STUDY OF FACTORS INFLUENCING THE SOLID PARTICLES ON A FLAT INCLINED SURFACE

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Abstract: This article presents a study on how to determine the coefficient of friction of solids. Experimental measurements were made on a laboratory bench experimental work using the surface materials used in a block of the site that the braided wire mesh with mesh size variable.
Following the experimental measurements there is a proportional variation between the coefficient of friction and mesh size sieve. It also shows that for the same batch of particles coefficient of variation of friction coefficient has values in the range 8.62 ÷ 12.24%.

Keywords: solid particle, friction coefficient

1. INTRODUCTION

A mixture of particles obtained in agriculture or industry is made of components with different properties that form a heterogeneous mixture or a heterogeneous type SS.

Heterogeneous mixtures generally consist of two or more phases with different physical properties, well defined, leading to the appearance of surface separation in the mixture, and separation of these phases can be achieved through several methods: mechanical separation, chemical separation, electrical isolation, separation, ultrasonic, magnetic separation etc. Depending on the nature of the mixture of particles and its properties one can choose the appropriate separation method [1].

The most used method of differentiation is the separation of heterogeneous mixtures by means of a flat swing, provided with holes of different shapes and sizes, which aims to differentiate the width and thickness of the particle fractions of heterogeneous mixture.

Separation of the flat particle mixtures is influenced by many factors, and the most important are [2]:

a) sieve:
- loading sieve;
- mesh size;
- hole sieve size;
- regime cinematic (motion) of the site;

b) for the material to be sorted:
- size composition of the material to be sorted;
- the difference between particle sizes that it is sorted;
- nature of the particles that are sorted;

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- humidity of the particles etc.

Theoretically analyzed, the particle size separation process comprises two phases [1]:

• first phase: small particles pass through the thickness of the particles on the sieve, sieve surface reaching so the mixture gets stratification;

• second phase: particles smaller than sieve opening size passing through the sieve holes, this phase represents the actual separation.

The two-phases of the separation occur due to the movement of the sieve and / or its inclination. To achieve the separation process on sieves, the particle must move on the work surface thus giving rise to friction between the two elements (solid particle and work surface) [3]. Besides the above factors we must consider this present friction and the respectively friction coefficient.

2. THEORETICAL CONSIDERATIONS

The angle of flow of a mixture of different particles on the surface grading is the angle that a certain surface, which is a particle of the, should be inclined, for it to slide or roll. The value of this angle depends on the coefficient of friction between particles and that surface which is also called external friction.

Particle will move the plane if the condition is met (Figure 1):

$$G \cdot \sin\alpha - F_f > 0 \tag{1}$$

where: G is the represents the gravitation force of the particle; α is the inclination angle of the working surface; F_f is the friction force between the work surface and the particle.

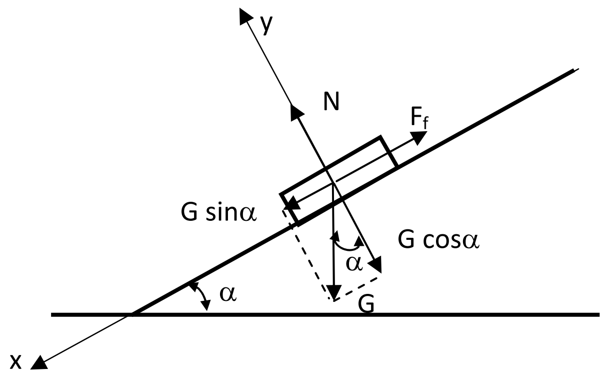


Fig. 1. Inclined plan for determining the friction angle [4, 5].

The friction force will be determined by the relation [4]:

$$F_f = \mu \cdot N \tag{2}$$

where: N is the represents the normal pressing force and μ is the friction coefficient between particle and the working surface.

But:

$$N = G \cdot \cos\alpha \tag{3}$$

Replacing relations (2) and (3) in relation (1), results:

$$G \cdot \sin\alpha - \mu \cdot G \cdot \cos\alpha > 0 \tag{4}$$

$$\sin\alpha > \mu \cdot \cos\alpha \quad (5)$$

$$tg\alpha > \mu \quad (6)$$

$$\mu = tg\varphi \quad (7)$$

where φ is the corresponding friction angle.

