ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2004, Tome II, Fascicole 1

DYNAMICS OF THE DISPLACEMENTS BY VIBRATIONS ON PLANE SIEVES

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Abstract:

The separation operation of different materials at a large range of machines is effected thanks to the vibration of the working element. The separation operation is analyzed with the help of the model of particle what executes displacements by vibrations on a rough plane. Displacement regimes of the particle are studied, by forward and backsliding and by detachment. Because of the velocity discontinuity what appears as a result of the friction between the particle and plane or of the fall on the plane in the case of detachment, vibro-impacting motion regimes appear. In consequence, for the motion study, the well-known methods are applied, concerning the study of vibro-impacting regimes.

The obtained results are in concordance with the experimental data, obtained on the machines what generate displacements by vibrations. At each machine, series of measurements were performed, in different points and different working conditions.

Keywords:

motion, plane sieves, sliding regimes, vibrations

1. INTRODUCTION

The dynamic study of the separation processes, effected by the material displacement, in the presence of friction on the surfaces of plane sieves, is developed on the basis of the two mass model in contact with friction [1] - [3].

It must underline that in a lot of processes, based on vibrational displacements, can also appear, motions with detachments and falls of the particle on the vibrating plane. This kind of regimes are vibro-impacting phenomena and form an up-to-date field [4] - [5]. Initially, only vibrational displacements with sliding on the vibrating plane are taken into account; these ones have vibro-impacting character, because of the discontinuity of the friction force.

In a series of anterior papers [6] - [7], new models and study methods were conceived for the determination of motion regimes with impacts and important conclusions were established. This paper represents a trial of solution of the problem of the vibrational displacements in the presence only of the sliding with friction.

2. SLIDING REGIMES

In the study of the plane sieves, driven by a generated kinematic drive, the motion of the particle on the plane in the presence of friction and also the motion with detachments and impacts at fall were analysed. It is important to underline that in both the situations, motions with velocity discontinuities appear; for these motions, the general methods of vibration theory are not applicable.

As example it is in detail treated the case of the motion of the particle on an inclined plane of angle α in relation to the horizontal, what executes a translation motion, u(t)=r sinωt, on the direction making the angle β with the horizontal. It is supposed that the particle executes a relative sliding motion on the plane, forward in relation to the plane.

As a rule, at a certain moment, the particle begins to slide on the plane, from the repose position, forward or back. The moment when the forward sliding begins is noted by t_1 and, consequently, $\psi_1=\omega t_1$, and for the beginning of the back sliding, by t_2 and, consequently, $\psi_2=\omega t_2$. It is specified that these moments correspond to the condition that the acceleration $\ddot{x}$ to be null. If the expression of the acceleration is annulled, for the initial moments of the sliding motion are obtained the equations

$$\sin\psi_{1,2} = \frac{g}{r\omega^2}\cdot\frac{\sin(\alpha\pm\varphi)}{\cos(\beta\mp\varphi)} \qquad (1)$$

where the first sign corresponds to the forward sliding and the other one, to the back sliding.

From these relations, there are determined the parameters ψ_1 and ψ_2, respectively t_1 and t_2 what determine the beginning moments of the sliding motions, from the repose position.

Because that for the determination of the angles ψ'_1 and ψ'_2, the equation has the same form, the solution can be simultaneously made. As consequence, in order to describe the initial and final moments of sliding, the variables ψ'=ωt', can be considered.

Taking into account that the sliding regime ceases at the moment t=t' what corresponds to the annulment of the relative velocity, that is to say $\dot{x}=0$, it is deduced the equation.

$$\sin\psi = \frac{\cos\psi' - \cos\psi}{\psi' - \psi} \qquad (2)$$

Diagram from fig.1 illustrates the dependence ψ'= ψ'(ψ) according to the relation (2).

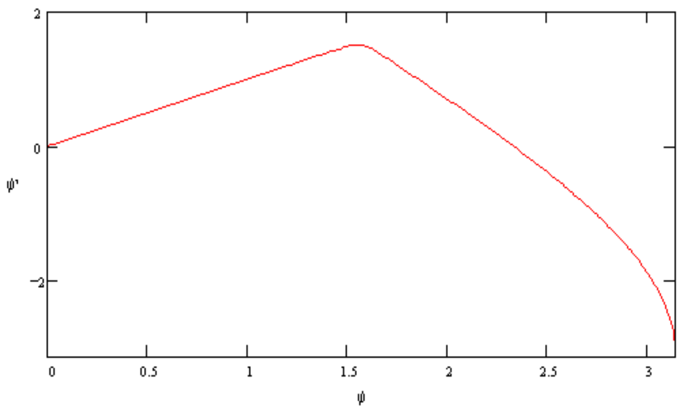

Fig.1

This equation permits the calculus of the quantity ψ', consequently of the moment t=t', corresponding to the ceasing of sliding.

