

GRAPHICAL SELECTION OF SIEVE MESH FOR GRAIN SIEVES

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ABSTRACT

A graphical method was established to obtain the accurate screen apertures of sieves used for separating grain seeds from foreign matter at maximum efficiency thereby facilitating the proper design of a cleaning system. The method depends upon the statistical analysis of the physical/mechanical properties of both grain seeds and foreign matter, taking into consideration that these properties such as the linear dimensions, may be considered as variables which follow the law of normal distribution.

NOTATION

a = major diameter of particle (length) mm
 b = intermediate diameter of particle (thickness) mm
 c = minor diameter normal to a and b (width) mm
 L = seed dimension, mm
 m = number of classes
 λ = class interval

2. EXPERIMENTS

Two sets of experiments were conducted to determine the magnitudes and variation of the properties of seeds and foreign matter which are relevant in grain cleaning systems.

2.1. MEASUREMENT OF PHYSICAL DIMENSIONS

1. INTRODOCTION

It is well known that separation of grain seeds from the associated foreign matter can be achieved by utilizing the difference between some of their physical or mechanical properties. The usual characteristics useful for this purpose are size, shape, specific gravity, surface properties and colour [1]. The size of seeds is defined in terms of the dimensions of thickness, width and length. The surface characteristics influence the frictional properties of both seeds and foreign matter. The magnitude of anyone of the above parameters varies within certain limits even within the same variety of grains harvested from the same area [2]. Therefore, these properties may be expected to behave as variables with randomized magnitudes. In the work described here, the mathematical methods of statistics are used to analyse the numerical data of these variables determined experimentally to provide a basis for selecting accurate screen aperture of sieves used in grain cleaners.

To obtain data on the dimensional characteristics of seeds and impurities, samples of about 500 grain seeds and their associated foreign matter were used. The dimensions of major (a), intermediate (b) and minor (c) diameter of all particles in the sample were measured using a photographic enlarger. The outline of the projection of each particle at a known magnification of the enlarger was traced. Fig.1 shows the shape and the three mutually perpendicular diametrical dimensions a, b, and c of a wheat grain obtained by this method [3]. The data obtained are recorded in a correlation table where the percentages of particles within the same dimension range in a sample are placed within the appropriate class range for drawing the frequency curves as explained later.

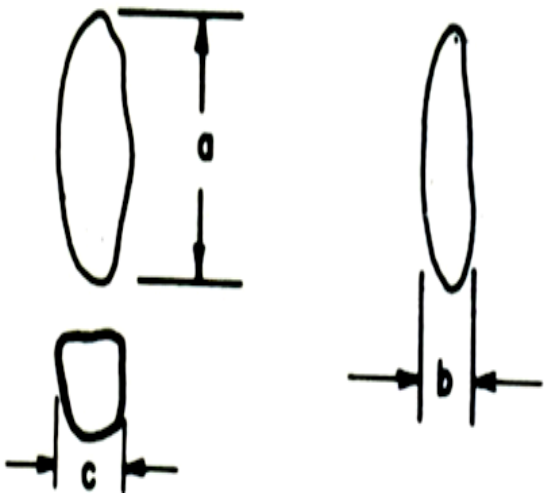


Fig 1: The principal dimensions of wheat grains.

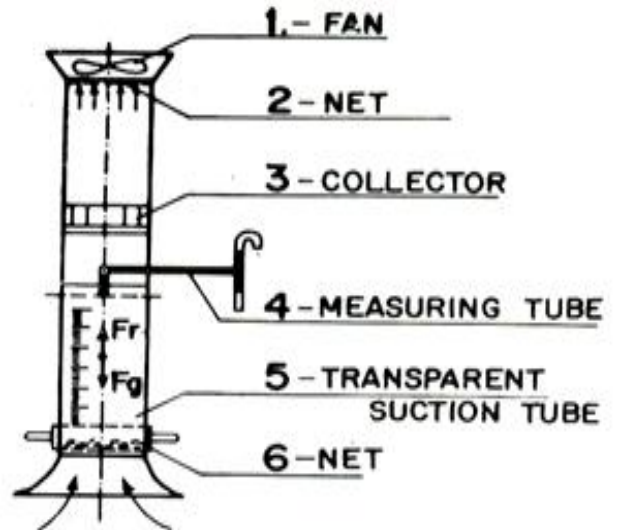


Fig. 2: The Aerodynamic Tube

2.2 DETERMINATION OF TERMINAL VELOCITY

When an air stream is used for the separation of a product such as oats and barely from their associated foreign matter, such as twigs, husk particles, foreign seeds, etc., A knowledge of the terminal' velocities of all the particles involved would define the range of air velocities affecting good separation. For this reason, terminal velocity has been used as an important aerodynamic property of materials in pneumatic separation operations.