Replacing relation (7) in relation (6) one can get:

$$tg\alpha > tg\varphi \quad (8)$$

$$\alpha > \varphi \quad (9)$$

Relationship (9) shows that the particle slides on the inclined plane under the action of its own weight. Particles on an inclined plane will move at different speeds depending on the angle of friction between particles and the inclined plane, i.e.: particles with larger external friction angle will move slower and vice versa.

3. MATERIALS AND METHODS

To determine the coefficient of friction between solid particle and mesh there was used only one type of particle, respectively beans (large grain) and three types of surfaces, which are braided wire sieves having side mesh: L1 = 4.6 mm , L2 = 3.4 mm, L3 = 2.6 mm (Figure 2).

a) b) c)

Fig. 2. Types of sieves used for the experiments:
a) sieve having L=4.6; b) sieve having L=3.4; c) sieve having L=2.6.

Of total mass of solid particles there has been chosen a batch consisting of 20 particles, for which there has been determined the following characteristics:

- length L (mm);
- width L (mm);
- thickness, g (mm);
- particle mass, m (g).

For this batch of particles it has been determined the sphere with the help of the relation [6-10]:

$$\Phi_s = \sqrt[3]{\frac{L \cdot l \cdot g}{L^3}} \quad (10)$$

in which

L, l and g represents the dimensions of the solid particles;

Table 1 presents the values obtained for the above mentioned characteristics.

Table 1. The characteristics of the solid particles.

Current no.	Particle no.	The characteristics of the studied particles				
		Dimensions [mm]			Mass [g]	Sphere Φ
		L	l	g		
1.	1	19.80	13.10	8.40	1.17	0.654747
2.	2	19.50	13.00	10.40	1.36	0.708439
3.	3	19.80	13.10	8.40	1.13	0.652489
4.	4	18.50	13.00	9.00	1.22	0.69922
5.	5	18.80	13.10	8.50	1.12	0.680443
6.	6	18.20	12.90	8.20	1.17	0.683524
7.	7	20.50	14.00	7.70	1.21	0.635385
8.	8	18.50	13.00	9.60	1.30	0.714426
9.	9	18.40	12.40	8.70	1.07	0.683023
10.	10	18.70	12.50	8.70	1.13	0.677509
11.	11	19.62	13.88	7.34	0.97	0.642041
12.	12	16.74	13.00	9.12	1.11	0.750716
13.	13	19.62	13.24	8.43	1.17	0.66187
14.	14	20.00	9.46	8.16	1.28	0.577884
15.	15	18.68	7.90	8.46	1.19	0.576432
16.	16	17.68	12.64	7.58	1.21	0.674244
17.	17	18.20	13.46	8.10	1.10	0.690445
18.	18	17.50	8.36	8.70	0.98	0.619274
19.	19	20.60	13.80	8.38	1.06	0.64833
20.	20	21.54	14.24	9.58	1.11	0.664959

Another method used to identify the shape of solid particles in the experimental determinations lot that was conceived in 1958 by Sneed and Folk [2, 11, 12], which requires some correlation between the dimensional characteristics of a particle. Thus, in Figure 3, can be seen falling in class each particle of the lot chosen.

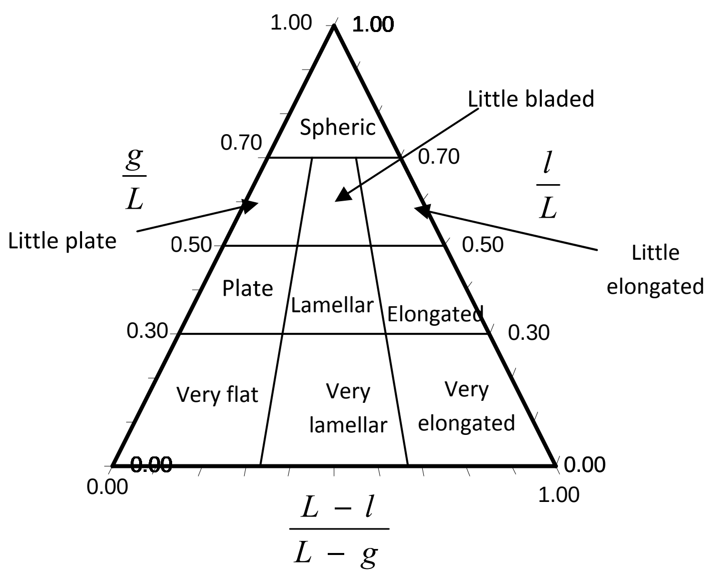


Fig. 3. Identification of solid particle correlations in form depending on its dimensions between its elements Sneed and Folk.

