DETERMINING THE MATHEMATICAL VALUE AND THE DIRECTION OF THE PEA'S SPEED AFTER THE IMPACT

Gheorghe ABRUDAN, Ion BRATU
Universitatea din Oradea

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Resume: 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.

1 Determining the parameters kinematics

The simulation program accomplishes (on top of the diagrams of the oscillation process) the calculation for the trajectory of the pea after the impact with the transporting strip, considering also its complex oscillating movement**.** [5]

It is considered that the pea starts from a point above the strip, with the coordinates X_{ma0} and Y_{ma0} and has a geometrical drawing uniformly accelerated movement until the moment of its first impact with the transporting strip. The position of the pea (X_{ma0}, Y_{ma0}) as well as its speed has to be calculated for each cycle of the simulation program separately. Also, the distance between the pea and the points $A(D_{a\_ma})$ and B(D_{b_ma}), points of contact of the strip with the edges of the drums is being tested in every cycle. If the sum of the distances to the points A and B is close to the distance between the points A and B that means that the pea is near the contact point. These distances are subtracted:

$$D = (Da\_ma + Dma\_b) - Da\_b \qquad (1)$$

It is considered that the impact had already taken place if D is smaller than a reestablished limit *e*. This limit is established taking into consideration the geometrical dimensions of the model, and also the fact that the errors that result should have the smallest influence possible on the simulation's final results.

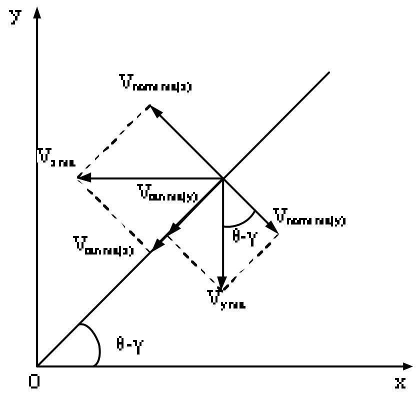


Fig.1

The principle scheme of the pea's first impact (where the pea is considered to have a spherical shape) with the sorting strip is presented in picture 1. Before the impact the pea has a geometrical drawing trajectory and its speed is v_{yma} the v_{x_ma} component is 0, for the first impact.

This speed can be decomposed in two components, one that is perpendicular on the strip and the other one that is tangent to the strip:

$$v_{norm\_ma} = v_{norm\ ma\ (x)} - v_{norm\ ma\ (y)} = v_{x\_ma}\, sin(?\text{-}?) - v_{y\_ma}\, cos(?\text{-}?) \qquad (2)$$

$$v_{tan\_ma} = v_{tan\ ma\ (x)} + v_{tan\ ma\ (y)} = v_{x\_ma}\, cos(?\text{-}?) + v_{y\_ma}\, sin(?\text{-}?) \qquad (3)$$

For the fore coming impacts both the v_{x_ma} component as well as the v_{y_ma} differs from 0.

Along with the movement of the pea, the movement of the sorting strip should also be taken into consideration. The mathematical value, as well as the direction of the speed of the sorting strip is calculated in the moment of collision. For this, the program detects the impact point M_a and the distance between this point and the point *B*. Because the length of AB segment varies, you have to establish the ratio k_{ma} , between the length of B_iM_{ai} segment and A_iB_i segment for the current cycle ("i") and then, using this ratio to calculate the position of point M_{ai-1} from the previous cycle. For this calculation you can use the formulas:

$$\frac{Y_{ma}\quad Y_{Bi}}{Y_{Ai}\quad Y_{Bi}} = K_{ma} \qquad (4)$$

$$Y_{ma\,i-1} = K_{ma}(Y_{Ai\quad 1}\quad Y_{Bi\quad 1}) + Y_{Bi\quad 1} \qquad (5)$$

$$X_{ma\,i-1} = K_{ma}(X_{Ai\quad 1}\quad X_{Bi\quad 1}) + X_{Bi\quad 1} \qquad (6)$$

The meanings of the markings used in formulas (4–6) are shown in picture 2.