An aerodynamic tube sketched In Fig.2 was used to determine the terminal velocities of both seeds and foreign matter. A suction fan was fitted at the top of a transparent tube. To smooth out the air blast a net and a collector were added. The particles under study were placed on the net at the inlet side of the transparent tube. The air velocity at which the particles floated in the active part of the transparent tube was measured to give the terminal velocity. The terminal velocities thus obtained for the different particles in grain samples were recorded in correlation tables and used to draw the frequency curves of Figs.3 and 4.

3. ANALYTICAL PREEDURE

To analyse and synthesize the data from the experiments, the maximum, L_{max} and minimum, L_{min} values of the measured dimensions for the seeds and foreign matter were determined as described in section 2.1. Then the range is divided into an appropriate number of classes to get a convenient class interval, given as

$$\lambda = (L_{max} - L_{min})/m$$

The limits of the classes are determined such that each class falls between two limits, L_{n+1} and L_{n+2} where

$$L_{n+1} = a + n\lambda, n = 0, 1, 2 \dots \dots \dots n$$

The number of particles within each class, separately for seeds and foreign matter, is then calculated in percent of the total number in the sample. The terminal velocity values are similarly analysed. The results are then presented in a table correlating two characteristics such as length and width or thickness and terminal velocity, etc as shown In Figs.3-6. The correlation table is divided

