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TURNING THE PULSATING FLOW INTO LAMINAR FLOW, REDUCTION / ELIMINATION OF EFFECT OF VACUUM, NEW CONSTRUCTIVE SOLUTIONS

Abstract: *The article, as a new concept, analyzes the notion of « pulsating flow », the physical phenomenon seen when emptying bottles of PET or Tetra Pak; which do not have a disposal system of the vacuum created while emptying them, situation in which the fluid stream becomes oscillating in terms of the speed and the flow of the fluid passing through the drain area / section. Pulsating flow is a result of the vacuum created in the container, as opposed to laminar and turbulent flow whose existence is determined by the relative speed of the layers of fluid and the friction forces* [2]. *In the paper I present some new constructive solutions, designed by AutoCAD and created physically with rapid-prototyping*

Keywords: *pulsating flow, preforms, plastics injection, injection and injection stretch blow molding* [1], *rapid-prototyping, limited technology, CAD, modelling*

1. INTRODUCTION: DESCRIPTION OF THE PHENOMENON

When emptying liquids from containers such as PET or TETRA-PAK type, after a period of time from the beginning of the flow, will appear the following phenomenon: the speed and flow rate decrease, due to the vacuum that is created within the container, the minimum area through which the fluid flows is entirely covered by the fluid. During the continuation of the flow, at one time, air enters into the container, which eliminates the vacuum created, at that time the speed and the debit increase too. After a time, the varying/pulsating phenomena is repeated until the fluid no longer covers entirely the minimum drain section, moment when the atmospheric pressure and the pressure from the container become equal and the flow becomes laminar. This pulsating evolution creates discomfort to the user (spraying of the others, of the various objects, some being under-voltage supply, etc.). In this paper, we will present two solutions to reduce or eliminate this discomfort:

- A solution accessible to the current technological level;
- A solution that requires a current technology development.

2. INFORMATION. CURRENT SITUATION

2.1 Existing technology for making PET bottles and TETRA-PAK Pakages

2.1.1 Manufacture of PET bottles

The process takes place in two distinct phases:

- Obtaining preforms - injection molding technology.

the preforms are obtained in different sizes and weights depending on the volume of the final product (0,25L;0,50L;1L; 2L ; 2,5L and 3L). Plastics injection machines of high productivity are used, the molds produce simultaneously 20 preforms or more, as the demand is very high (bottled water, juices, various alcoholic beverages) ;

- In the second phase it is used the injection stretch blow moulding, through which, out of these preforms, using a special machine is done the heating and then the increase of the volume to the desired level using appropriate preforms [1].

In Fig. 1 can be seen some models of preforms.

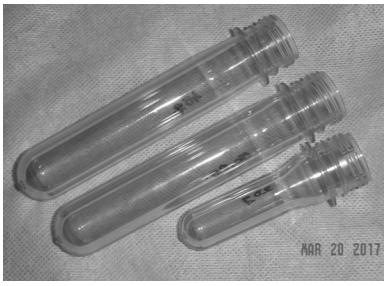

Fig. 1 Models of performs.

2.1.2 Obtaining TETRA-PAK Pakages

On the market, there are specialized lines of high productivity that make Tetra-PAK Pakages. In a certain phase, through ultrasound welding, is fixed the filling-emptying mouth of the box

In Fig. 2 and Fig. 3 can be observed these areas before and after unsealing.

Fig. 2 Sealed product.

At this moment, these types of products don't have a system to eliminate the vacuum phenomenon when emptying them.

Fig. 3 Product for use.

There are other kinds of bottles, obtained by extrusion blow molding, that have a specific construction (Fig. 4) allowing the equalization of atmospheric pressure with the pressure inside the container (opening the cover with larger diameter) or using an additional accessory (Fig. 5) which has a construction that allows equalization of the two pressures (external and internal) to give a laminar flow. In the second case, the bottle has a special area which allows storage of the accessory during transport or when not in use (Fig. 6).

