AERODYNAMIC SEPARATION OF CHIPS FROM POTATO SEED PIECES [1]

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Abstract

This article shows fundamentally why an air-blast system can effectively eliminate chips from seed pieces, what percentages of separation and loss of acceptable seed pieces might be expected, and some methods for turning the concept into a practical machine. Preliminary laboratory data show that air velocities of 4500 to 7000 feet per minute (23-36 m/s) may be required for pressure separation. With proper adjustment, an air separator can be expected to eliminate 80 percent of the chips with a loss of only 4 percent of seed pieces slightly over 1 ounce (28 g) in weight. The under-1-ounce pieces not eliminated will be blocky in shape; the over-1-ounce pieces lost will be slabs. An experimental machine is under development to define design requirements for both pressure and suction separators.

Introduction

Potato seed cutting and planting research at Washington State University proceeds on two fronts: long-term, new solutions, and short-term improvements in current methods. The overall goal of the effort is to efficiently produce uniform field stands of potato plants and more uniform tuber size, shape and quality.

There are two main reasons for irregular potato stands: irregular spacing of the seedpieces, and irregular seedpieces (especially undersize). Irregular seedpiece size and shape contribute to lack of crop uniformity even if seed spacing is perfect; but odd sized and shaped seedpieces also cause much of the irregular seed spacing in the field.

Effects of operating variables on the seed quality produced by rotary-blade seed cutters have been defined, and are being defined for stationary-blade machines (Hyde et al. 1988). However, since no current cutter can work perfectly, an experimental aerodynamic seedpiece separator, based upon the fundamental work already completed (Zhao 1986), is being developed to eliminate chips and slabs from the cut seed produced by production cutters.

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Field experiments demonstrate the value of chip elimination in improving crop uniformity, quality, and marketable yield. Thornton et al. (1983) showed that a grower can actually make money by discarding seedpieces that are under 1 ounce (28 g). However, experience of operators of seed cutting equipment shows that the usual roller separators do not eliminate nearly all of the chips and small seedpieces. One operator asked whether air separation might be used, so research was initiated to find out. The answer was yes, air separation can be used effectively (Zhao 1986, Hyde et al. 1988).

The three major seedpiece shapes (Fig. 1) have differeing aerodynamic properties[1]. However, since aerodynamic separation depends upon differences between drag and gravity forces, it turns out that small pieces of nearly any shape can be separated from larger pieces up to a certain size. According to our experiment, that size is about 40 grams (1.4 oz), the seedpiece mass at which the graph (Fig. 2) of terminal velocity vs. mass begins to flatten out. Figure 2 shows further that, if we want to blow away seedpieces of 1 ounce (28 g) or smaller, we need to use an air velocity of about 24.5 m/s (4820 ft/min). A separate experiment in which an air stream was used to separate many seed pieces, an air velocity of 24.5 m/s was shown to eliminate 80% of the undersize seedpieces (Fig. 3). More air velocity would eliminate more undersize, but then the loss of seedpieces larger than 1 ounce (28 g) begins to increase. Figure 4 shows a loss of desired size seedpieces of 4% at that air velocity; however, the loss of good seedpieces is really much less, because the kind of pieces blown away that are over 1 ounce tend to be slabs (top two images, Fig. 5). The separation is also really better than 80% because the kind of seedpieces less than 1 ounce that are kept tend to be blocky (bottom image in Fig. 5).

The next task is to design a machine to take advantages of these fundamental physical principles in order to separate chips, slabs, and undersize seedpieces from cut potato seed. Figures 6 and 7 show two variations of one design concept; the first uses pressure or blowing separation; the second uses the suction or intake side of the fan. Figure 8 is a different suction arrangement, where undersize seedpieces are vacuumed up off a perforated conveyor. A cyclone type separator keeps the seedpieces out of the fan.

