THE NUMERICAL FORMING OPERATION AND THE SIMULATION OF THE WORKING OF THE PEAS SORTING MACHINE

Gheorghe ABRUDAN, Mircea VERES
Universitate din Oradea

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Resume: The purpose of this study is to discover which one of the working systems is critical, regarding the vibrations; which one of the working systems is best for the sorting.

There may be working systems that provide a good sorting of the working material but, on the other hand, generate an increased level of vibration for the machine, as well as working systems that only generate low level of vibration for the machine, but they can't ensure a good sorting of the working material.[3]

So, the problem that needs to be solved consists in finding working systems that can satisfy both criteria, avoiding the field of critical vibrations, meanwhile ensuring a good sorting of the working material.

1. The purpose of the functional forming operation of the peas sorting machine

In order to analyze the working of the peas sorting machine, considering the vibrations generated by the strip conveyer it would be useful to accomplish their mathematic design. The mathematic design is the basis of the elaboration of the program simulating the working of the machine. In this way, with the help of simulation, different working systems and the vibrations generated for different values of the working parameters can be studied. The working of the strip conveyer implies a dynamic and not geometrical drawing (as the drums of the strip are not cylindrical), that is necessary for the process of peas sorting. The complete elimination of vibrations and shocks is not possible, because of the fact that the sorting process itself is based on this kind of functioning. [1], [2]

2. Elaborating the mathematical model

The transporting strip of the peas sorting machine is different from a conventional transporting strip because it carries out an oscillating movement and in the same time it moves forward in the direction given by the rotation of the drums.

The oscillating movement is due to the fact that the drums do not have a cylindrical shape, but consist in bars; that make up the edges of prisms with polygonal bases. In the practical construction, currently, three sided polygons are used as a base polygon for the leading drum, and four sided ones for the leaded drum. The difference between the numbers of sides for the two drums generates a specific oscillation movement that favorites the sorting of the peas beams from the pods and other impurities. Because of its polygonal shape the leaded drum will have o rotation movement with an oscillating character. The position at a given moment in time of a point on the surface of the strip is given by the position of the vertexes of the polygon.

The necessary elements for the calculating the speed of the leaded drum is given in picture 1. the mathematical value of this speed will determine, in the simulation program, the position of the point B. The AB segment represents the upper branch of the sorting strip and the angle ? is the angle formed by the strip with the drums' centers' axis. Angles a and ß are the angles of the radius r_a and r_b in the contact points of the drums with the strip A and B, considering the drums' centers' axis. To make the calculations easier, angles a_v and $ß_v$ as the angles between the tangents to point's a trajectory circle, respectively point B with AB segment.

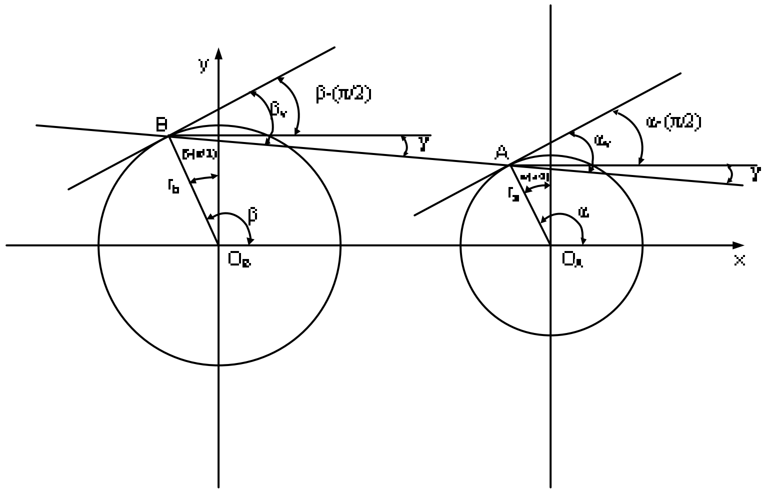


Fig.1

For the calculation of the angles a_v and $ß_v$ formulas have been inferred:

$$ß_v = ß \quad \frac{p}{2} + ? = (ß + ?) \quad \frac{p}{2} = \quad [\frac{p}{2} \quad (ß + ?)] \tag{1}$$

$$a_v = a \quad \frac{p}{2} + ? = (a + ?) \quad \frac{p}{2} = \quad [\frac{p}{2} \quad (a + ?)] \tag{2}$$

