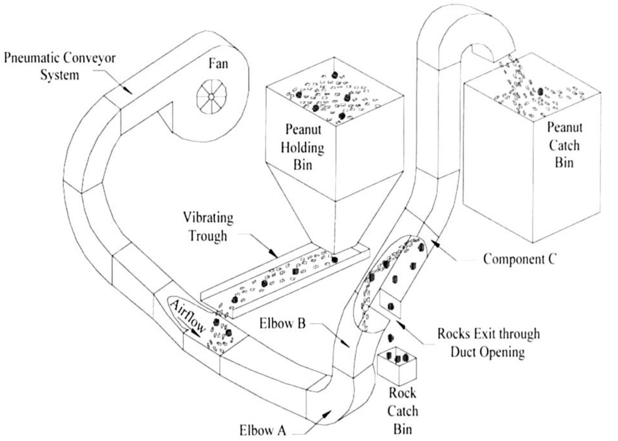

Fig. 1. Schematic of the pneumatic system evaluated during the development of the rock remover design.

During initial PCS operation, it was noted that FS peanuts were deflected in tangent lines moving through Elbows A and B instead of sweeping around elbow circumferences. Peanuts moving through Elbow B were deflected to the top of the lower end of Component C (Fig. 1). Peanuts were then deflected through Component C to the bottom of the upper end (Fig. 1). As the FS peanuts moved through Component C, some rocks were noted dropping out of the peanut stream flowing towards the upper end. Rocks that had dropped out would then slide along the bottom of Component C opposite the peanut flow back into Elbow B. The rocks would then intersect and begin moving again with the stream of peanuts within Elbow B. Because of the visually observed flow characteristics of the FS peanuts through the PCS, static pressures at various perimeters along the lengths of Elbow A, Elbow B, and Component C were measured. An area along the bottom of Component C where the rocks were flowing opposite the peanut mainstream was found with zero or very low static pressure. I theorized that a properly positioned opening within this area would provide a means for removal of rocks but would not affect material flow or contribute to air or FS peanut loss during PCS operation. After preliminary testing for appropriate opening dimensions and placement, a 15.24 cm x 23.81 cm opening was positioned in the bottom of Component C immediately past Elbow B for evaluation as a rock remover (Fig. 2). FS runner-type peanuts from Terrell County, GA (TC) were used to evaluate the performance of the rock remover design. Prior to the evaluation, the

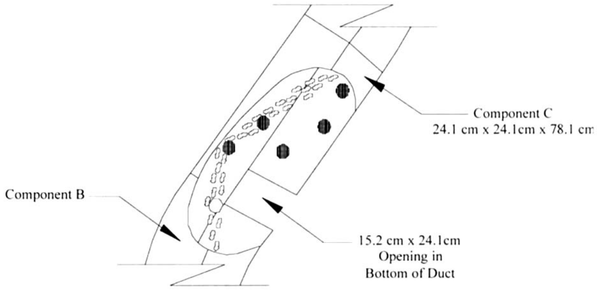

Fig. 2. Schematic of Component C of the pneumatic system evaluated during the development of the rock remover design.

peanuts were cleaned at a buying point with a commercial cleaner for foreign material removal. After cleaning, the peanuts were subdivided into three samples. Randomly selected TC rocks of various sizes previously removed by the commercial cleaner were mixed with the peanuts of each sample as the peanuts were transferred from the cleaner to pallet bins. TC rocks were composed of sand, clay, marl, or limestone (4). Additionally, Caliche rocks common to some soils in west Texas were mixed with the peanuts to provide data relevant to the west Texas peanut-producing area. Caliche is a form of calcium carbonate (5).

Samples were run through the PCS at flowrates commonly expected during conventional peanut combining. Rocks removed from the peanuts with the experimental rock remover were weighed individually. After passing through the PCS, peanuts were metered across a picking table in a 30 to 40 cm-wide single layer for hand removal of rocks remaining in the peanuts. Rocks hand picked from the peanuts were weighed individually. Caliche rocks prior to the tests were artificially colored to facilitate identification and recovery during hand separation. Caliche rocks mixed with the FS peanuts in a sample were recovered after running through the PCS and mixed with the peanuts to be run with the succeeding sample. Data collected provided an estimation of the performance of the opening in Component C in removing rocks from peanuts moving through the PCS.

