FRICTION CHARACTERISTICS OF RAPESEED AND FLAXSEED

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INTRODUCTION

Production of rapeseed has increased dramatically in recent years. There have also been sizable increases in the production of flaxseed and sunflowers although not as spectacular as for rapeseed. In some cases new structures have been built to store oilseeds; more frequently, existing storages formerly used for cereal grains have been adapted for the purpose.

Properties of grains that affect forces produced in storage structures vary considerably from one kind of grain to another. It has been common practice to design grain storages to hold wheat; a structure strong enough to hold wheat will be more than strong enough for other cereal grains, but coefficients of friction in oilseeds are likely to be appreciably lower than in cereal grains and this could alter the patterns of forces and stresses in grain storage structures.

Information on friction characteristics is also important in the design of materials-handling equipment.

LITERATURE REVIEW

The basic relation for friction, $F = \mu N$ is generally accepted as valid within reasonable limits. The difference between static and kinetic friction is also broadly understood. Static friction was defined by Sir W.B. Hardy (3) as the tangential force per unit area which just fails to cause motion. Since kinetic friction is generally less than the static value, it is difficult to precisely establish the maximum value. It is simpler and more usual to measure the force which will just barely cause motion than the maximum force that will not.

Recent studies by Richter (6), Lorenzen,[a] Buelow,[b] Balis (1), and Brubaker and Pos (2) have increased the information available in the field of friction of various seeds. These studies, as indicated by Stewart et al. (7), show the importance of such variables as moisture content of the seeds and the surface, hardness, environmental conditions, and the time factor on friction coefficients. These studies also indicate that in general, the magnitude of the normal load and relative velocity between the materials (both within limits) had no significant effect on the coefficient of friction.

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EXPERIMENTAL EQUIPMENT AND PROCEDURE

After considering the various devices used by other workers, it was decided that for our purposes an apparatus similar to that used by Brubaker and Pos (2) would be most suitable. A steel cylinder, 8 inches in diam and 3 inches deep (28.3 X 7.6 cm) was used to hold the grain. A cable attached to the cylinder was pulled at a rate of approximately 0.8 inches/min (2.8 cm/min) by means of an electric motor and gear reducer. In line with the cable was a Statham universal cell and force transducer. Output from the force transducer was fed into a Varian G 2000 recorder which was calibrated to read directly in pounds. The cable was attached as low on the cylinder as possible to reduce the tendency of the cylinder to overturn and allow grain to run out beneath its rear side.

Grain inside the cylinder was covered by a metal plate which could be moved vertically relative to the cylinder by means of adjusting screws. In this way, the cylinder could be raised very slightly so that only the grain, and not the cylinder was sliding on the surface.

[a] Lorenzen, R.T. 1959. Moisture effect on friction coefficients of small grains. ASAE Paper no. 59-416. Amer. Soc. Agric. Eng., St. Joseph, Michigan.

[b] Buelow, F.H. 1961. Determination of friction coefficients of materials handled on the farm. ASAE Paper no. 61-882. Amer. Soc. Agric. Eng., St. Joseph, Michigan.

The literature review disclosed that moisture content of the seed has a significant effect on friction coefficient. To prevent changes in the surface-moisture content of the seeds, the tests were run under conditions of controlled temperature and humidity. The relative humidity necessary to maintain equilibrium conditions for various moisture contents was determined from published equilibrium moisture data (4, 5).

The moisture content of the grain to be tested was adjusted by adding water, mixing the sample continuously for 24 h, and then allowing it to stand for at least another 24 h before testing. Some difficulty was encountered when rewetting flax in this manner, as the flax would tend to stick together in clumps. The problem was overcome by allowing the required amount of water to soak into a cloth. This cloth was then placed in the sealed mixer with the flaxseeds. Moisture content of the samples was measured with a Halross Model 919 electric moisture meter. Several samples were oven-dried to check the calibration.

Preliminary tests were made using a range of velocities and some variation in normal force. These tests confirmed the reports of other investigators, in that within a broad range, the value of the friction coefficient is not dependent on velocity or normal force. Therefore a velocity of 0.8 inches/min (2.8 cm/min) and a pressure of 0.7 psi (4.8 kPa) were used for all subsequent tests.

For a particular seed-moisture content, the test room was conditioned to the corresponding relative humidity and tests were run on all the surfaces for that moisture content. Each test was repeated three times but for each repetition the cylinder was emptied and refilled with fresh seed.

Four moisture levels covering the range of values likely to be found in stored seed were used. For flaxseed these were 7.4, 8.6, 9.7, and 11.4% whereas for rapeseed they were 7.2, 8.7, 10.0, and

12.5%. All moisture contents are stated on the wet-weight basis. The corresponding equilibrium relative humidities at 75°F (23°C) were 55, 65, 72, and 80%. The moisture contents of the two grains were slightly different so that the same relative humidity could be used in the test chamber for two sets of tests.

Rapeseed used for the tests was of the Echo variety, an Argentine type, while the flaxseed was of the Redwood 65 variety.

RESULTS AND DISCUSSION

A tracing of the typical output of the force transducer is shown in Figure 1. Appreciable variation in the force required to cause motion at the very slow speed is apparent. Sliding appeared to proceed in a stick-slip-fashion with the maximum value occurring after some sliding had taken place. The same general trend occurred in all tests but the amount of oscillation in the output varied with the surface being tested. The peaks of the curves were taken as the static friction values; the valleys would be more representative of kinetic friction. The maximum value of the force curve was established visually by the same individual for all tests. Variation in the three repetitions was generally less that 3% of the mean value.