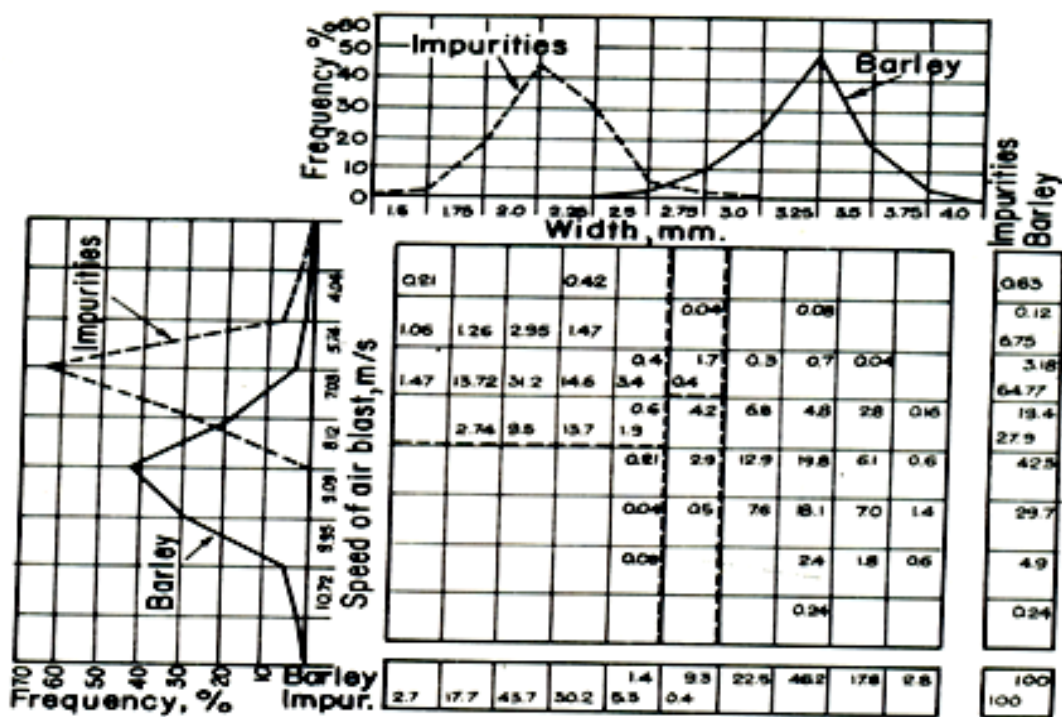


Fig. 3: Correlation Table of Width and Air Velocity for Barley and Impurities

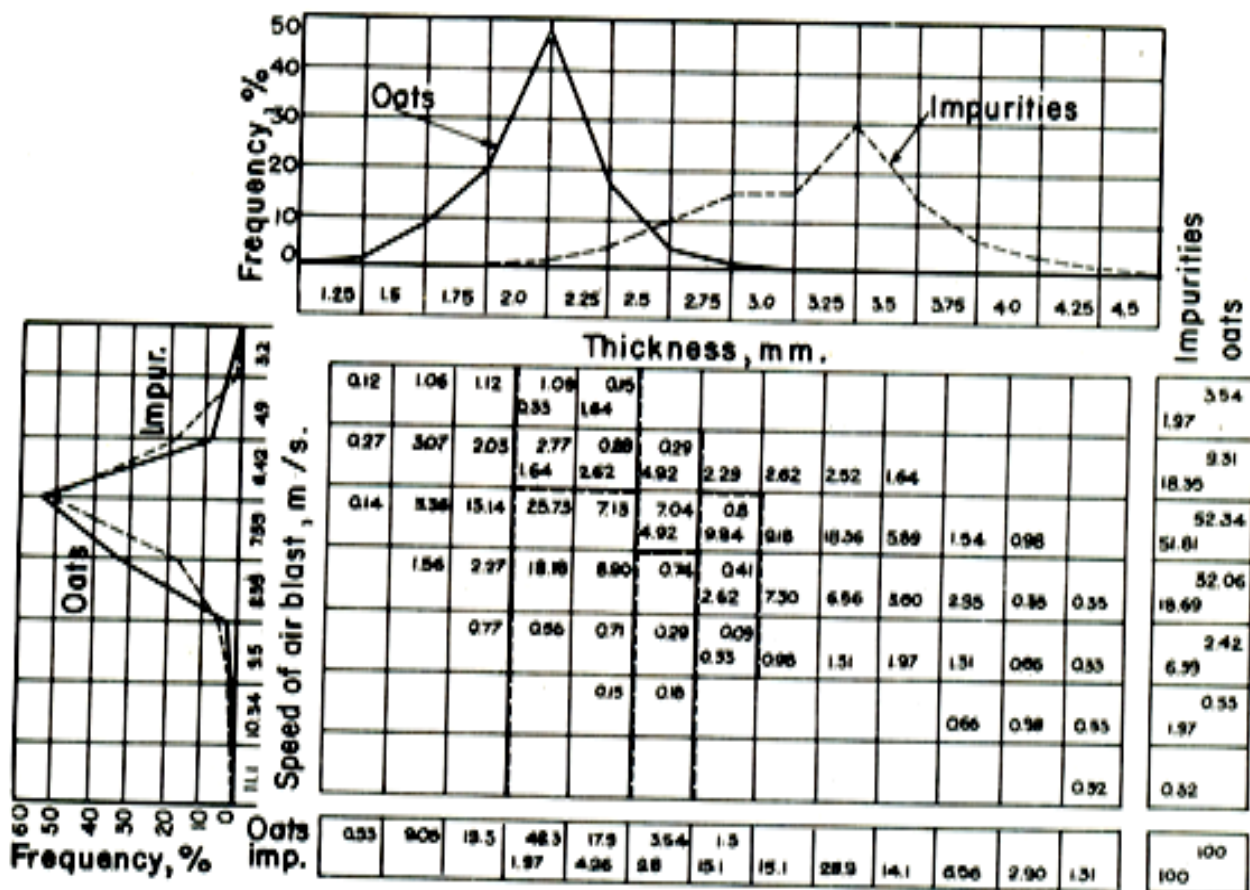


