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NUMERICAL STUDY REGARDING THE INFLUENCE OF THE LENGTH OF INDENTED CYLINDER SEPARATOR ON THE AXIAL SPEED OF THE MATERIAL AND THE ARROW OF THE SEGMENT OCCUPIED BY USEFUL MATERIAL

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Abstract: *In the paper is studied the behavior of the arrow of area occupied by the material to be sorted into the indented cylinder separators and the axial displacement velocity of material. Based on the mathematical model and a set of experimental data, a numerical simulation was carried out regarding the variation of the arrow of the useful material and axial velocity depending on the length of cylinder separator. After comparing the travel time of useful material through the cylinder separator, determined as well based on experimental data as based on numerical study conducted, it was found that experimental data confirm the mathematical model numerically simulated.*

Keywords: grain conditioning, cylinder separator, numerical study, axial velocity

1. ASPECTS REGARDING THE BEHAVIOUR OF TWO IMPORTANT PARAMETERS FOR THE WORKING PROCESS OF THE INDENTED CYLINDER SEPARATOR

An interesting aspect for the characterization of indented cylinder separator functioning is the behavior of the arrow of area occupied by the material which has to be sorted and the behavior of the axial displacement velocity of material (Figure. 1).

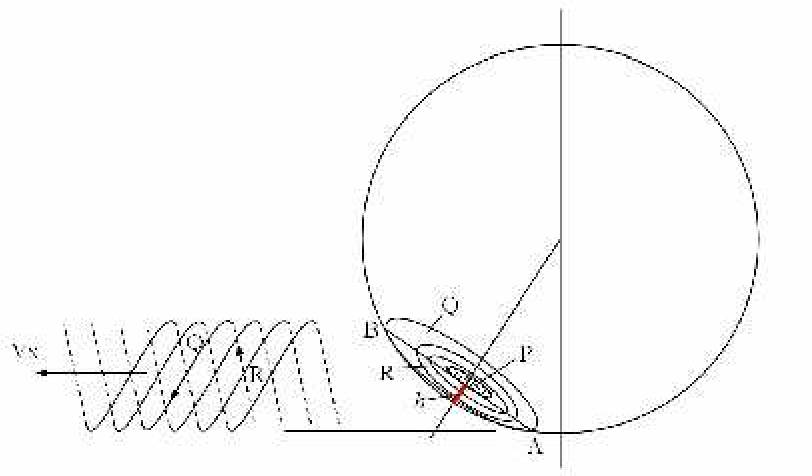

Figure 1: The axial displacement of the grains during the cylinder rotation

The sense of the notations from figure 1 are: *Vx* – the axial displacement velocity of material; *AB* – marks out the contact area of material lens with the surface of indented cylinder; *h* – the arrow of the area occupied by material; *P* – central nucleus of the material; *R* – the area of displacement by friction on the cylinder; *Q* – the area of displacement by falling away of the material.

In [3] there are presented two important mathematical relations which can widen the comprehensiveness area of mathematical modeling regarding the working process of the indented cylinder separator. The first relation is:

$$v(x) = \frac{\Omega h(x)}{tg\theta}\sin\sqrt{1 - tg^2\theta}\,, \tag{1}$$

in which: v is the axial displacement velocity of the seeds layer on the inner surface of the cylinder; Ω – angular velocity of the seeds which are in direct contact with the indented surface of the cylinder; θ – the dynamic natural slope angle of the seeds layer; h – the arrow of the cylinder segment occupied by the seeds layer.

In the relation (1) also, the appearance of x variable, shows that the parameters v and h are functions dependent on the length of the cylinder. In the cited reference [4] this issue is less explicit, placing only an index x to the velocity variable. Normally, both, velocity v and arrow h, are functions dependent not only on spatial variable but also on time. The variation with the time of these parameters is manifested preponderantly in the transitive fazes of the separation process or in faze where some control parameters varies, more or less intentionally. In normal working conditions, the process has a stationary character and for this reason, the dependence on time disappears or it is neglected. For this paper work, the stationary working process has importance and not the transitive one. For this reason, further, only the dependence of the working process on spatial variable will be taken into consideration.

A second important relation that the cited reference [3] gives is the relation (12.45) from the page 482. This relation is not a homogeneous relation from the dimensional point of view, a correct version of the relation (12.45) would be obtained eliminating the exponent 2 and the square root:

$$h(x) = \frac{q(x)}{2\gamma v(x) R}\,, \tag{2}$$

where: q is the flow of seeds which pass through the layer section, in *N/s*; R – the cylinder radius, in *m*; γ – the specific weight of the seeds, in N/m^3.