The viability of pressure separation was confirmed in the laboratory; and all three concepts are based upon proven fundamental principles. Some observers prefer the blowing separation idea of Figure 6, because it allows better observation of the separation process. The blower, cyclone separator and conveyors are being mounted on a framework so that all of the concepts can be field tested using the same equipment. Design of the nozzles for the three arrangements, sizing of fans, and best adjustments of conveyor speeds are yet to be determined.

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1 The drag coefficient for the end piece is approximately that of a cone. The coefficient for the middle piece varies from that of a cylinder with its axis parallel to the flow to that of one with its axis perpendicular to the flow. The coefficient for the half piece is approximately that of a cube. Zhao (1986) gives details on this.

References

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Thornton, Robert E., Tom Schotzko and Gary Hyde. 1983. Some other factors in obtaining good plant stands. Proceedings, 22nd Annual Washington State Potato Conference and Trade Fair, 108 Interlake Rd., Moses Lake, Wa., Feb.

Zhao, Kai. 1986. Potato Seed Piece Optimization and Seed Piece Separation. Master of Science Thesis, Agricultural Engineering Dept., Washington State University, Pullman, Wa.

Figure 1. Three major seedpiece shapes.

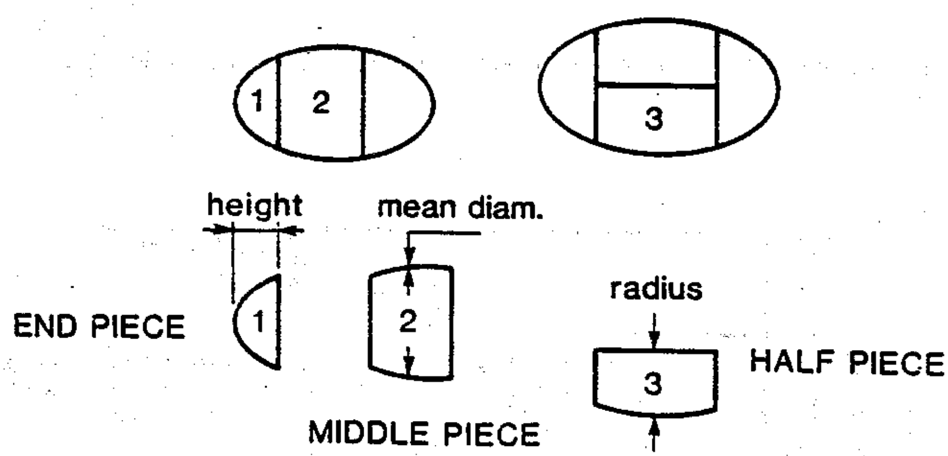

Figure 2. Terminal velocity vs. tuber mass.