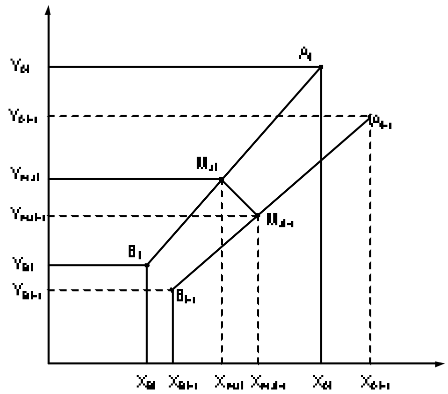


Fig.2

In picture 2 the distance that is covered by the contact point between two cycles of the program is (M_{ai} , M_{ai-1}), whose projections on the coordinates axis is:

$$?X_{ma} = X_{mai}\quad X_{mai\ \ 1} \qquad (7)$$

$$?Y_{ma} = Y_{mai}\quad Y_{mai\ \ 1} \qquad (8)$$

From the formulas (7, 8) the projections of point's M_a speed on the co ordinate's axis can be calculated, knowing the time step for a program cycle *?t:*

$$v_{xban} = \frac{?X_{ma}}{?t} \qquad (9)$$

$$v_{yban} = \frac{?Y_{ma}}{?t} \qquad (10)$$

You can then express the speed of the impact's point on the strip on the perpendicular, respectively tangential to the sorting strip:

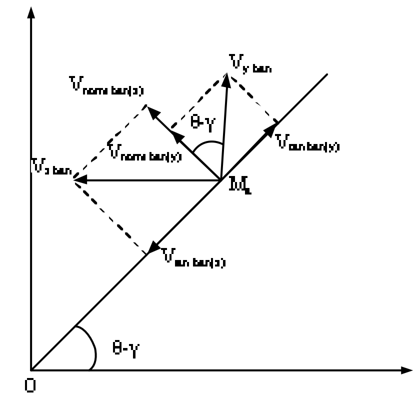


Fig.3

$$v_{norm\_ban} = v_{norm\ ban\ (x)} + v_{norm\ ban\ (y)} = v_{x\_ban} \sin(?-?) + v_{y\_ban} \cos(?-?) \quad (11)$$

$$v_{tan\_ban} = v_{tan\ ban\ (x)} - v_{tan\ ban\ (y)} = v_{x\_ban} \cos(?-?) - v_{y\_ban} \sin(?-?) \quad (12)$$

The relative (total) speed of the pea related to the impact point on the sorting strip:

$$v_{norm\_tot} = v_{norm\_ban} + v_{norm\_ma} \quad (13)$$

$$v_{tan\_tot} = v_{tan\_ban} + v_{tan\_ma} \quad (14)$$

The principle scheme of the speeds, after the collision is presented in picture 4

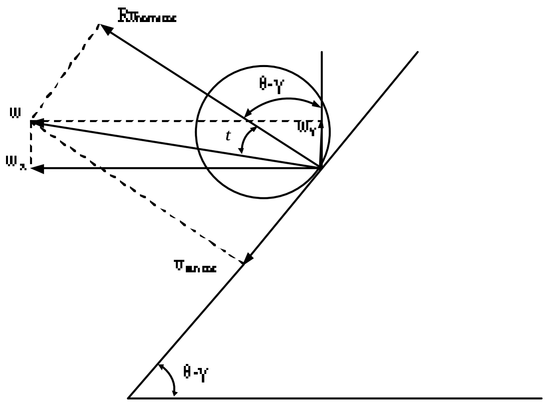


Fig.4

The components of the pea's speed, after the collision (w_x and w_y) are calculated with the formulas:

$$w = \sqrt{v_{tan\_tot}^2 + R^2 v_{norm\_tot}^2} \quad (15)$$

$$t = arctg\left(\frac{v_{tan\_tot}}{R \quad v_{norm\_tot}}\right) \quad (16)$$

$$w_x = w \quad \sin(? - ? + t) \quad (17)$$

$$w_y = w \quad \cos(? - ? + t) \quad (18)$$

In these formulas τ is the angle of the speed's direction after the collision, related to the strip's surface.