Taking account of the equations (2) for the calculus of ψ', the displacement is

$$s = \frac{r\cos(\beta \mp \varphi)}{\cos\varphi}\Phi(\psi) \qquad (3)$$

where it is used the notation

$$\Phi(\psi) = \sin\psi - \sin\psi' + \frac{\psi' - \psi}{2}(\cos\psi + \cos\psi') \qquad (4)$$

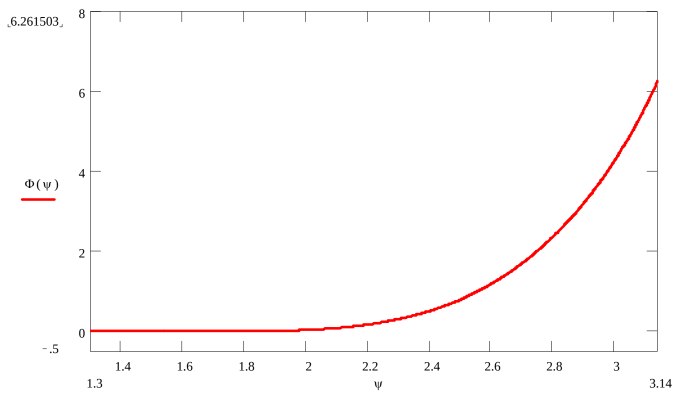

Fig.2

The function Φ(ψ) given by (4) is represented in fig.2 for ψ∈(0,π).

The plotting of absolute velocity v and velocity of transport v_1 and, also, of the displacement $s_1 u\cos\beta$, along the plane, together with the sliding s can be easily watched in the plotting of a cycle of the plane vibration.

3. DETERMINATION OF SLIDING MOTIONS

It is important to notice that the determination of regimes of sliding motions consists in the solution of the equation (2) and calculus of the function (4). This remark makes that the problem to be reduced oneself to the study of the function (4) of variable ψ, the variable ψ' being linked to ψ by the equation (2).

Concerning the equation (2), it can also make an important remark which simplifies the study; if ψ and ψ' are replaced by $\pi - \psi$ and $\pi - \psi'$ the equation (2) is also, verified. It means that the backsliding takes place in the same way as the forward sliding, that is to say it is necessary to resolve only one time this equation.

Evidently, the equation (2) has the trivial solution $\psi' = \psi$ what corresponds to the beginning of sliding.

In fact, it is of interest only the solution $\psi' \neq \psi$ $(\psi' > \psi)$ what determines the end of sliding.

Without resolving the equation (2), it can consider the implicit function ψ'(ψ), which, by differentiation, conducts to the expression

$$\frac{d\psi'}{d\psi} = \frac{(\psi' - \psi)\cos\psi}{\sin\psi' - \sin\psi} \tag{5}$$

derivative whose sign depends of cos ψ.

A special importance has the function (4) for the calculus of relative displacements. Taking account of the equation (2), after a simple calculus, the function ɸ(ψ) can be written as

$$\Phi(\psi) = \frac{1}{2\sin\psi}(\sin\psi' - \sin\psi)^2 \tag{6}$$

what shows that the displacement given by the relation (3) is always positive.

The study of the function Φ(ψ) necessitates, also, the calculus of derivative, in order to define the mode of variation. If the equation (2) and derivative (5) are considered, it is obtained, by the differentiation of the function (6), the expression

$$\frac{d\Phi}{d\psi} = -\frac{1}{2}(\psi' - \psi)^2 \cos\psi \tag{7}$$

The sign of this derivative is determined by the quantity cos ψ. As consequence, the function Φ(ψ) is increasing for cos ψ >0 and decreasing for cos ψ < 0.

The characteristics, established for the functions ψ'(ψ) and Φ(ψ) permit the discussion of all possible situations, using the corresponding graphic plotting, too.

The determination of sliding motion regimes can be simply made, starting with the equation (1), from which it is deduced, and then, from the relations (1) and (4) or the corresponding diagrams, the quantities ψ' and then Φ(ψ) are deduced. In this way, for a motion cycle, the moments of sliding beginning and end are deduced and, also the value of the sliding displacement, in accordance with the relation (3).

After the determination of these quantities, it is easy to calculate the characteristic elements for the duration and velocity of the displacement on the vibrating sieves and the degree of separation or the productivity of vibrating sieves.