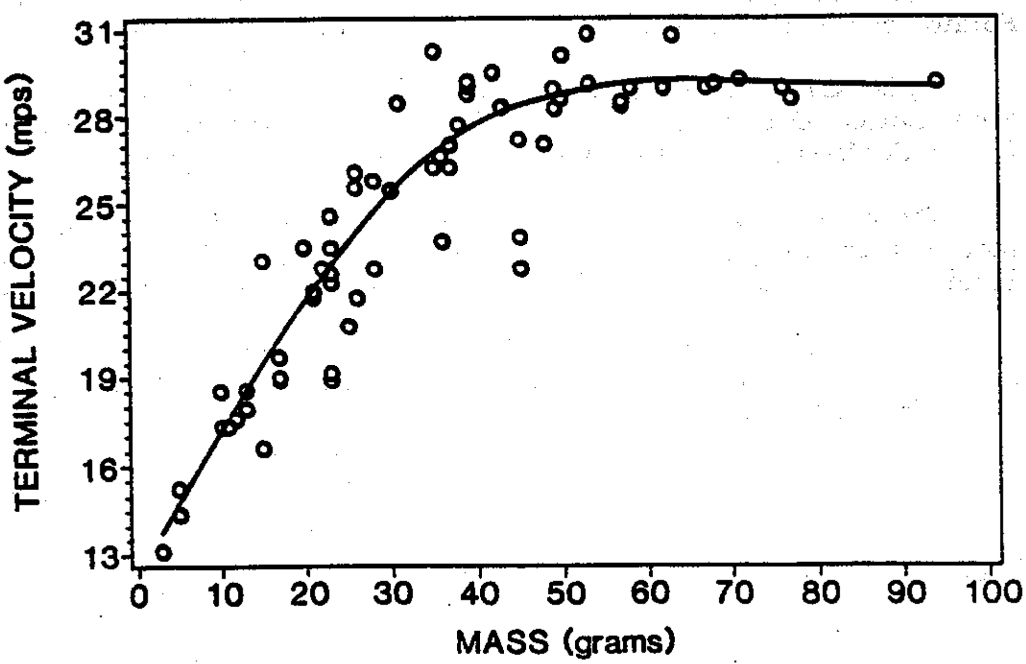

Figure 3. Percentage separation of undersize seedpieces vs. air velocity.

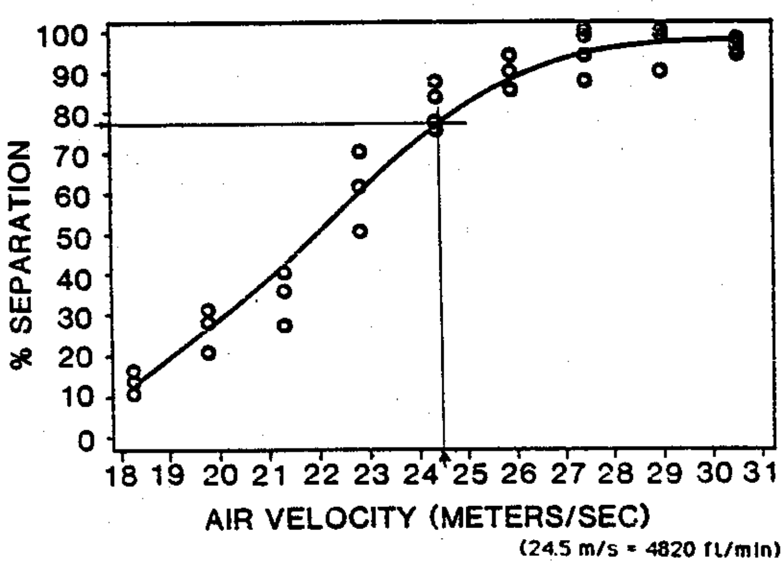

Figure 4. Percentage loss of seedpieces over 1 ounce (28 g) vs. air velocity.

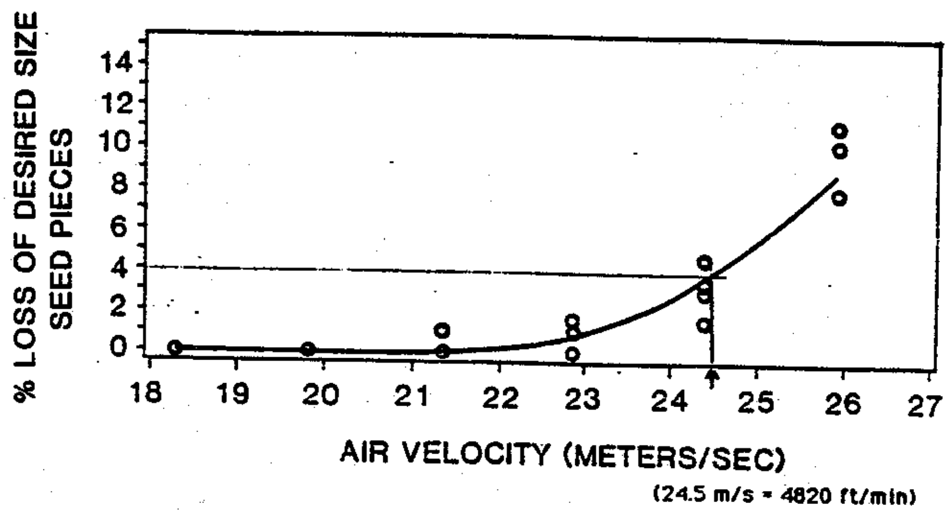

Figure 5. Kinds of desirable size seed loss and undersize not separated.