After the impact moment, during the pea's movement on its trajectory, the components of the pea's speed are:

$$w_{xmom} = w_x \qquad (19)$$

$$w_{ymom} = w_y - g\,t \qquad (20)$$

The position of the pea on the trajectory for the cycle "i" of the simulation program in given by the formulas:

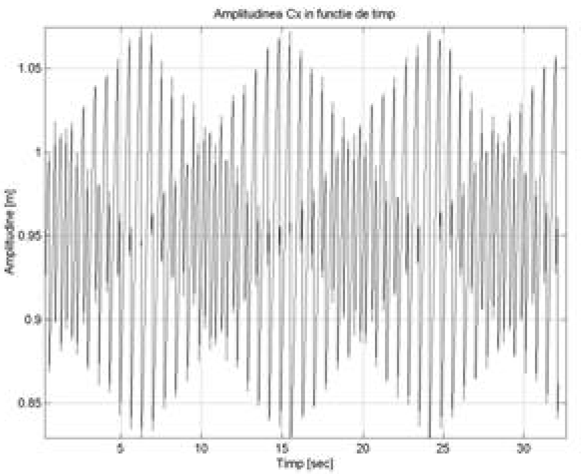
$$X_{Mai} = X_{Mai\text{-}1} - w_{xmom}\,t \qquad (21)$$

$$Y_{Mai} = Y_{Mai\text{-}1} + w_{ymom}\,t \qquad (22)$$

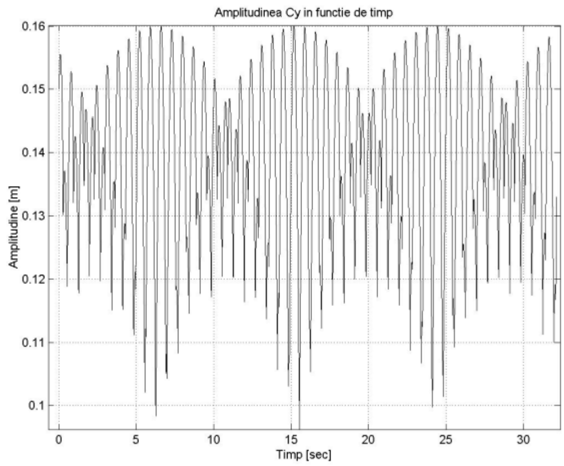
Next the proximity of the pea to the sorting strip is tested, so that the following impact can be detected, using the same formulas as for the first impact (1).

Previous to every impact the components of the pea's speed are up-dated: $v_{x\_ma} = w_{wmom}$; $v_{y\_ma} = w_{ymom}$, and the calculations above are done again.

The pea's trajectory is traced by the simulation program, based on the formulas (15–16). Analyzing this trajectory for different parameters of the simulation (the revolution of the leaded drum, the drums' number of bars, different coefficients of refund), the mathematical values of this parameters, for which the sorting reaches its optimal level can be found. In diagrams the results of the pea's trajectory simulation are presented, in the case of a 3-bar leading drum and 4-bar leaded drum. Simulations have been carried out for revolutions of the leading drum from 16 to 38 rotations/minute and for reimbursement coefficients of 0.3; 0.5, respectively 0.7.



a) on the Ox direction, for a 30 seconds



b) on the Oy direction, for a 30 seconds

Fig.5. The movement diagram of the median point (C), on the upper branch of the sorting strip, depending on time