Thus, our particles according to their size, one will obtain the representation in Figure 4.

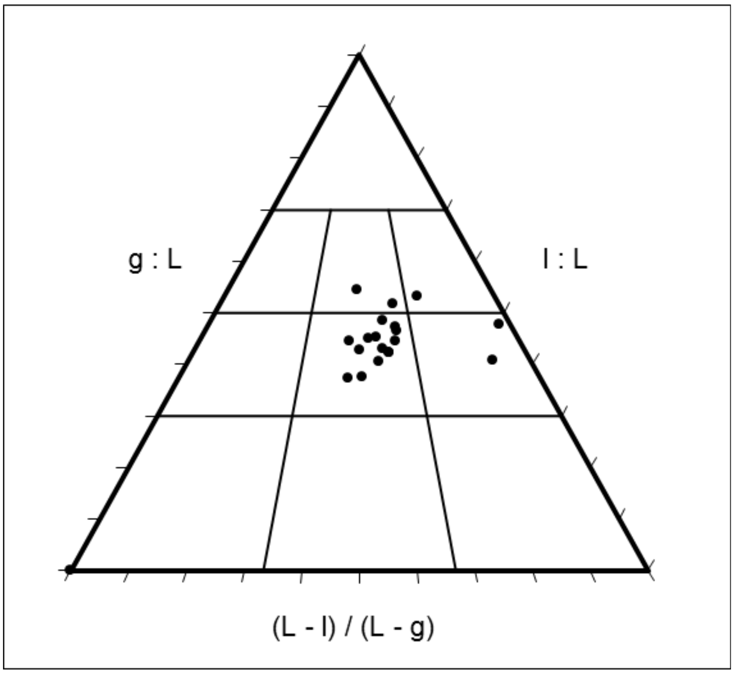


Fig. 4. The characterization of the bean particles shape (big grain).

In order to determine the friction coefficient there was used a laboratory stall presented in Figure 5.

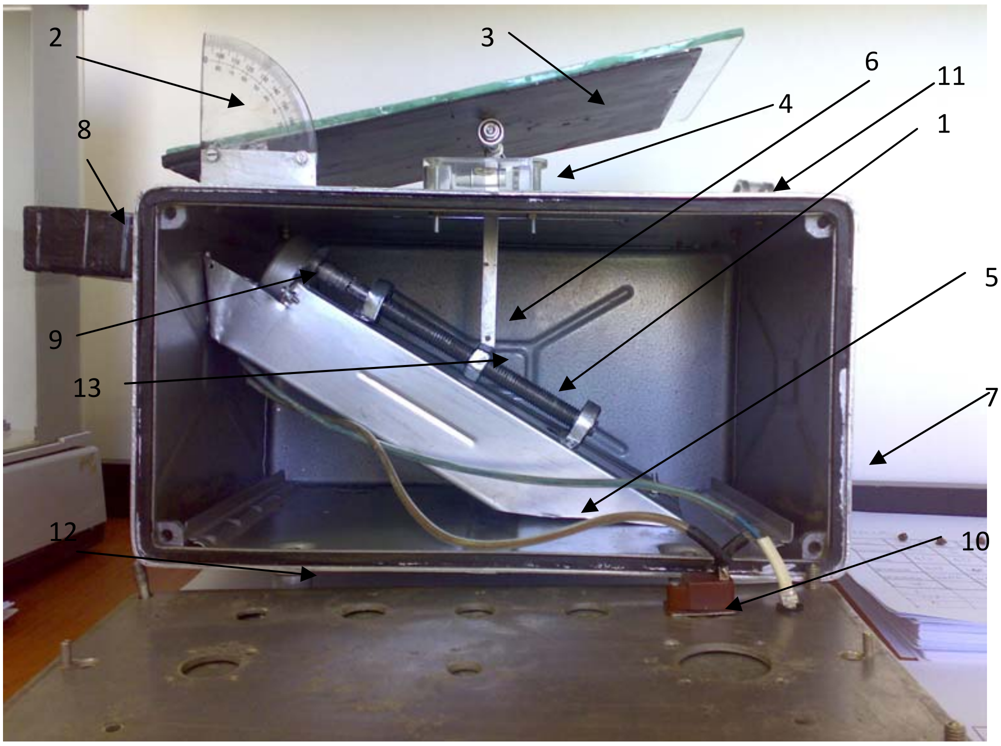
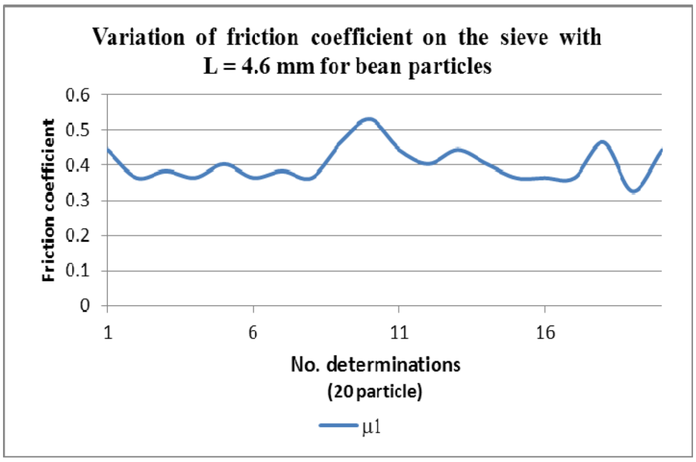