The angular speed of the leaded drum depending on the radius of the two drums, the angular speed of the leading drum, the angles of the radius with point A and B and the angle between the strip and the centers axis can be inferred from the scheme in picture 1.
The formula of the angular speed of the leaded drum is:

$$?_b = \frac{r_a \quad \cos a_v}{r_b \quad \cos ß_v} \quad ?_a \tag{3}$$

or:

$$?_b = \frac{r_a \quad \sin(a + ?)}{r_b \quad \sin(ß + ?)} \quad ?_a \tag{4}$$

The formula (4) is the basis for simulating the movement of point B, depending on the movement of point A. The formulas above are defined on time periods with a continuous variation, while calculation programs can as well be conceived only for a discreet variation of the parameters. This is the reason why the calculation formulas defined above have to be converted.
The simulation program of the way the sorting strip works also presents the calculation of the parameters that are studied in successive programs' cycles depending on periods of time and space.
The angular speeds of the leading and leaded drum, at a certain program cycle *"i"* can be expressed in their discreet form with the formulas:

$$??_{bi} = \frac{?ß_i}{?t} \tag{5}$$

$$??_{ai} = \frac{?a_i}{?t} \qquad (6)$$

The step of the leading drum’s rotation angle is:

$$?a_i = a_{i+1} \quad a_i = \text{const.} \qquad (7)$$

The mathematical value of the leaded drum’s angle is:

$$ß_{i+1} = ß_{i} + ?ß_i \qquad (8)$$

And the time step is:

$$?t = t_{i+1} \quad t_i \qquad (9)$$

For calculating the angular step of the leaded drum, the formula (4) is transcribed in a discreet shape:

$$\frac{?ß_i}{?t} = \frac{r_a \sin(a_i + ?_i)}{r_b \sin(ß_i + ?_i)} \quad \frac{?a}{?t} \qquad (10)$$

As the time step is constant, formula 10 can be transcribed:

$$?ß_i = \frac{r_a \sin(a_i + ?_i)}{r_b \sin(ß_i + ?_i)} \quad ?a \qquad (11)$$

Using the formulas (11) and (8) you can calculate the position of point B for the cycle *“i+1”* (given by the angle $ß_{i+1}$) depending on the position in the cycle “i”.

3. Determine the correlation of the sorting strip’s movement with the pea’s movement

The time interval between two consecutive cycles of the simulation program is given by the characteristics of the calculation system in which the program works (RAM memory, the microprocessor’s time, and the saving times for HD). In order to achieve, on the diagrams, the results of the real working of the sorting strip, a correlation has to be established between the size used in the simulation program and the real ones.

The size through which this correlation takes place is given by the number of simulation cycles that correspond to a second of real working of the strip. This number is *N* and has the formula:

$$N = \frac{2p \dfrac{n}{60}}{?a} \qquad (12)$$

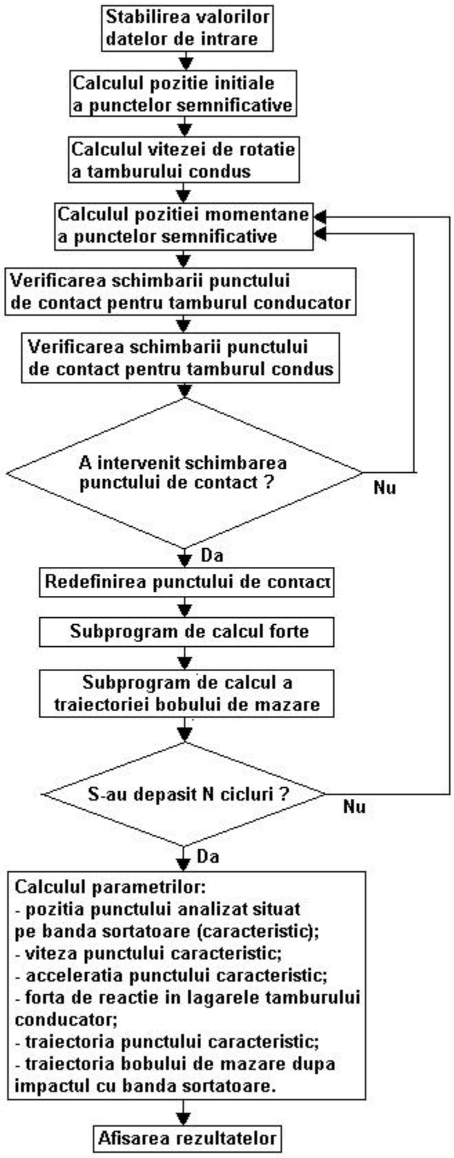
Where n is the revolution of the leading drum in rotations/minute, and *?a* is the angle that this drum makes for one of the simulating program’s cycle.

Using formula (12) the real time is calculated (*?t*), in seconds that corresponds to a cycle in the simulating program:

$$?t = \frac{1}{N} \quad (13)$$

Using this correlation, the speeds and accelerations that characterize the movement of the strip and the pea can be calculated, the resulting diagrams being in concordance with the real working of the sorting strip.

The logics scheme of the simulation program



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