Fig. 4: Correlation of Table of Thickness and Velocity of Oats and Impurities

1.08
= 2.42%

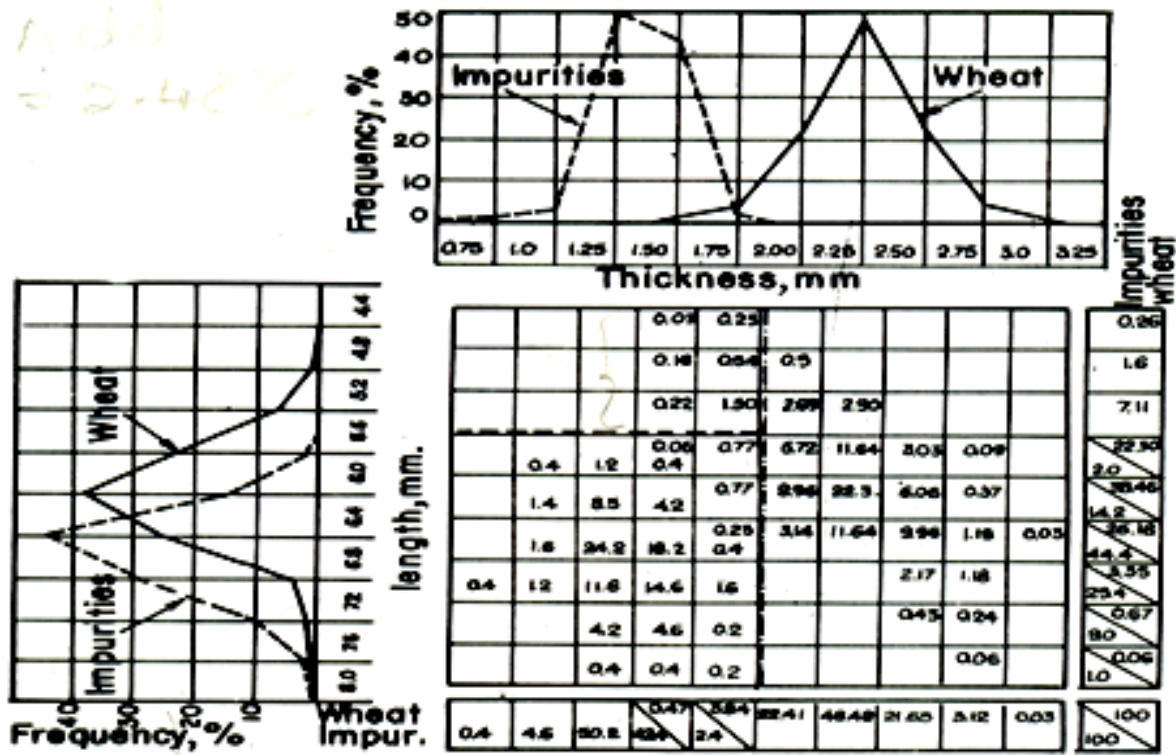


Fig. 5: Correlation of Table of Thickness and Length of wheat and Impurities seeds