For Ω, in [3] a table is given, where this parameter is linked to the rotational angular velocity of the indented cylinder:

$$\Omega = c\omega\,, \tag{3}$$

where ω is the rotational angular velocity of the indented cylinder in *rad/s*, and c is a constant given in table 12.18 from [3], page 483. From the table, for wheat, the constant c takes values between 0.34...0.51. Also, in the same table, are given the values for the natural slope angle, in grades, in the interval 39^o...40^o. Thus, the relation (1) gets the form:

$$v(x) = \frac{c\omega h(x)}{tg\theta}\sin\sqrt{1 - tg^2\theta}\,. \tag{4}$$

Thus, the relation (4) links the rotational angular velocity of the indented cylinder to the axial velocity of the seeds layer in cylinder. By eliminating the arrow h from the relations (2) and (4) it obtains the expression of axial displacement velocity of seeds layer on the inner surface of the cylinder, as function of seeds flow (which are separated):

$$v(x) = \sqrt{\frac{c\omega \sin\sqrt{1 - tg^2\theta}}{2\gamma R tg\theta}\,q(x)}\,. \tag{5}$$

If, after the notations of Tit model, is accepted:

$$q(x) = g\left(Q - Qi(x)\right), \tag{6}$$

and the link between the rotation speed and the rotational angular velocity:

$$\omega = \frac{n\pi}{30}\,, \tag{7}$$

then, for the axial displacement velocity of seeds layer on the inner surface of the cylinder it obtains the relation:

$$v(x) = \sqrt{\frac{cn\pi \sin\sqrt{1 - tg^2\theta}}{60\rho R tg\theta}\left(Q - Qi(x)\right)}\,, \tag{8}$$

where: ρ is the mass density of material which has to be sorted; Q – material flow, considered constant; n – the rotation speed, in *rpm*; $Qi(x)$ – the flow of impurities separated at position x on the cylinder length. This way, it can establish a link between Tit model and the model from [3].

In [3] is given an interesting relation (12.46), page 482, which give us the medium axial displacement velocity of seeds, but this relation has a pure experimental character, and from the dimensional point of view, raises questions at which, presently, we have no answers. This relation takes into account, also, the inclination angle of the indented cylinder.

An interesting relation can be obtained starting with expressing the material flow through the down side of the cylinder (variable flow, because from the initial material are continuously extracted impurities and also good grains that can not be counted in this model).

It can be started from the expression of useful material flow:

$$Q - Qi(x) = v(x)\cdot s(x)\cdot \rho(x)\,, \tag{9}$$

where $s(x)$ is the area of the circle sector occupied by the material in axial displacement, and $\rho(x)$ is the density of sorted material, which also is modified depending on spatial variable, because from the initial material is extracted a component with possibly different characteristics of density. Yet, for not complicating too much the model and because it can be neglected the modification of material density due to the small mass of material eliminated in comparison with the mass of material introduced, further, it will suppose that mass density is constant. The relation of the circle sector area occupied by the material which has to be sorted, it can be expressed depending on the cylinder radius and the arrow of segment (which depends itself on *x* variable, the material flow through the cylinder being variable). With these remarks, the area of the sector is:

$$s(x)=\left(\arccos\frac{R-h(x)}{R}-\frac{R-h(x)}{R}\sqrt{1-\left(\frac{R-h(x)}{R}\right)^2}\right)R^2\cdot \tag{10}$$

From (9) and (10) it obtains the relation:

$$Q-Qi(x)=v(x)\cdot\rho\cdot\left(\arccos\frac{R-h(x)}{R}-\frac{R-h(x)}{R}\sqrt{1-\left(\frac{R-h(x)}{R}\right)^2}\right)R^2\cdot \tag{11}$$

The relation (11) replaces the relation (2) from [3]. The Tit model let us know the flows, and in the two relations, the velocity and arrow remain unknown. In fact, from the relation (4), the axial displacement velocity of material within the indented cylinder is explained, and the relation of velocity it can be introduced in (11), resulting a nonlinear functional equation, which, for a fixed *x*, it transforms itself in a transcendent nonlinear equation that has to be numerically resolved.

$$Q-Qi(x)=\frac{c\omega h(x)}{tg\theta}\sin\sqrt{1-tg^2\theta}\cdot\rho\cdot\left(\arccos\frac{R-h(x)}{R}-\frac{R-h(x)}{R}\sqrt{1-\left(\frac{R-h(x)}{R}\right)^2}\right)R^2\cdot \tag{12}$$

For *x* fixed, it is calculated *h*=*h*(*x*), then from the relation (4), it results *v*(*x*). After the calculation in sufficiently enough locations, it can be calculated the medium velocity and after that, it can be calculated the time in which a particle of useful material passes through the indented cylinder.