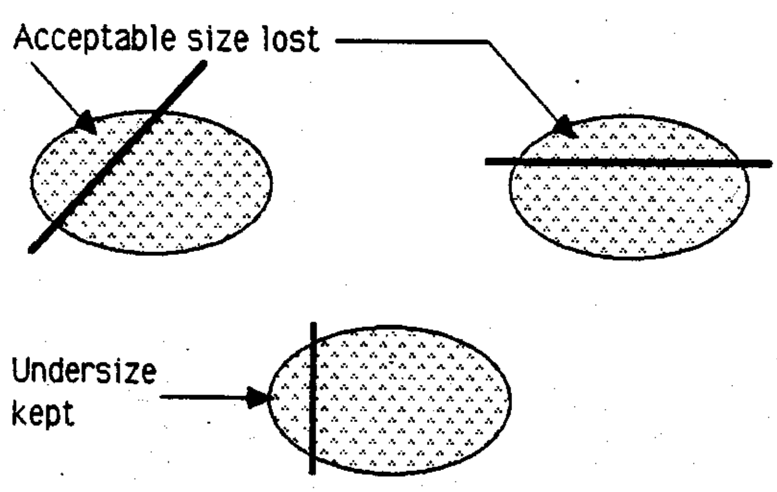

Figure 6.

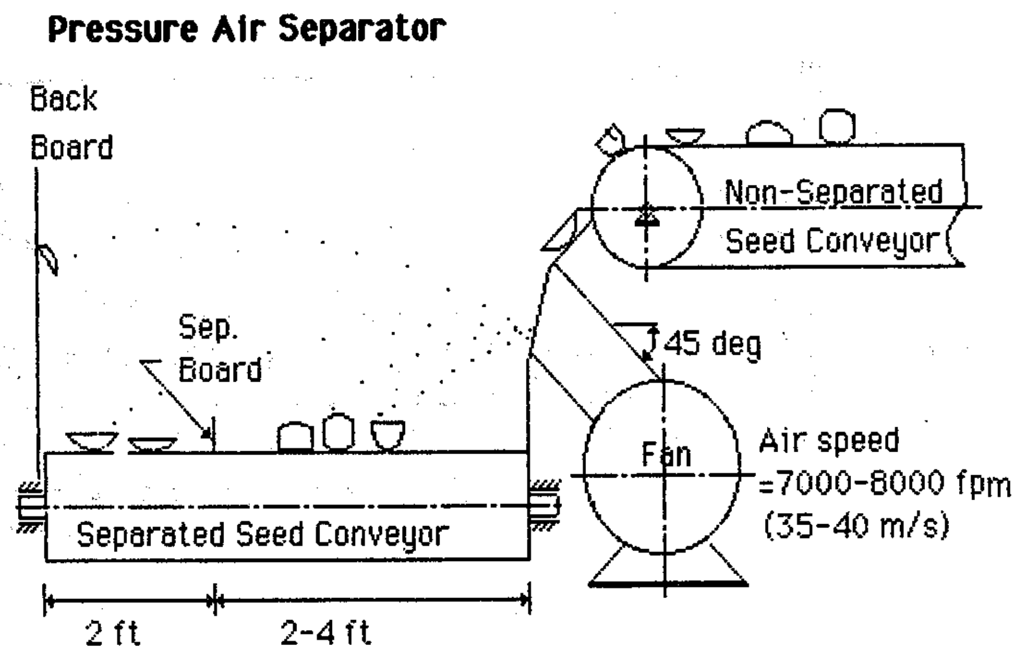

Figure 7.