Fig. 5. Working stall for determining the friction angle:
1 – screw; 2 – rapporteur; 3 - work surface; 4 – level device; 5 – metal support; 6 - metallic rod; 7 - cabinet stand; 8 - collection box; 9 - electric motor; 10 - start – stopping switch; 11 – level device.

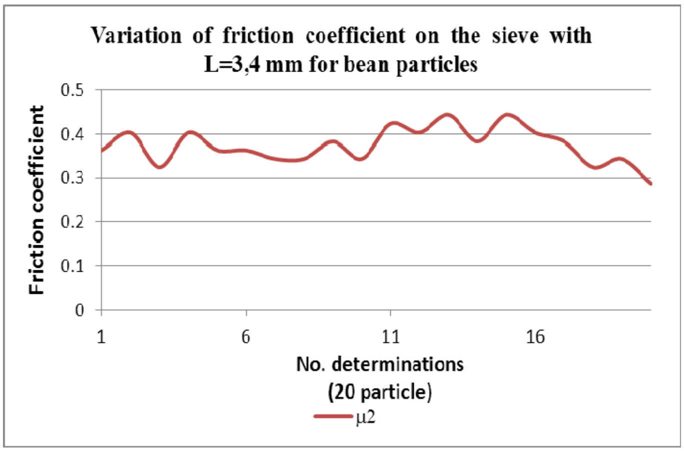
How to determine the angle of friction, the friction coefficient involves changing the angle of inclination of the work surface to the horizontal plane using a travel system and reading the value of solid particle unbalance angle when at rest on work surface.

4. EXPERIMENTAL RESULTS

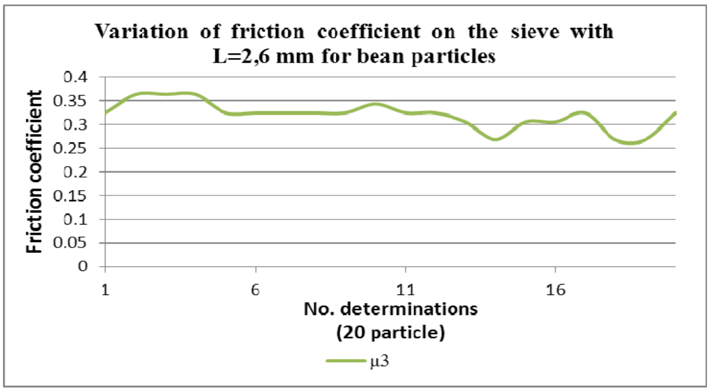
Following the experimental measurements it could be represented the friction coefficient for each particle studied, taking into account the work surfaces (Figure 6. a, b, c).



a)



b)



c)

Fig. 6. Graphical representation of the variation coefficient of friction between particles and site: a) mesh with L = 4.6; b) mesh with L = 3.4; c) mesh with L = 2.6.

To find out the degree of variation of coefficient of friction between particles and the site will calculate the coefficient of variation (v) of it, which is the ratio of standard deviation and the mean of the series. It is usually expressed as a percentage.

The coefficient of the calculation variation is done by the relationship [13]:

$$\nu = \frac{\sigma}{\mu} \cdot 100 \qquad (11)$$

where: ν is the coefficient of variation; σ is the square average deviation; μ is the average coefficient of friction.

