Hulling-Separating Cottonseed without Delintering

S.P. CLARK, Oilseed Products Division, Food Protein Research and Development Center, Texas A&M University, College Station, TX 77843

ABSTRACT AND SUMMARY

Saw delintering of cottonseed is coming increasingly into disfavor for several environment and economic reasons. Hulling of undelintered seed would facilitate control of the environmental problems. This process has been estimated to require considerably less energy than saw delintering; therefore, it may become increasingly attractive for this reason. This is a description of experimental, pilot-plant-scale hulling-separating of underlintered seed and the pelleting and baling of the fuzzy hulls. A method is described which has been used to estimate the additional machinery needed to convert a mill from hulling delintered seed to hulling undelintered seed.

INTRODUCTION

Saw delintering is the usual procedure applied to cottonseed before hulling of the seed and subsequent processing of the meats (kernels mixed with hulls) into oil and meal. However, this procedure is coming into increasing disfavor for several environmental and economic reasons.

In many mills the delintering machinery is inadequately protected with safety guards. The machinery is noisy, and engineering or administrative controls will probably be necessary to deal with the noise. Bringing a mill into compliance with OSHA regulations in just the two areas of guarding and noise is costly because of the large number of individual machines in the delintering room. In addition, delintering machinery tends to contribute to workroom dust, and control of this dust is not easy, especially in older mills. Also, flue systems for collecting the linters removed are potential sources of atmospheric pollution, sometimes requiring expensive control measures.

Effective linter room operation requires high quality, trained labor which is difficult to find and retain. Electric power requirements for delintering are large, and the cost of power is rising continually as energy costs increase. Along with all of the above factors which tend to increase the cost of production, the market for linters often is subject to low prices and sluggish demand.

A recent economic study (1) of saw delintering and alternatives to it showed no alternative processes to be attractive with linters selling at $0.04/lb or above (weighted average of first and second cuts). However, at the estimated break even linters price of $0.30/lb or lower, hulling of undelintered seed and dilute sulfuric acid delintering were quite attractive alternatives. The break even price of $0.03/lb for saw delintering included new capital investment charges only for control of atmospheric emissions. No investment costs for control of noise or workroom dust were included because no recognized technology for control had been developed. Costs for these additional environmental controls will increase costs of production and make alternative processes even more attractive.

Environmental problems would be more easily controlled if delintering were eliminated and undelintered seed were hulled. This process was estimated to require only about 5% to 30% of the energy required for saw delintering; therefore, energy savings make this process an especially attractive alternative.

This paper is a companion to the previous one (1). It will describe experimental hulling-separating of undelintered seed and the results of trials on pelleting fuzzy hulls.

PILOT PLANT HULLING-SEPARATING OF UNDELINTERED SEED

Hulling-separating of undelintered seed is frequently conducted in our pilot plant because this technique will produce the nearly hull-free kernels needed for food processes. The pilot plant size machinery used, made by Carver, is of the same design as standard Carver oil mill machinery including huller, shaker, purifier, hull and seed separator, hull beater and tailings beater. Our machinery installation has been described previously (2). It is normally operated as a single hulling process (3) with recycle of unhulled seed back to a single huller.

This machinery is operated on undelintered seed in nearly the same way as it is operated on seed which have been saw delintered to 2-3% residual linters (2). The principal difference is that the feed rate to the huller is only about one-half as great on undelintered seed as on delintered seed because the shaker cannot handle the fuzzy seed as effectively. Some unhulled seed and kernels are carried in the fuzzy hulls all the way through the hull beater. We believe this carryover would be difficult to avoid in an oil mill operation on fuzzy seed even though the mill would not be attempting to produce hull free kernels. For salvage of kernels from hulls in an oil mill operation, a universal hulling process would be desirable (3,4). In this process the hulls from the regular single hulling, containing unhulled seed and some kernels, are run through a second stage huller set more closely to cut all the unhulled seed. This huller is then followed by separating machinery to remove the kernels from the hulls.

In order to test these ideas, universal hulling was applied to a batch of seed in our laboratory with the following results. The whole seed contained 15% linters and 7% moisture. These seed were hulled by single hulling with a feed rate of about 1,500 lb/hr to the huller or 0.75 tons/day/in. of huller width. The huller was set to produce a relatively large recycle of 25% to 30% (based on feed plus recycle) in order to produce a large yield of coarse kernels coming from the top of the second tray of the shaker. This coarse kernel fraction contained only a few hulls, and therefore for an oil mill operation aspiration of hulls from the end of this tray could be eliminated. This aspiration is called meats purification. Elimination of meats purification would eliminate the need for the purifier and the tailings beater as well.