Results and Discussion

A comparison of the composition of the three samples used for evaluation of the design of rock remover is shown in Table 1. Peanuts in the samples averaged 437.4 kg and 96.8% of the total sample mass (Table 1). Rocks in the samples averaged 14.3 kg equaling 3.2% of total mass. TC rocks averaged 7219.1 g or 1.6% of total sample mass, while Caliche averaged 7108.6 g (1.6%) of total sample mass (Tables 1 and 2). Though nearly equal in average total masses, the mass of individual Caliche rocks averaged 65.8 g and was 2.5 x the mass of the TC rocks at 26.7 g (Table 2). Samples contained an average of 263 TC rocks versus 108 Caliche rocks (Table 2). In a comparative analysis, the density of TC rocks (2.8 g/cm^3) was 1.3 x the density of Caliche rocks (2.2 g/cm^3) (unpubl. data). Based on this density comparison, the average volume of TC rocks used in the samples for the design evaluation is estimated at 9.5 cm^3 ranging from 0.6 to 62.3 cm^3. The average volume of the Caliche rocks was 29.9 cm^3 ranging from 8.2 to 145.8 cm^3. Data from these samples indicated a wide range of rock mass and volume within the samples used. Rocks added to the samples were assumed adequate to provide a reasonable evaluation of the rock removal capability to be expected from the PCS rock remover design.

Table 1. Comparison of the compositions of samples used in evaluating the performance of the Amadas combine rock remover design.

Sample number	Sample composition			
	FS peanuts mass		Rock mass	
	kg	%	kg	%
1	474.0	97.2	13.5	2.8
2	380.0	97.0	11.8	3.0
3	436.6	96.1	17.7	3.9
Mean	437.4	96.8	14.3	3.2

The flowrate of the three samples through the PCS during the tests is presented in Table 3. Sample flowrate averaged 63.9 kg/min. Flowrates achieved during the test runs approached flowrates comparable with harvesting high-yielding peanuts. The flowrates examined were adequate to estimate performance of the rock remover design during typical combine PCS operation.

Table 3. Comparison of sample mass flowrate through the PCS during evaluation of the design of the Amadas combine rock remover.

Sample	Sample mass	Run time	Flowrate	
	kg	min	kg/min	t/h
1	487.5	7.38	66.1	4.0
2	391.8	6.39	61.3	3.7
3	454.3	7.07	64.3	3.9
Mean	444.5	6.95	63.9	3.9

The performance of the rock remover design is summarized in Figures 3 and 4, and Table 4 (6). Mean masses of removed and not removed TC and Caliche rocks were significantly different (P = 0.05) (Table 4) (6). The mass distributions of removed and not removed TC and Caliche rocks are presented visually in Figures 3 and 4. Ninety percent of the rocks removed had masses greater than 50 g (Fig. 3). A total of 38 TC and 51 Caliche rocks were removed from the samples evaluated (Table 4). The TC rocks removed equaled 17.4% of the total TC rock mass but only 4.8% of the number of TC rocks. The mean mass of the TC rocks removed was 99.0 g with a minimum of 18.7 g and a maximum of 172.2 g (Fig. 3; Table 4). The

Table 2. Comparison of composition of the rocks used in evaluating the performance of the Amadas combine rock remover.

	Terrell County, GA rock mass						Caliche rock mass					
Sample	n	Total	Min.	Max.	Mean	SD	n	Total	Min.	Max.	Mean	SD
		g						g				
1	230	6,404	1.9	202.8	27.8	30.8	108	7108	18.1	320.7	65.8	64.9
2	216	4,650	1.8	149.3	21.5	20.4	108	7108	18.1	320.7	65.8	64.9
3	343	10,602	1.7	171.2	30.9	32.9	108	7108	18.1	320.7	65.8	64.9
Mean	263	7,219	1.8	174.4	26.7	28.0	108	7108	18.1	320.7	65.8	64.9

Table 4. Performance of the Amadas combine rock remover in removing Terrell County, GA and Caliche rocks.

Rock Type		n	Mass Total	 Mean[a]	 SD
			----------------	g	----------------
TC[b]	Removed	38	3,760.9	99.0 b	37.4
	Not Removed	751	17,896.5	23.8 d	24.0
Caliche	Removed	51	9,783.4	191.8 a	61.8
	Not Removed	273	11,542.9	42.3 c	27.2

[a] Means in a column followed by the same letter are not significantly different ($P \leq 0.05$).

[b] TC = Terrell County, GA.

