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EXPLORING THE IMPACT OF THE LEVEL OF PRODUCT IN AN OPEN CONTAINER ON THE PERFORMANCE OF FS (FILL AND SEAL) PACKAGING MACHINE

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Summary: *The design of the shape and dimensions of the package often depends on the capabilities of the used packaging equipment for filling and closing. Conversely, when there is already an established market package with specific structural design is needed when designing or configuring the packaging machine to bring some of its parameters. One of the most important cost-effective technique is to increase efficiency. The article discussed the possibility of using modern methods of computer analysis for optimum design of packaging and packaging machinery. As the main criterion for optimality is to achieve minimum time to move from one position to another with maximum possible level of product packaging, which prevents leaking or pollution of the zone for heat sealing of the above closing film. The results can be used both in the design of new packaging and new packaging machine type FS.*

Keywords: *packaging, optimum level of filling, modeling, simulation, FEM.*

1. INTRODUCTION

The behavior of the liquid during start and stop when the speed is variable has been studied by several authors [1-9].

Analytical description of the surface of the liquid packaging, which moves at a constant speed of the rotor axis, is done in [9].

When the pack runs discreetly with the rotor, the behavior of the fluid changes. Analytical description is difficulty or inaccurate. In this case you can use the modeling process in which to accumulate residual data on the surface of the liquid product at start and stop.

In [4] studied the process of filling the containers in which the rotation due to their changing conditions of leakage.

2. FORMULATION OF THE PROBLEM

In its moving from position of filling to position of closing the packages with yoghurt are open. With overcoming the distance, the speed changes in a certain law. At the beginning it is zero, gradually it reaches its maximum, and then it begins to decrease to zero. This allows not receive large accelerations at the beginning and in the end of motion, which can cause discharge of part of the product over the edge of the container. In practice these accelerations depend on the amendment of speed. There are maximum ones at the beginning and in the end of motion, which ensure reliable work of the packaging equipment. Modern systems for management of electric tractions allow getting law

of motion of the actuator- in this case the rotating table with such speeds and accelerations, which should allow not contaminating the area of heat sealing lid container. This allows receiving of qualitative stitch and reliable sealing of the package. In practice it is still widely used mechanisms such as the Maltese, which allow receiving of suspended motion of the table and the laws of motion are suitable for the package.
Obviously, to avoid contamination of the area's thermal bonding, they limit the speed of the rotating mass, and consequently productivity and packing machine. At lower levels of the product allowable accelerations are larger. Under a certain value of the product level in the package it does not affect the motion speed and hence the productivity of the machine.
Searching a level of the product in the package in which the productivity of the given amount product will be maximum .Practically that's the level , at which the maximum acceleration won't lead to appearance of inertia in the product to pour it above the rim, where it will get dirty or the product will pour out of the package.

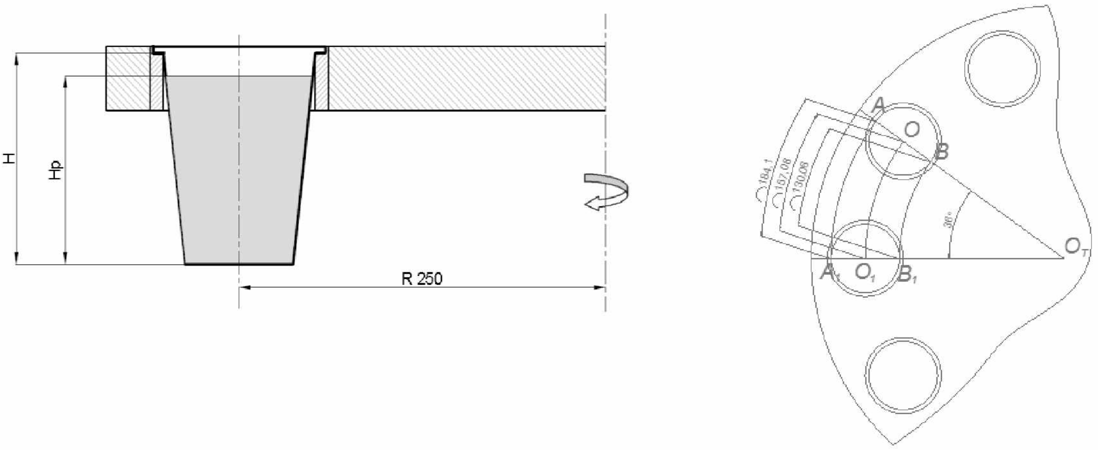


Figure 1: Scheme of the rotating table

On figure 1 is shown the cheme ot the rotating table and it's geometrical parameters. The theoretical productivity of the packaging machine can define with the formula:

$$Q_t = Z_y / (T_d + T_m), \tag{1}$$

Where:

