ASPECTS REGARDING THE FRICTION PROCESS OF THE OPERATING PARTS OF A DRAWER TYPE PULSATOR OF OWN CONCEPTION

C-tin Chirilă[1*], R. Roşca[1]

[1]*University of Agricultural Sciences and Veterinary Medicine from Iasi, Romania*

Abstract

The paper presents the results of tests performed in order to evaluate the friction coefficient of the sliding operating parts for a drawer-type, electromagnetic pulsator, own conception. The evaluation of the friction coefficients allows the proper sizing of the electromagnetic pulsator coils. The tests were performed on two drawer-type operating parts, built from different materials. During the tests the pressure was set at a level of 0.05 MPa. Calculation of the normal force over the slider and measurement of the friction force allowed the evaluation of the real the value of the sliding friction coefficient. The tests led to the conclusion that the lower values of the friction coefficient were recorded by the operating parts containing bronze plates and Teflon sliders.

Key words: milking equipments; pulsators

INTRODUCTION

The proper functioning of the pulsators, equipping milking equipments is conditioned by the way their active operating parts work.

Their reliability is influenced by the materials used in their construction.

Taking into account the operating parts of the pulsators are moving parts frictional forces appear, which must be counterbalanced by the command elements.

For the case of the analyzed prototype pulsator (electromagnetic type) the friction forces must be counterbalanced by electromagnets and the coefficients of friction of the materials used in their manufacture must be evaluated.

Generally the friction surface of the operating parts is not smooth, but is characterized by a series of small asperities (roughness) occurring as a result of processing operations.

For the same type of material the friction coefficient may have different values, values which are affected by the processing degree of the surfaces in contact.

Several papers [3], [4], [5] present the range of the friction coefficient values for different materials used in the manufacturing process of the operating parts of the pulsator.

In order to properly size the coils of the electromagnetic pulsator in the present paper the real friction coefficients of the pulsator working parts were evaluated during the operating process.

MATERIALS AND METHOD

The prototype pulsator [2] has drawer-type operating parts (Figure 1) and is electromagnetically actuated. The electromagnetic actuation allows the achievement of different pulsation ratios.

By means of two electromagnets the drawer gets a reciprocating motion, over the plate, between two extreme positions.

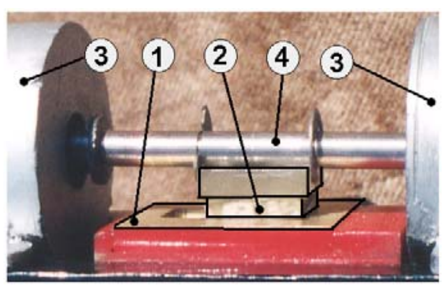

Figure 1 Operating parts of drawer type prototype pulsator
1 – plate; 2 – drawer; 3 – electromagnets; 4 – rod

*Corresponding author: chirilac@uaiasi.ro
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A friction force appears due to the contact between the drawer and the plate; the friction force F_f depends on normal force F_n produced by the operating pressure (Figure 2).

During the tests the vacuum system of a mechanical milking machine was used in order to obtain the normal force.

The working pressure was adjusted to a value of 0,05MPa (value recorded before the vacuum regulator). This pressure should normally be comprised between 0.038 and 0,048 MPa, but the above mentioned maximum value was chosen in order to simulate the most unfavourable situation that could occur in terms of friction force between the operating parts of the pulsator.

The bodies contained the contact surfaces (plate and drawer), subjected to the relative sliding movement, form the friction coupling [4].

The dry type friction between the plate and the drawer is characterized by the direct contact between the friction surfaces, without any intermediate lubricant film.

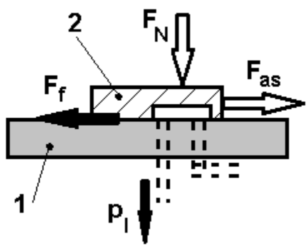

Figure 2
F_f – friction force; F_N – normal force; F_{as} – force acting drawer 1 – plate; 2 - drawer;

Dry friction creates coefficients of friction with large values and is affected by a number of factors: load size, roughness size, and the pair of materials constituting the friction coupling.

The sliding friction force that occurs as a result of the movement of drawer over the plate was called dynamic. When the sliding speed of the drawer is null, the frictional force was called static.

Sliding friction force is not influenced by the size of the contact surface.

The sliding friction coefficient, μ_{fa}, is dimensionless and it can be calculated as the ratio between the sliding friction force, F_{fa}, and the normal force over the motion surface, F_N:

$$\mu_{fa} = F_{fa}/F_N$$

The dry sliding friction coefficient depends on the nature of the parts into contact, their speed, size, temperature, surface conditions.