4. EXPERIMENTAL RESULTS CONCERNING THE WORK OF VIBRATING SIEVES

The separations of seeds from the heap on the sieves of the cleaning systems of the cereal-picker-combines or machines for seed cleaning and sorting, takes place thanks to the phenomenon of material stratification in its components what are separated according to the density, as well thanks to the sieving state of the material on the separation surface, produced by the sieve motion.

In order to verify the results obtained by theoretical study, experimental measurements were effected for the duration and velocity of displacement of the material on the surface of vibrating sieve, the degree of separation of the components from the mixture what is conditioned and the sieve productivity, as function of the kinematic parameters of the motion of cleaning system, respectively the number of rotations of the driving mechanism, the amplitude and frequency of vibrations.

In order to obtain edifying results, the experimental tests were effected in working conditions at self-driven cereal-picker-combines and machines for seed cleaning and sorting.

For the experimental tests, it was used the selector S-5 (fig.3 – where: 1-sieve frame, 2-top sieve, 3-bottom sieve, 4-springs, 5-shift with eccentric, 6-crank, 7-collecting trough) of the seed cleaning machine MCS-5/2,5, where the supply discharge and sieve inclination angle were modified.

The tests were effected with identical samples of wheat, resulted from the direct harvesting in field with the combines of the Didactic Station of Timişoara.

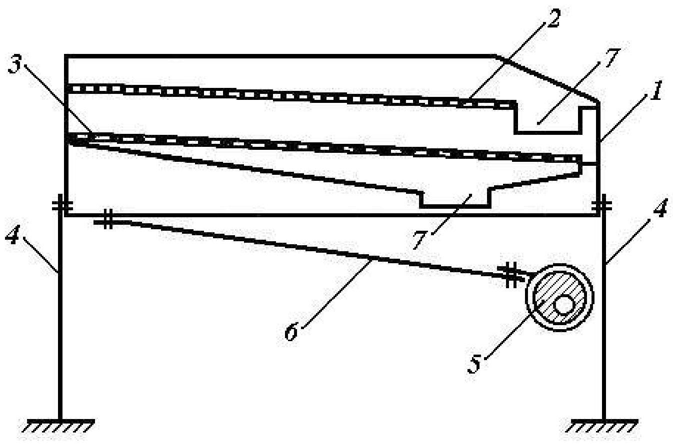

Fig.3. Driving mechanism of sieves

The material for an experimental test, having the mass of 25 Kg, was uniformly distributed on the supply sieve.

The results concerning the duration of displacement of the material sample and, also, the productivity and the separation degree of the material on the sieves, at the number of rotations of the shaft with eccentric of 410 rot/min, are centralized in the table 1.

Analysing the values, centralized in the table, the following remarks can be made:

- the duration of displacement of the seeds on the surface of the vibrating plane decreases with the increasing of the inclination angle of sieves and increases with the increasing of the supply discharge;
- the velocity of displacement of the seeds on the vibrating plane is so much bigger as the duration of displacement is more little and inversely;
- the purity of the cleaned material, given by the degree of separation of the mixture components is so much higher as the supply discharge is more little. The purity of selected material decreases with the increasing of inclination of the sieves. It must also mention the fact that the degree of separation inversely proportionally varies with the velocity of flowing, that is to say the purity of the selected material is so much more little as the velocity of displacement of seeds on the sieves is bigger;
- the productivity of sieves increases with the increasing of the velocity of displacement of the seeds on the sieves, the angle of inclination of sieves and, also, the supply discharge with material. It must notice that the purity of the selected material decreases with the increasing of productivity of the sieves.

The analysed situations are in concordance with the calculus, effected on the basis of the proposed dynamic model.

Table 1

Nr. crt.	Angle of inclination (degrees)	Supply descharge (Kg/s)	Number of rotations of driving shaft 410 rot/min			
			Duration of displacement (s)	Velocity of displacement (m/s)	Degree of separation (%)	Productivity (g/m^2s)
1	2	0,83	17,68	0,77	95,65	432
		1,11	23,11	0,59	93,70	540
		1,40	28,89	0,47	88,30	704
2	4	0,83	16,11	0,84	95,00	464
		1,11	21,36	0,63	91,80	584
		1,40	26,79	0,51	87,60	776
3	6	0,83	14,88	0,91	94,40	500
		1,11	19,96	0,68	90,10	624
		1,40	24,86	0,55	84,30	840
4	8	0,83	14,00	0,97	94,00	536
		1,11	18,73	0,72	87,50	664
		1,40	23,29	0,58	78,40	892

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