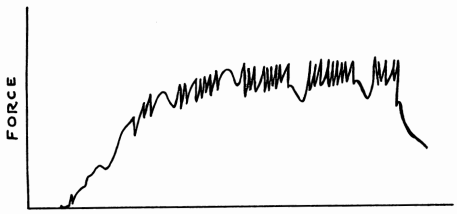

Figure 1. Typical output of force transducer.

Values of the coefficient of friction of the two grains at four moisture levels on seven surfaces are given in Tables I and II. As might be expected, the results show higher coefficients for the rougher surfaces such as concrete and plywood than they do for smoother surfaces such as teflon and galvanized steel. Douglas-fir plywood, G1S grade was used for the tests. The results also show distinct differences between rapeseed and flaxseed. Change in moisture content has a pronounced effect on the friction coefficient of flaxseed on wood and concrete. Values for rapeseed are affected but to a much lesser extent. For intermediate values of moisture, coefficients for flaxseed and rapeseed are approximately the same except in the case of teflon, which gave much lower values for flax than for rape.

There are a number of possible explanations for the differences between the two grains. The seeds are distinctly different in shape, rapeseed being almost spherical whereas flaxseed is shaped like a flattened speedboat. Rapeseed thus might roll where flaxseed would not. On rough-textured surfaces, rolling might occur in rapeseed at a layer one or two seeds from the surface. That is, the friction force measured might actually be the internal friction due to some combination of rolling and sliding. Measured values of the angle of rupture for the two seeds are only slightly different but the difference in shape could very well be the reason for the difference in results obtained. Another explanation is the difference in the nature of the surface of the two seeds. The seedcoat on rapeseed does not change greatly with increased moisture content, whereas flaxseed becomes obviously sticky when damp. This could explain the difference in values at high moisture content on concrete and plywood.

There is also an obvious difference in the effect of moisture on different surfaces. The friction coefficient on plywood increases considerably with an increase in moisture content whereas on galvanized steel this did not occur. It seems probable that the change in moisture content of the plywood produced this, as much as the change in moisture content of the seeds.

In comparing these results to those obtained by Brubaker and Pos (2), it is obvious that friction coefficients for rapeseed and flaxseed are considerably lower than they are for cereal grains, shelled corn or soybeans, particularly for wood and concrete surfaces. Lateral pressures in deep bins of rapeseed are therefore likely to be much higher than in similar bins of wheat, particularly if the bins are of concrete or timber.

TABLE I COEFFICIENTS OF FRICTION OF FLAXSEED ON VARIOUS SURFACES

		Surface material						
Moisture content (% WB)†	RH (%)	Galvanized Steel	Teflon	Plywood: perpendicular to grain	Plywood: parallel to grain	Polyethylene on plywood	Concrete: wood float	Concrete: steel trowel
7.4	55	.22	.14	.18	.18	.25	.25	.26
8.6	65	.23	.12	.34	.35	.26	.29	.36
9.7	72	.22	.16	.37	.36	.27	.35	.44
11.4	80	.25	.16	.43	.43	.26	.46	.53

† WB = wet basis.

TABLE II COEFFICIENTS OF FRICTION OF RAPESEED ON VARIOUS SURFACES

		Surface material						
Moisture content (% WB)†	RH (%)	Galvanized steel	Teflon	Plywood: perpendicular to grain	Plywood: parallel to grain	Polyethylene on plywood	Concrete: wood float	Concrete: steel trowel
7.2	55	.25	.19	.36	.35	.27	.28	.28
8.7	65	.20	.27	.34	.33	.28	.34	.34
10.0	72	.23	.28	.35	.35	.31	.36	.35
12.5	80	.23	.20	.36	.37	.25	.38	.36

† WB = wet basis.

SUMMARY

Static coefficients of friction were determined for flaxseed and rapeseed on seven surface materials. Within broad limits, coefficients were not affected by normal force and velocity. Increases in moisture content had little effect on the friction coefficients of these seeds on galvanized steel, polyethylene, or teflon, but on plywood and concrete increased moisture content caused an increase in friction coefficient, particularly with flaxseed.

Published data for cereal grains show that on galvanized steel surfaces there is little difference between the coefficients for rapeseed, flaxseed, wheat or barley. However, on concrete surfaces, the coefficient for rapeseed is much lower than it is for wheat. This could produce considerably higher pressures in deep concrete bins of stored rapeseed than in similar bins of wheat.

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REFERENCES

1. Balis, J.S. 1961. Methodology on the determination of friction coefficients of agricultural materials. Unpublished M.S. Thesis, Library, Purdue University, Lafayette, Indiana.

2. Brubaker, J.E. and J. Pos. 1965. Determining static coefficients of friction of grains on structural surfaces. Trans. Amer. Soc. Agric. Eng. 8(1): 53-55.

3. Hardy, Sir W.B. 1936. Collected works. Cambridge University Press.

4. Larmour, R.K., H.R. Sallans, and B.M. Craig. 1944. Hygroscopic equilibrium of sunflower seed, flaxseed and soybeans. Can. J. Res. F22: 1-8.

5. Pichler, J.H. 1957. Sorption isotherms for grain and rape. J. Agric. Eng. Res. 2: 159-165.

6. Richter, D.W. 1954. Friction coefficients of some agricultural materials. Agric. Eng. 35(6): 411-413.

7. Stewart, B.R., Q.A. Hossain, and O.R. Kunze. 1969. Friction coefficients of sorghum grain on steel, teflon, and concrete surfaces. Trans. Amer. Soc. Agric. Eng. 12(3): 415-418.