2. NUMERICAL STUDY REGARDING THE INFLUENCE OF THE INDENTED CYLINDER LENGTH ON THE AXIAL DISPLACEMENT VELOCITY OF MATERIAL AND ARROW OF THE SECTOR OCCUPIED BY USEFUL MATERIAL

The Tit-Krasnicenko combined mathematical model, synthetically described by the equations (1) and (12), give us other important process parameters, such as the axial displacement velocity of seeds layer on the inner surface of the cylinder (without consider the component given by the axial inclination of the cylinder) and the arrow of sector occupied by useful material along the indented cylinder. Having at our disposal the experimental data, is interesting to verify if the mathematical model can be used with sufficient trust. If it proves precise enough, then it could be used in prediction of some working processes for indented cylinder separators, regarding the parameters previously outlined. For numerical simulation it was used the experiment from the rotation speed of 45 *rpm* (the quantity of 100 *g* of material passed through the indented cylinder in 143 *s*) [5].

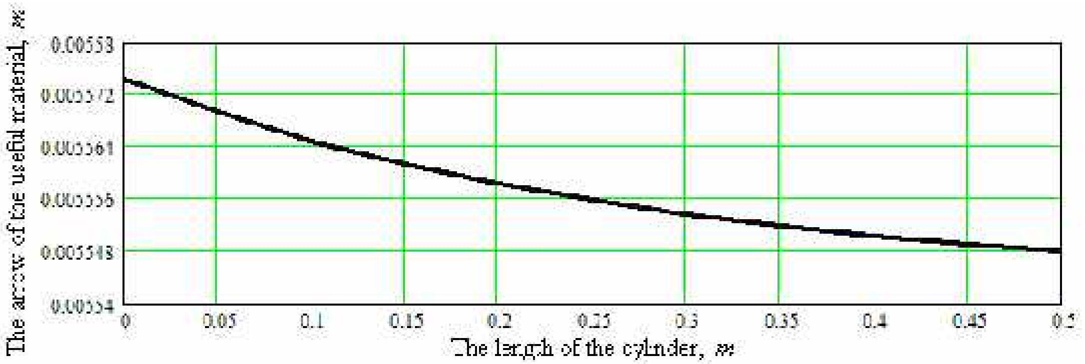

Figure 2: *The variation of the arrow of sector occupied by useful material, along the cylinder length*

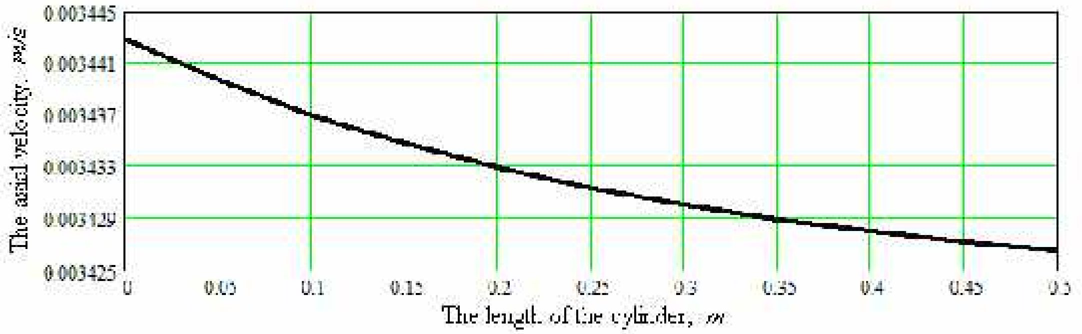

Figure 3: *The variation of the axial displacement velocity of useful material, along the cylinder length*

The variation of the arrow of sector occupied by useful material and its axial displacement velocity in relation with the abscissa, measured along the cylinder length, appear in Figures 2 and 3.

3. CONCLUSION

It notices that as departing from origin (the place where the material enters the indented cylinder) both, the arrow of sector occupied by useful material, and its axial displacement velocity, are decreasing. The decreases are small, neglectable (below 0.5 *%),* for the experimental case within this paper work. The passing of a quantity of 100 *g* through the cylinder in 143 *s*, conducts at a flow of 2.52 *kg/h* [5]. The medium velocity of material through the cylinder is calculated with the relation:

$$v_{med} = \frac{1}{L}\int_0^L v(x)dx\,, \tag{13}$$

and performing numerical calculation, it obtains the value v_{med}= 0.00343327 *m/s*, and then obtains a time T= 145.634 *s* for passing through the 0.5 *m* cylinder of a quantity of 100 *g* of raw material, with an error of 1.8 *%* comparing with experimental timing. Because the alveoli of indented cylinder were slightly different compared with the ones from [3], it has used the value 0.28 for the *c* constant and a dynamic natural slope angle of 42°.

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