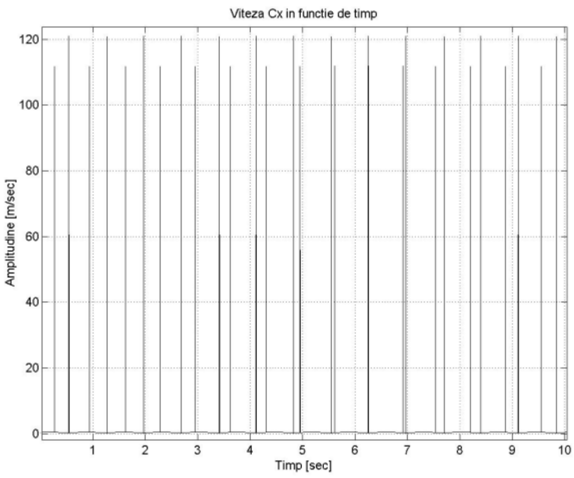


Fig.6. The movement's speed diagram of the median point (C) on the upper branch of the sorting strip, depending on time, on the Ox direction for a 10 seconds period.

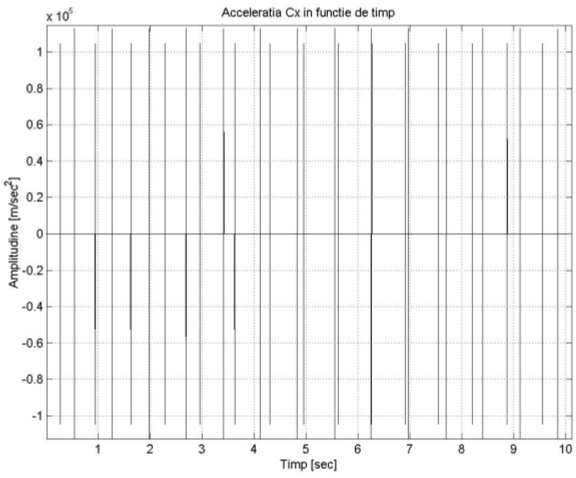
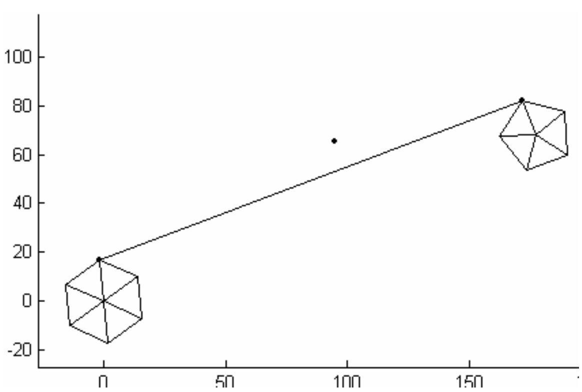


Fig.7. The acceleration dyagrame of the median point (C) on the upper branch of the sorting strip, depending on time, on the Ox direction, for a 30 seconds period.

Next, the simulation of the working of the sorting strip for a leading drum with 5 bars and a leaded drum with 6 bars has been presented. The results of the simulation are presented in pictures 8 – 12**.**

a)



b)

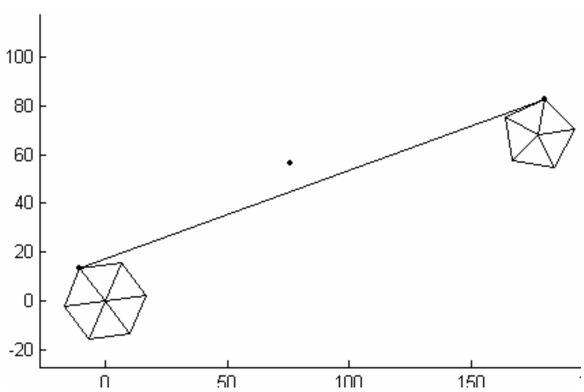


Fig.8. The simulation of the drums' and sorting strip's movement (Dimensions are given in în cm).