Hulls from the (first stage) single hulling-separating contained high percentages of unhulled seed and kernels. This was shown by a recovery of kernels from the second stage hulling-separating amounting to about 11% of the weight of the hulls fed to the huller.

Hulls were accumulated from single hulling, and they were fed back into the machinery for second stage hulling-separating. For second stage, the machinery was operated with the same flow sequence and with nearly the same settings as for the first stage. The principal difference was that the second huller setting was close enough to hull all unhulled seed, as shown by inspection of the hulls coming from the hull beater.

No problems were experienced with the huller during second stage hulling although the hulls tended to feed out of the roll feeder into the huller in clumps. Several chokeups occurred when the hulls which had gone through the huller hung up in the discharges of the cyclone collectors or in the inlet throat on the hull beater. Because of these choking tendencies the feed rate to the huller was only about 300 lb/hr, equivalent to 0.15 tons/day of hulls or about 0.31 tons/day of seed/in. of huller width. Even at this low rate the huller shaker was considered to be overloaded for good separation of kernels and hulls; however, 75% of the kernels recovered came from the shaker and only 25% came from the hull beater. As in the first stage hulling-separating, the purifier and tailings beater received hardly any material and they could have been eliminated without affecting the results.

The hulls coming from the hull beater had the following analysis: moisture 5.7%, oil 0.49%, nitrogen 0.49% (average from three samples). These oil and nitrogen contents were quite close to the levels of these components found in fuzzy hulls from hand hulling of seed. They show that the hulls from the hull beater were quite free of particles of kernels and oil absorption was low.

The laboratory trial of universal hulling showed that the bulkiness of fuzzy hulls will be likely to cause flow problems in machinery which is not designed to handle the bulk; however, these problems are not considered to be insurmountable. Under the conditions of the test the efficiency of separation of kernels was very high.

At greater loading of the machinery, such as would be likely in an oil mill, some loss in efficiency would probably occur. However, losses less than those estimated in the previous paper (1) for hulling undelintered seed could be expected. Those losses (in kernels) were estimated to be 1.5% of the weight of fuzzy hulls. Low moisture seed would cause the production of greater percentages of fine meats, which would tend to remain in the fuzzy hulls. Low percentages of recycle in first stage hulling would likewise contribute to production of fines. These factors might make results, as good as the ones reported, difficult to achieve in an oil mill. Adequate machinery capacity would tend to overcome these problems.

The meats fractions coming from the huller-shaker, in both hulling-separating stages, contained quite low levels of hulls. These meats would have made solvent extracted meal higher than 50% protein. If commercial meal were to be produced using this process, having 41% or even 50% protein guaranteed, a source of hull bran would be needed to blend with the meal to adjust the protein content.

PELLETING AND BALING HULLS

The bulkiness of fuzzy hulls might cause storage problems in some mills, and it would also cause problems and inefficiencies in shipping and storage by users. Therefore, both pelleting and baling were investigated.

Some of the hulls from both the first and second stages of laboratory hulling-separating were shipped to Sprout-Waldron Co. in Muncy, PA for pelleting tests. First stage hulls were tested in order to measure the effects of the second stage hulling which appeared to fluff up the hulls. Data on the pelleting tests and on the hulls are shown in Table I (R.B. Collier, private communication.)

TABLE I

Pelleting Tests

	Hulls from stage no.	
	1	2
Die holes diameter, in.	1/4	1/4
Roll clearance, in.	0.01	0.01
Temperature hulls to conditioner, F	60	60
Temperature hulls to die, F	160	160
Power required, lb/hp-hr.	80	60
Density of hulls, lb/cu ft	7	8
Density of pellets, lb/cut ft	30	30
Production through-put, lb/hr	2,400	2,400

The pellet mill would take unheated hulls, but it would not produce pellets. Pellets were produced when hulls were conditioned with live steam to a temperature of 160 F. Both types of hulls handled about the same, but hulls from second stage hulling required 25% more power input to the pellet mill. A force feeder to feed hulls to the die is considered necessary for best results.

The pellets from both types of hulls had the same appearance; they were not slick but fuzzy. They were fairly easily broken and might not have enough strength for pneumatic conveying without excessive breakage.