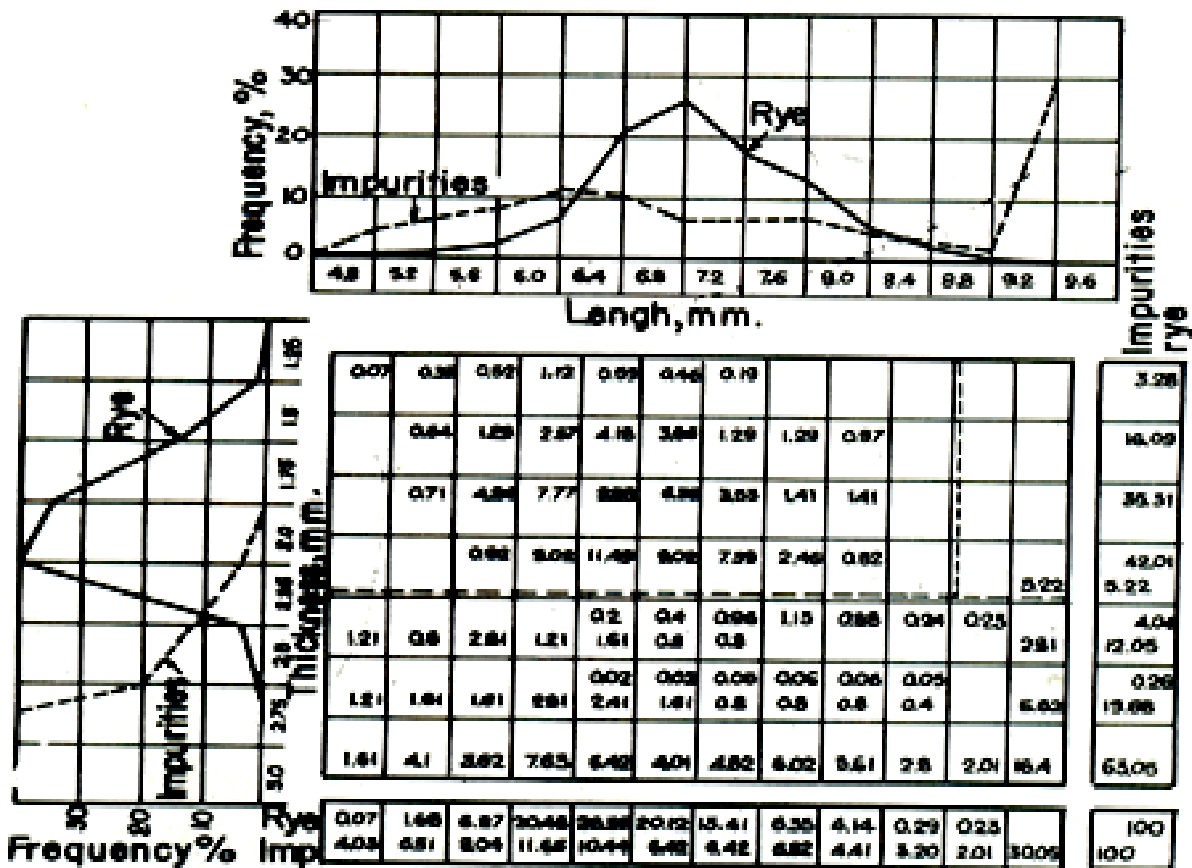


Fig. 6: Correlation of Table of Thickness and Length for rye and impurity seeds.

into vertical and horizontal sections. The number of vertical sections is equal to the number of classes of a given characteristic identified at the top of the table. The number of horizontal sections is equal to the number of classes of the second characteristic for correlation identified at the left-hand side of the table. Inside the squares obtained from the intersections of vertical and horizontal class lines there are two figures given. The upper figure is the percent of seeds whose characteristic falls within the limits of the intersecting class lines. The lower figure is the percent of foreign matter within the same limits. Where the figure is zero, no entry is made for the sake of clarity. Next, using the data of the correlation table, the frequency curves for seeds and foreign matter are plotted with the sample class mean of a given characteristic on one-co-ordinate axis and its frequency or percentage on the other axis (see Fig. 3 - 6)

3.1 USE OF THE FREQUENCY CURVES

The usefulness of the frequency curves may be evident from consideration of Fig.7, which gives three possible relationships of grain seeds and the associated foreign matter. In Fig.7 (a)

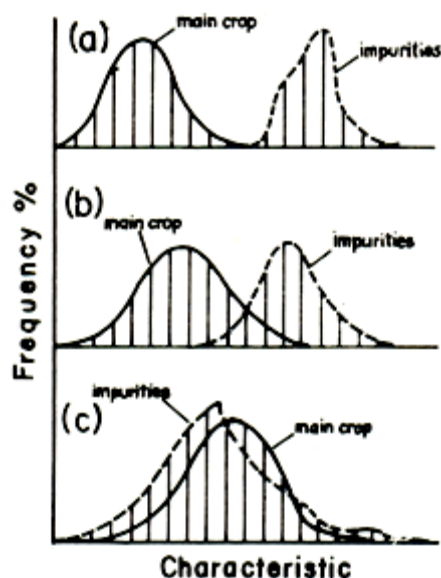


Fig. 7: Frequency Curves

where the specific characteristics of grain and foreign matter are quite dissimilar, 100% separation is possible by using one sieve size. But when the situation is as represented by 7(b), with the frequency curves partially over-lapping, complete separation on the basis of this one characteristic is

impossible. If complete recovery of grain is desired, some impurities must be tolerated. If completely clean grains are desired, some loss of grains must be expected. Fig.7(c) represents the most difficult situation where the given characteristic for both grains and impurities is so similar that the frequency curves practically coincide.