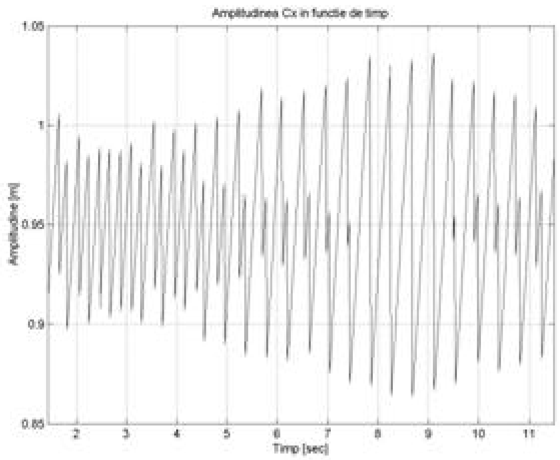


Fig.9. The movement diagram of the median point (Cx) on the upper branch of the sorting strip, on the Ox direction, for a 10 seconds period.

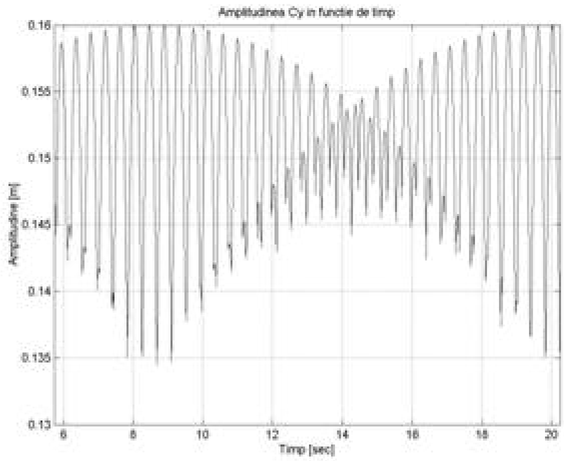


Fig.10.The movements diagram of the median point (C) on the upper branch of the sorting strip, depending on time, on the Oy direction, for a 14 seconds.

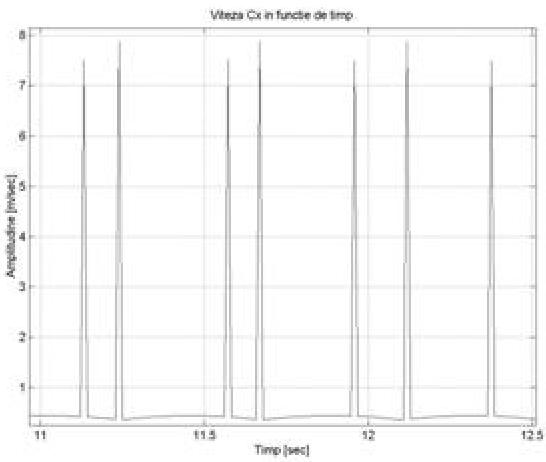


Fig.11. The movement speed diagram of the median point (C) on the upper branch of the sorting strip, depending on time, on the Ox direction for a 1,5 seconds period.

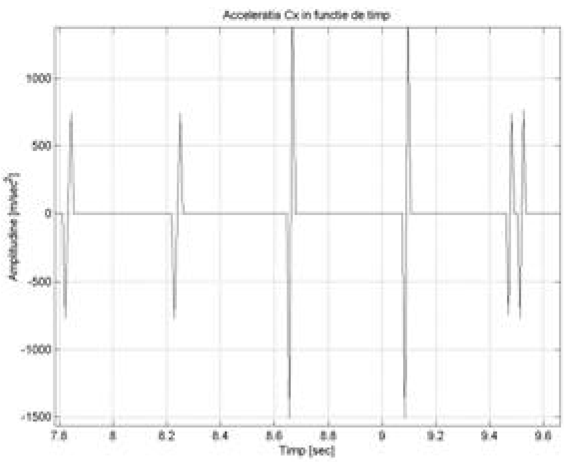


Fig.12. The acceleration diagram of the median point (C) on the upper branch of the sorting strip, depending on time, for a 2 seconds period.

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