The square average deviation of the coefficient of friction is calculated by the relationship [13]:

$$\sigma = \sqrt{\frac{\sum \left(\mu_i - \overline{\mu}\right)^2}{n}} \qquad (i=1, 2, ... 20) \qquad (12)$$

where: μ_i is the coefficient of friction and corresponding particle and n is the number of particles that determine the standard deviation (in our case n = 20).

The coefficient of variation can take values from zero. The lower value is, the particular group is more homogeneous and therefore more representative series. It is considered that if a coefficient of more than 35 - 40 %, is not a representative series, and data must be separate components in series, groups, depending on the variation of other characteristics of the group [13].

The coefficient of variation of coefficient of friction determined for each sieve is represented in Figure 7.

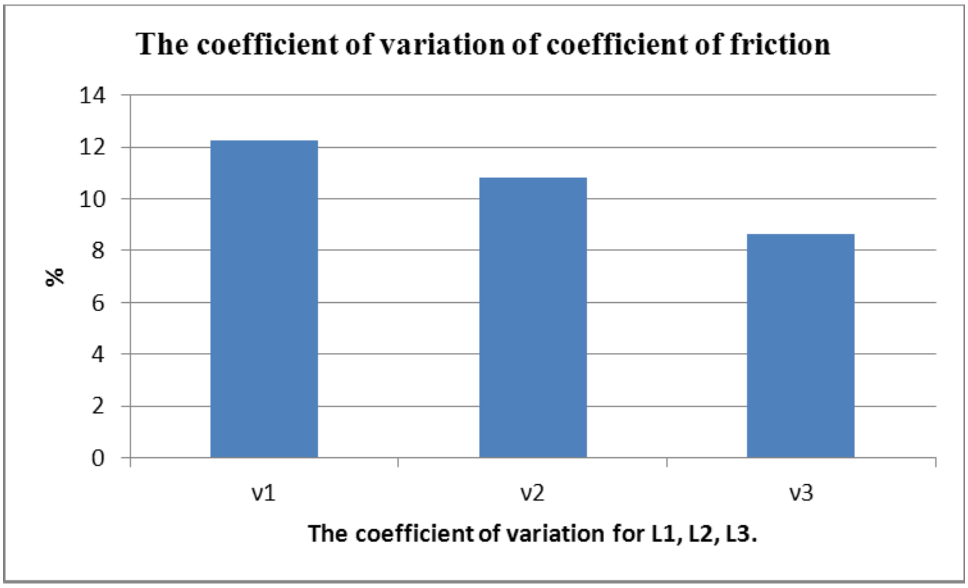


Fig. 7. Graphical representation of the coefficient of the variation of the friction coefficient.

The coefficient of variation of friction coefficient has a value of 12.24 % for L1 = 4.6 mm sieve, 10.82 % for L2 = 3.4 mm sieve and sieve with 8.65 % for L3 = 2.6 mm. So, the batch of particles studied is homogeneous in terms of specific characteristics.

5. CONCLUSIONS

After analyzing the experimental results the following conclusions can be drawn:
1. the mixture of solid particles consists of real property with different components in this way forming a heterogeneous mixture;
2. to separate a heterogeneous mixture one can use different methods taking into account the characteristics which distinguish the components;
3. the friction coefficient is influenced by the work surface on which it is realized the economic process of separation;
4. the process of separating a mixture of particles by their size, in addition to operating mode of the block site and the nature of the material to be separation, is influenced by the coefficient of friction between particle and work surface.
5. to determine the coefficient of friction there are used experimental stands for determining the friction angle.
6. between the values obtained of the coefficient of friction and dimensional features (L, l, g) and the spherical mass there could not be determined a correlation.
7. with the same type of particles on the same area it is obtained a friction coefficient variation of 12.24 to 8.65 %. this results in a negative yield of separation.
8. the different friction coefficients for the same type of particles and on the same surface particles are a result of the non-uniformity of the real target bean grain. For the ideal particle this friction coefficient variation is very small or zero.
9. between the values obtained of the coefficient of friction and the work surface characteristics there is a close interdependence also due to the size of the side eyes of the sieve. The eye side sieve is greater the variation in the coefficient of friction is greater because the particles can lodge in the sieve eye. It is therefore necessary that the eye side sieve be close to the size of particles to be separated from the rest of the lot.

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