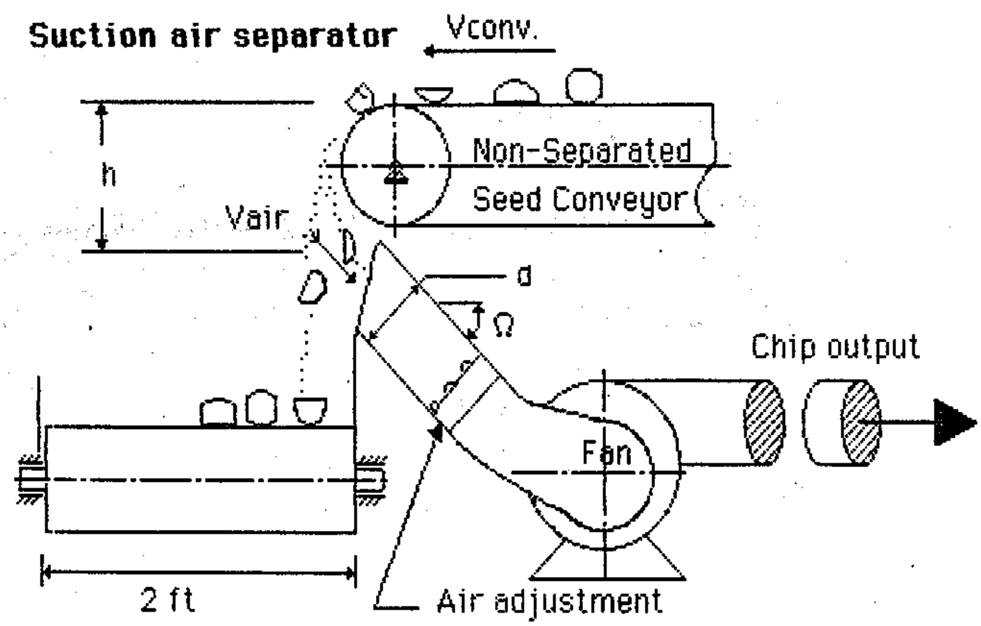

Figure 8.

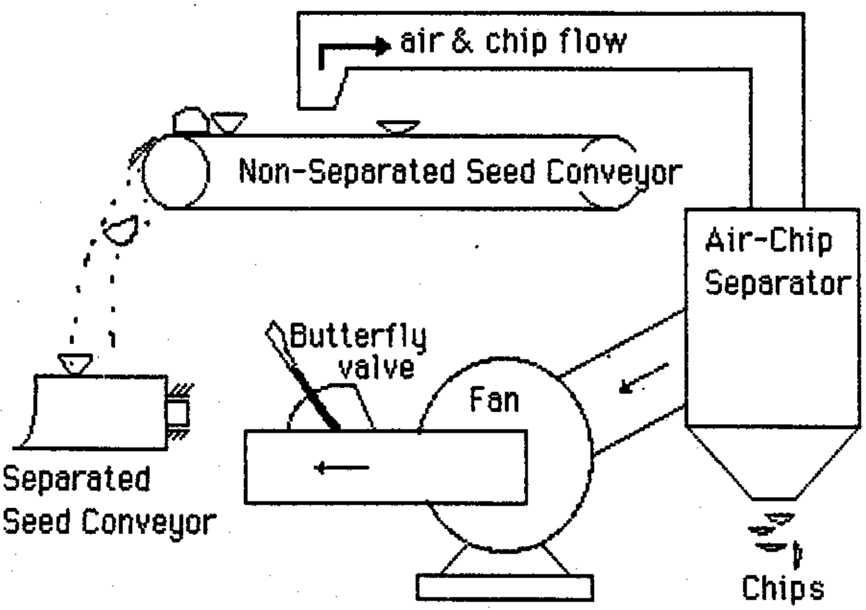

Figure 8.