T_d – Duration of the technological stay for dosage of the product or filling of the package with product, s;

T_m – Duration of the package moving between the technological positions and ascertainment, s;

Z_y – Number of the packages, which are produced from the machine in one technological feed in course of one work cycle
To reach a maximal productivity of the equipment, it's needed the time for filling of the package and the time for transport between the separate positions to be at the minimum:

$$T_d ; T_m \rightarrow \min .$$

The time for filling depends on the amount dosed product in the package and the speed, which the product flow out with. In its turn the speed depends on variety of factors, which can divide in two groups. In the first group are these, which are conditioned by the characteristic of the product. In the second group are the factors, connected with the constructive specialty of the filler mechanism.
The time for moving the package from position to position depends on the distance between the separate positions and the speed, which it moved with .The speed depends on the abilities of the construction and its power actuated and the product qualities in the package. Because the package is

open, while it is moving from position of filling to position of closing, it's important what maximal speed and acceleration can be reached without the fluid level in the period of acceleration and stopping to exceed definite value, over which the product will contaminate the area for heating.
Maltese mechanisms are often used for machine-automates for Food industry like leading mechanisms for inside machine transportation of workable objects, when its needed regular putting in action and stopping.

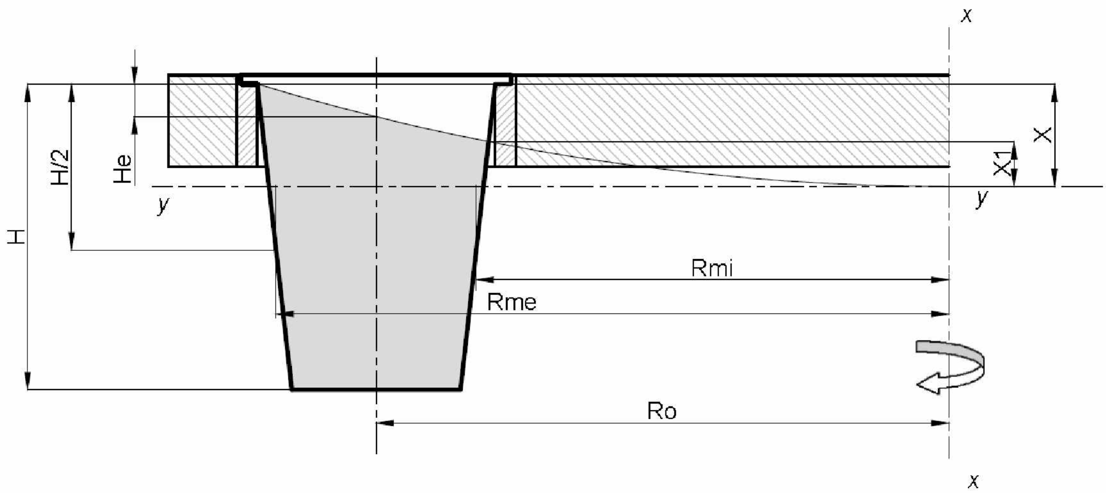


Figure 2: Level of liquid product in the package

The level of liquid product in the package, located in the nest of the rotating table accept position like in Figure 2 with average radius R_0 and distance between the packages equal to twice the radius. The curved line *a-a* figure is part of branch of the parabola.
The volume of part of the paraboloidal rotating amount to the formula:

$$V = \pi . H_e \left(R_{me}^{\ 2} - R_{mi}^{\ 2}\right) = \pi \int_{x_1}^{x} y^2 dx - \pi R_{mi}^{\ 2} (x - x_1), \tag{2}$$

or

$$H_e \left(R_{me}^{\ 2} - R_{mi}^{\ 2}\right) = 2p \int_{x_1}^{x} x dx - R_{mi}^{\ 2} (x - x_1). \tag{3}$$

It follows

$$H_e \left(R_{me}^{\ 2} - R_{mi}^{\ 2}\right) = p\left(x^2 - x^2{}_1\right) - R_{mi}^{\ 2} (x - x_1) \tag{4}$$

Where:

H_e - high of unfilled volume of the package *m*;

r_m - average radius of the package, *m*;

R_{me} - average value of the outside radius of location of the package, *m*;

R_{mi} - average value of the inside radius of location of the package, *m*;

R_o -radius of location of the axis of the package, *m*;

p -parameter of the parabola.