Fig. 4 Specific construction.

Fig. 5 Accessory mounted.

Fig. 6 Accessory stored.

3. PROPOSED CONSTRUCTIVE SOLUTIONS

For both proposed solutions I have used AutoCAD (2D and 3D) and the method of obtaining the physical product through rapid-prototyping.

3.1 Accessible solution with current technology

- Involves an accessory supplied with the product or that can be purchased separately and it is reusable;
- It is a thimble type accessory ;
- The design of this accessory seeks to create no additional effort to the consumer, except the moment of fixing the accessory, without any restriction (the container can be used in a comfortable position for the user, do not need a position specific to the new situation) ;
- Several access areas of air into the container have been created and several constructive solutions have been tried, aiming to be more accessible in terms of technology;
- In figures 7-14 are presented these solutions and their implementation through rapid-prototyping.

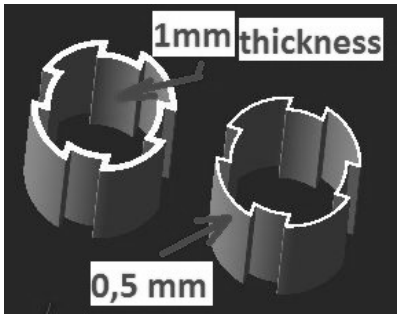

Fig. 7 The first version - 3D model.

Fig. 8 The first version – rapid-prototyping.

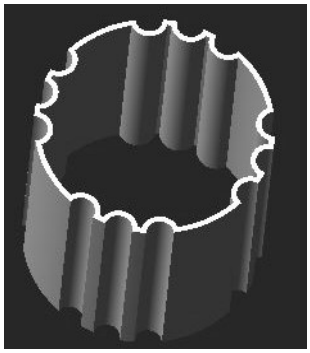

Fig. 9 The second version – 3D model.

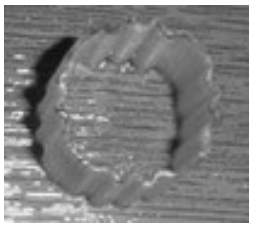

Fig. 10 The second version – rapid-prototyping.

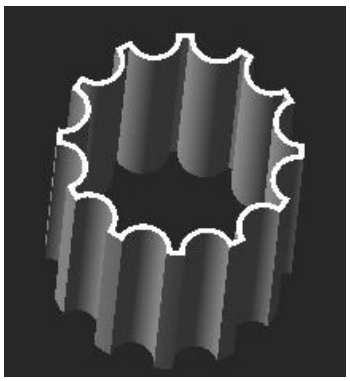

Fig. 11 The third version – 3D model.

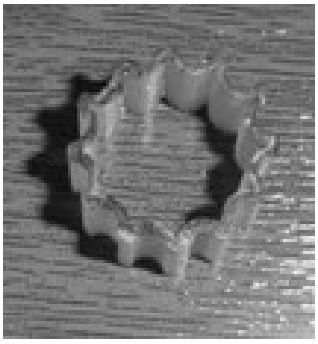

Fig. 12 The third version – rapid-prototyping.

These versions have been tested: they reduced the phenomenon and the duration of the vacuum and after a few moments it is eliminated

In the figures 13-17 are shown /presented different phases of parts assembling made through rapid-prototyping with PET bottles existing on the market.

Fig. 13 PET bottles with different rapid-prototyping accessory mounted.

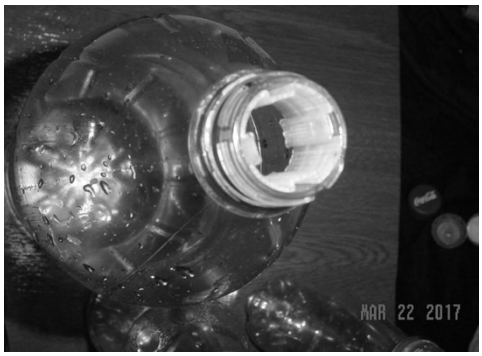

Fig. 14 Accessory first version ready to use.