Caliche rocks removed equaled 45.9% of the mass but only 15.7% of the total number (Table 4). Caliche rocks removed had a mean mass of 191.8 g and ranged 28.8 to 320.7 g (Fig. 3; Table 4). These data suggest that the rock remover was effective in removing only the larger rocks in the samples.The rock remover design requires an opening at an appropriate location in the PCS duct for removal of rocks larger than 50 g. Utilization of the rock remover design would not remove smaller rocks. Various methods could be used in fabricating the opening, including a hinged or sliding door to provide optional use of the opening for rock removal. Although peanuts grown on many soils in the U.S. do not have rocks as a foreign material problem, increased capacity for rock removal would be welcomed by some peanut farmers. Measurable economic benefits were not demonstrated by utilizing the rock remover during development of the design.

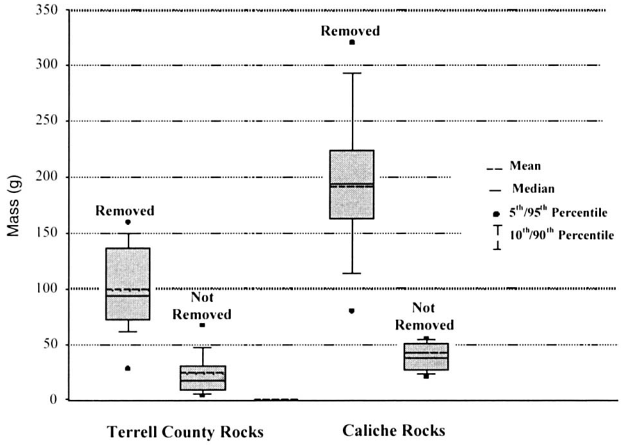

Fig. 3. Comparison of the distributions of removed and not removed Terrell County, GA and Caliche rocks.

Though the rock remover would provide potential for rock reduction, peanuts harvested with rocks might require post-harvest cleaning prior to shelling and marketing.

If utilized, one combine operation practice would be required, where PTO operation could not be stopped by depressurizing the PCS with peanuts being transported within the system. If depressurized, peanuts above the opening would reverse direction (from towards the combine basket) and slide downward along the bottom of the duct component containing the opening and be emptied out of the opening onto the ground. Although not a cure-all for rocks in peanuts, the rock remover design presented in this manuscript provides rock removal capability not currently available.

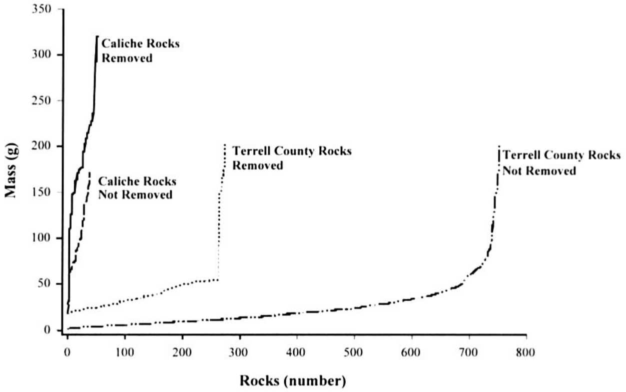

Fig. 4. Comparison of cumulative number distributions of removed and not removed Terrell County, GA and Caliche rocks.

Acknowledgments

The author thanks Lori Riles, Computer Programer; Bobby Tennille, Engineering Technician; and Larry Dettore, Mechanical Engineering Technician for their input into this project.

Literature Cited

Blankenship, P.D., and F.E. Dowell. 1998. A diverging belt screen for farmer stock peanuts. Peanut Sci. 24:37-41.

Blankenship, P.D., J.W. White, and M.C. Lamb. 1998. A screening attachment for an Amadas peanut combine. Peanut Sci. 25:110-114.

Davidson, J.I., Jr., T.B. Whitaker, and J.W. Dickens. 1982. Grading, cleaning, storage, shelling and marketing of peanuts in the United States, pp. 571-623. *In* H.E. Pattee and C.T. Young (eds.) Peanut Science and Technology, Amer. Peanut Res. Educ. Soc., Inc., Yoakum, TX.

Lawton, D.E. 1977. Geologic Map of Georgia-Coastal Plain. <http://home.att.net/~cochrans/gmapcp01.htm>.

Southwestern Archaeology Newsletter. 2002. Got Caliche? <http://www.swanet.org/news.html>.

Statistical Analysis System. 1993. Version 6.1. SAS Institute, Inc., Cary, NC.

USDA, AMS Farmers Stock Peanuts Inspection Instructions. Updated Aug. 1996. U.S. Government Printing Office, Washington, DC.

USDA, Federal-State Market News Service, Peanut Marketing Summary, 2000 Crop. U.S. Government Printing Office, Washington, DC.

USDA, Peanut Loan Schedule, 2001 Crop. USDA-FSA. U.S. Government Printing Office, Washington, DC.