For the exanimate case the meaning of X which conform with y is equal to R_{me}, and the meaning of X_1, which conform with y is equal to R_{mi}.
Thus, when we show in the equation the meaning of X, X_1 and p, we receive is the frequency of rotating:

$$n_M = 30\sqrt{\frac{4H_e}{R_{me} - R_{mi}}}\ . \quad \textbf{(5)}$$

But $R_{me} = R_o + r_m$, $R_{mi} = R_o - r_m$, then for revolutions of the rotating table we receive:

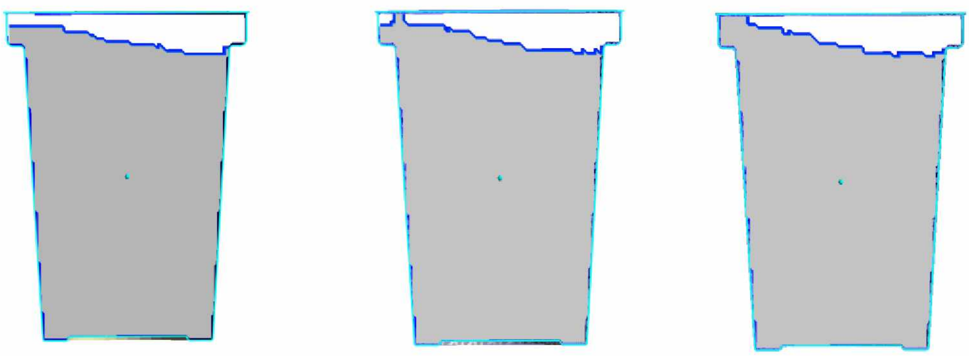
$$n_M = 30\sqrt{\frac{H_e}{R_o r_m}}\ . \quad \textbf{(6)}$$

Then the level of filling of the package for reaching the maximal productivity:

$$H_p = H - \frac{n_M^2 R_o r_m}{30^2} \quad \textbf{(7)}$$

3. COMPUTER MODELING

For the purposes of the study is created three-dimensional model developed packaging for liquid food products in the program Solid Works. The package has rotational symmetric form and has inverted truncated cone shape. In the upper part is shaped flange, where is placed on the upper foil. In this area is made heat seal. For quality realization it is necessary until the sticking to remain clean.
The developed model is imported in program Flow Vision. In it is made a simulation of the process of moving from one position to the next. It is studied the influence of the maximum achievement speed of move the package over the liquid level in the package.
In computer simulation it is used the equation of mathematic model of incompressible liquid.
The boundary conditions are: walls of the package with a small roughness (roughness value of the scale is 2), and the upper surface is free.
Problem is solved with the following initial conditions: an initial linear speed 0,15 m/s, package is full and begins to move.
The system uses for solution of the problem the method of the final elements.
Used final elements are three-dimensional cubic. For more correct solution the final element size on the surface of the liquid is three times smaller. The total number of final elements in the mesh is 15 000. It is used Iteration model for solution of the problem with step of 0,005 s.
Fig. 3 a, b, c shows the maximum level achieved with a tendency to splash respectively 0,15; 0,2 and 0,25 m/s, respectively.



a b c

Figure 3. State of the surface of the liquid in the container at various speeds of movement

3. CONCLUSION

1) The dependences (5) and (6) are presented to determine the frequency of rotation the table, where won't set in splashing of the product. Addiction (6) gives the connection between the high of the unfilled volume H_e, the average radius of the package r_m and the radius of the axle location of the package R_o for the concrete type of package, which is examined;
2) Dependence (7) is deduces for determining the filling level of package with product from the conditions for not spilling over of the filled product and reaching of maximal productivity;
3) From the numerical simulation it is found that the spilling over of the product starts in the range of speeds 0,2 and 0,25 m/s (Fig. 3).

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