The use of actual frequency curves such as those given in Figs.3-6 facilitates the choice of the best procedure as well as the characteristic or the combination of characteristics for optimum separation. For example, from Fig.5, it can be seen that on the basis of thickness, using a screen aperture of 2mm width, 95.69% of the grains is recovered (i.e. summation of 22.41 + 48.48 + 21.65 + 3.12 + 0.03 from the correlation table of Fig.5 to the right of the vertical dotted line) without impurities. If desired, a second separation by length using a screen aperture of 5.6mm diameter will lead to the recovery of a further 2.48% of the grains (see horizontal dotted lines of Fig.5). Thus, 98.17% (95.69 + 2.48) of the grains can be recovered without impurities in a two stage separation operations.

As a further example, Fig. 4 shows that to separate impurities from oats, on the basis of thickness using a 2.5mm screen aperture, 95.08% grain with 6.23% of impurities will be recovered. A second separation using 2mm screen aperture aided by an air stream at 6-7 m/s will clean the recovered grains from the contaminating impurities.

3.2 EXPERIMENTAL VERIFICATION

An experimental grain cleaner shown in Fig.8 was constructed to test the reliability of the analysis presented in section 3.1. The machine provided easy adjustment of the air flow and the replacement of sieves with different meshes. The cleaner consists of essentially of a pair of inclined sieves at a radial fan which is adjustable to give different air velocities. The experimental

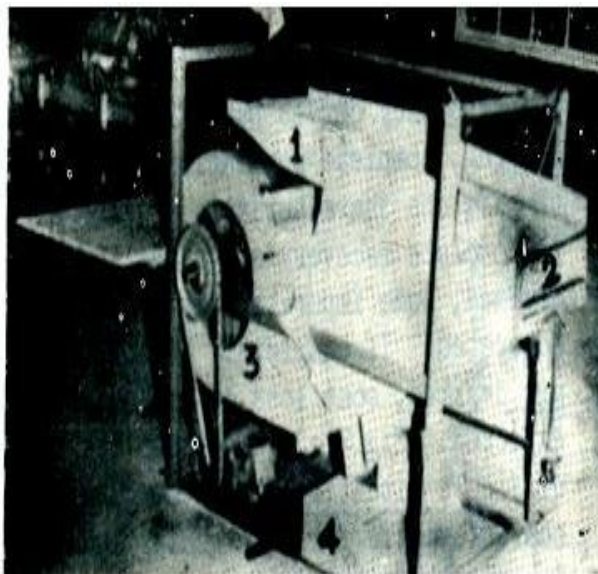


Fig. 8: Experimental Winnowing Machine (1-Platform, 2-Sieving unit, 3-Fan, 4-Seed Collector)

grain cleaner was then used to clean the different grains described in Figs.3-6, and the performance was found to agree closely with the analytical predictions. The results obtained in the case of barley are tabulated in Table 1. Screen apertures of 3.00mm diameter and 2.75mmdiameter were used in the upper and lower sieves respectively. The air velocity from the fan was adjusted to about 6-7 m/s. The average percentage grain recovery was 95.84% without any contaminating impurities near to that predicted from Fig.3.

TABLE 1: PERCENTAGE SEED RECOVERY OF BARLEY

Experiment No	Feed rate kg/hr	Diam. of Sieve Perforations (mm)		Grain recovery (percent)		Total grain recovery %	Degree of Cleaning %
		Upper	Lower	Upper	Lower		
1	113	3.00	2.75	88.55	8.24	96.79	99.8
2	150	3.00	2.75	88.60	8.07	96.67	99.7
3	195	3.00	2.75	89.75	6.07	95.82	99.5
4	249	3.00	2.75	90.40	4.90	95.30	99.3
5	331	3.00	2.75	91.20	3.40	94.60	99.1

Average percentage recovery = 95.84

CONCLUSION

On the basis of the verification afforded by the experimental grain cleaner, the usefulness of the analytical procedure outlined in this work for the selection of accurate screen aperture of sieves used in grain cleaners has been obtained.

REFERENCES

1. BAINER, R., Principles of Farm Machinery, Chapter 16, John Wiley & Sons, New York, 1955.
2. KLENIN, H.E., et al., Farm Machinery, Chapter 7, Kolos, Moscow, 1970.
3. MOHSENIN, N.N., Physical Properties of Plant and Animal Materials, Gordon & Breach Science Publishers, 197