Fig. 15 Assembly accessory first version with the bottle.

Fig. 16 Accessory second version ready to use.

Fig. 17 Assembly accessory third version with the bottle.

Based on the accumulated experience it has been designed an improved model, a version for PET bottles and one for TETRA-PAK Pakages (Fig. 18-19).

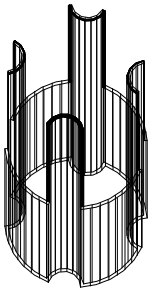

Fig. 18 The PET version – 3D model.

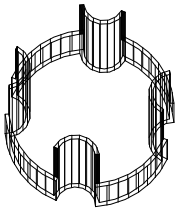

Fig. 19 The TETRA-PAK version –3D model.

There are similar constructive solutions adapted to the mounting areas.

There will be executed also rapid-prototyping models and will be tested.

This solution does not eliminate an additional element – thimble type element.

The following is a solution suitable only for PET bottles, but which requires an improvement of the equipment in the process and changes of the preforms.

3.2 Future solution for PET bottles

This solution involves the making of some channels during preforms injection phase that facilitate the access of air in the bottle (Fig. 20 and Fig. 22). The channels will be opened in the bottle thermoforming phase due to changes of the ecquipment. To reduce the length of the channel, the constructive shape of preform has been modified, for the 0.5L bottle only. For now the solution has a technological limitation in phase 2, thermoforming - creation of a special ecquipment that responds positively to this demand (allowing a precise fixing of the preform (possible solution Fig. 21) and an additional system for introducing air under pressure in the channels zone) but the fact that it does not require an additional accessory could be a powerful enough argument to determine the technological leap needed for the conception and implementation of such an equipment

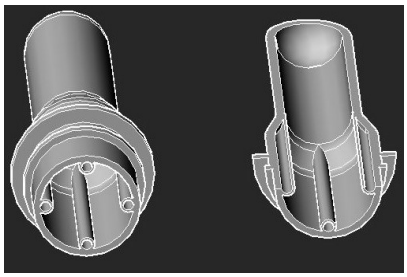

Fig. 20 Preform – 3D model.

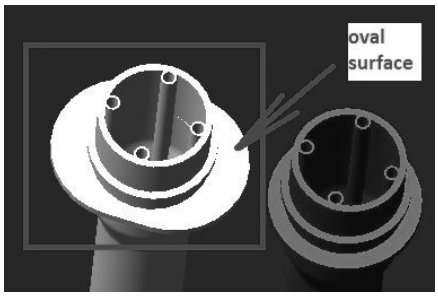

Fig. 21 Preform – rapid-prototyping.

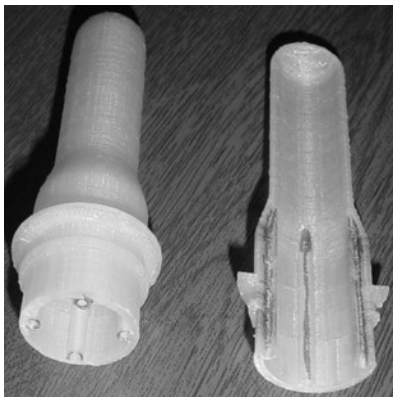

Fig. 22 Preform – rapid-prototyping.

4. CONCLUSIONS

The article presents a real situation which led to the introduction in the discussion of the concept of "pulsating flow".

The mathematics of this concept will be a challenge for the experts in the field of fluids.

It will continue through 3D modelling and rapid-prototyping by getting new solutions based on the experience gained in these experiments, with appropriate adaptations for containers of larger volumes than 0.5L.

If such a solution will be achieved into series production, it will be an improvement in the quality of the product from the consumer's point of view.

REFERENCES

[1]*http://www.bpf.co.uk/plastipedia/processes/Default.aspx.*
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