During the tests two types of operating parts (plate-drawer) were used for the prototype pulsator.

The plates were made of bronze for type 1 and also of bronze or Teflon for type 2. The two types of plates are different with respect to the placement of the connecting ports (for continuous vacuum, intermittent vacuum and atmospheric air - Figure 3).

Drawers were also manufactured from Teflon, in two versions, Type 1 and Type 2. The two types of drawers are different with respect to the size of the alveoli (Figure 4).

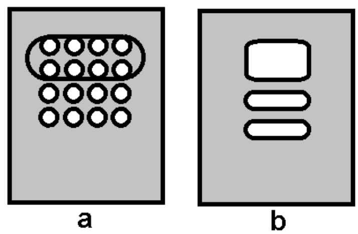

Figure 3 Plates
a –Type 1; b – Type 2

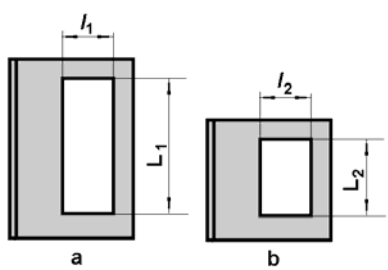

Figure 4 Drawers
a –Type 1; b – Type 2 [4]

The type 1 plate operates together with the type 1 drawer and the type 2 plate operates with the type 2 drawer.

During the tests the values of the force values for which the drawer starts to move over the plate [4], simulating real working conditions. This is the force that overcomes of the sliding friction force.

It may be considered that these two forces have equal values but are opposite. This force values for which the drawer starts moving over the plate can be used to calculate the sliding friction coefficient.

RESULTS AND DISCUSSION

In order to obtain the value of the sliding friction coefficient, it was necessary to evaluate the values of the normal force F_N and of the sliding friction force, F_{fa}.

Normal force, F_N, is dependent on the pulsator working pressure, p_l, and sectional area of alveoli, parallel to the supporting surface of the drawer, A_s.

$$F_N = p_l \cdot A_s \text{ [N]}$$

where:
- $A_s = L \cdot l$ [m^2];
- L is the length of alveoli [m];
- l is the width of alveoli [m].

The values of the normal force, F_N, depending on the type of the drawer used are presented in table 1.

The sliding friction force was determined using a proprietary measuring device [1]. The device allows the connection of the operating parts of the pulsator pressure to the vacuum pipe. The prescribed value of the pressure during testing was obtained by changing the settings to the vacuum regulator.

Table 2 presents the values of the sliding friction force, F_{fa}, depending on the type of operating parts used and on the material used in their construction.

Table 1 The values of the normal force, F_N, depending on the drawer type used

No.	Drawer type	Alveolus length [mm]	Alveolus width [mm]	Sectional area of the alveoli [mm^2]	Normal force, F_N [N]
1	I	19	8	152	7.6
2	II	11	8	88	4.4

Table 2 Values for the sliding friction force, F_{fa}, and the sliding friction coefficient value μ_{fa}, depending on the type of operating parts and the materials used in their construction

No.	Plate type	Plate material	Drawer type	Drawer material	Sliding friction force, F_{fa} [N]	Sliding friction coefficient, μ_{fa}
1	I	bronze	I	acrylic glass	4.13	0.57
2	I	bronze	I	**textile laminate**	2.84	0.37
3	I	bronze	I	aluminium	3.45	0.45
4	I	bronze	I	Teflon	1.59	0.21
5	II	bronze	II	Teflon	1.20	0.27
6	I	Teflon	II	Teflon	1.39	0.31

Knowing the values of the two forces it was possible to calculate the sliding friction coefficient, μ_{fa}, for the two types of active parts (Table 2).

It was noted that the lowest value of the sliding friction coefficient was obtained when the drawer was made of Teflon and the plate was made of bronze.

The highest value of this coefficient (double compared to the previous case) was obtained when the drawer was made of acrylic glass and the plate was made of bronze.

Although both acrylic glass and Teflon are plastic materials, there were significant differences between the values of the sliding friction coefficients.

Small differences were recorded between the values of the sliding friction coefficients for the two types of Teflon drawers moving over the respective bronze plates because of the manufacturing process and of the precision of measuring device which was used.

CONCLUSIONS

1. The tests proved that the most favourable solution imposes the use of type I operating parts (bronze plate and Teflon drawer).
2. The lowest values of the sliding friction coefficient were recorded for the type I operating parts.
3. The values of the sliding friction coefficient are placed towards the upper limit accepted by the specialized literature [3], [4].
4. The use of the type I operating parts has the potential to downsize the coils of the electromagnetic pulsator due to the lower values of the operating forces involved.

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