Grinding the hulls before pelleting would probably allow better pellets to be produced. However, the total energy used would be greater. An additive, such as cottonseed meal, would also improve the pellets.

Fuzzy hulls are amenable to baling as well as pelleting. Fuzzy hulls without delintering, from a different lot of seed with 12% linters and 7.5% moisture, were baled in the laboratory linters baling press. Operation of the tramper as the press box was filled was necessary to produce a bale of satisfactory density. The best bale weighed 652 lb and measured 51-1/2 in. x 25 in. x 37 in. Density was 23.7 lb/cu ft. It was covered with bagging on both ends and held with 8 band-type ties as though it were a bale of linters.

MACHINERY FOR CONVERSION

It is difficult to specify machinery which will fit all mills for converting from hulling delintered seed to hulling undelintered seed. However, some of the criteria used by the writer in preparing the cost estimates given previously (1) may be helpful to others. For these estimates, the normal machine capacities for hulling and separating machinery were estimated for delintered and undelintered seed. The additional machinery required for undelintered seed in any size of mill was then merely the total machinery for undelintered seed minus the total for delintered seed. (The

TABLE II

Machinery Capacities for Carver Machines

	Delintered seed, single hulling capacity[a]	Undelintered seed, universal hulling	
		Hulling stage	Capacity[a]
48 in. wide huller	80	1	80
54 in. wide shaker	80	1	80[b]
66 in. wide hull & seed separator	80	1	40
Double drum hull beater	120	1&2	60
48 in. huller		2	250
54 in. wide shaker		2	250[b]

[a]Approximate maximum capacity in tons of seed per day.

[b]Parallel flow over two decks, recommended by Verdery (6).

machinery for delintered seed was assumed to already be on hand.)

As described above under experimental hulling, no purifying of meats on the end of the two tray huller shaker is necessary for undelintered seed. A pan can be installed under the top tray to receive both coarse and fine meats. If the flow of seed from the huller is split for parallel flow over both shaker trays, both can be used for the primary separation of meats and hulls (4). This arrangement will then give a huller and shaker combination the same capacity on undelintered seed as on delintered seed. On undelintered seed the size of holes in the shaker screen can be larger than for delintered seed and this helps to increase the capacity of the shaker.

The capacities of hull and seed separators and double drum hull beater for undelintered seed were estimated to be one-half of their capacities on delintered seed. The former would be needed only in first stage hulling while the latter could be needed in both stages. The size of holes in hull beater screens can be larger when handling fuzzy hulls. Alternatively hull and seed separators and recycle of seed to the first stage huller could be eliminated if more second stage huller and shaker capacity were provided.

A second stage 48 in. huller was estimated to be able to handle hulls from 200 to 250 TPD of seed (5). A shaker under this huller was specified even though it might have limited value under such a great load. These considerations are summarized in Table II of machinery capacities for Carver machines.

The capacities cited in Table II would fit Bauer systems as well, except that a separate hull and seed separator for first stage hulling might be desirable in place of the hull and seed separator mounted over the shaker.

A mill converting to hulling undelintered seed should allow room for additional machines in case more were judged later to be needed. Initial use of seed with first cut linters removed may be desirable in order to gain experience before the entire volume of linters on hulls must be handled.

Verdery (5) has a detailed discussion of hulling–separating machinery and of the specifics for handling fuzzy hulls.

For defibrating hulls from undelintered seed to produce hull bran to use in adjusting protein in meal, the production of a defibrator was estimated to be ca. 6,000 lb of hull fiber (R.B. Sanders, private communication) and 14,000 lb of hull bran per day. This is in general agreement with Verdery's (6) figures of 16,000 to 20,000 lb of hull bran per day for a defibrator operating on hulls from saw delintered seed.

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REFERENCES

1. Clark, S.P., JAOCS 53:684 (1976).
2. Clark, S.P., L.R. Wiederhold, C.M. Cater, and K.F. Mattil, Ibid. 51:142 (1976).
3. Wamble, A.C., in "Cottonseed," edited by A.E. Bailey, Interscience Publishers, New York, NY, 1948, pp. 588-614.
4. Verdery, M.C., "The Hulling and Separating of Cottonseed," Houston, TX, 1974.
5. Verdery, M.C., Ibid. pp. 21, 116, 117.
6. Verdery, N.C., Ibid. p. 125.

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