



## COMPARISON OF BOTTLE WALL THICKNESS DISTRIBUTION OBTAIN IN REAL MANUFACTURING CONDITIONS AND IN ANSYS POLYFLOW SIMULATION ENVIRONMENT

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### **Abstract**

*Extrusion blow molding (EBM) is a widely used and known manufacturing process to produce thin or thick thermoplastic hollow object like cosmetics container or big drums. This process can be realized on extrusion blow molding machine and tooling. Each extrusion blow molding machine has a programming die head. The initial parison thickness distribution should be depended on final bottle geometry. However, to determine the proper distribution of parison thickness to get the most uniform thickness of the container wall, it is not an easy task. In order to precisely define this distribution is simple using Ansys Polyflow. The article includes a comparison of bottle wall thickness distribution obtain in real manufacturing conditions and in realizing Polyflow simulation. Also it will be propose an initial parison thickness distribution (programming) for the bottle design, which is manufacturing in the industry to pack nail polish remover. This will allow the packaging manufacturer to produce a bottle of a higher quality in terms of distribution of wall thickness.*

**Keywords:** *extrusion blow molding, parison programming, wall thickness distribution, Ansys-Polyflow*

### **1. Introduction**

Design of extrusion blow molding process for a specific product is aided by various computer techniques. One of the most advanced processes, allowing assessment of blowing and shaping the final selected features of the products, is using CAE software Ansys Polyflow [7]. It allows you to establish multiple relationships running during the consideration process. One of them is able to determine the initial distribution of wall thickness of extruded parison so as to obtain the most uniform distribution of wall thickness in container. It is extremely important for the plastics unit consumption on the blowing product, as well as achieving a more even distribution of cooling rates, which may prevent distortion and deformation products [6]. If the product has a uniform distribution of wall thickness of the container, you can shorten the cooling time in a bottle, so you can improve the energy efficiency [5] of the process realized, that a year can bring significant economical savings.

Wider information about extrusion blow molding process and assumptions to Polyflow simulate are available in the position [2, 4].

## 2. Determination of parison thickness distribution for blowing product

The articles produced by non unbounded extrusion blow molding process are large differences in wall thickness distribution of the product, but it is depended on production process. In order to ensure uniform wall thickness of the blowing product, extruded parison should have a thicker wall, where the later is more blow ratio, including the stretch in the longitudinal direction. This is achieved by changing the width of the gap between the moveable mandrel and die [1].

Consequently, one of the most important aspects in the extrusion blow molding process is the identification and selection of the initial parison geometry, in order to obtain the desired products of locally constant or variable wall thickness distribution with a minimum weight of the blowing product [2].

Utmost helpful step in the determination of correct geometric parison profile is realized blowing simulations for the initial constant thickness of parison [4], in order to achieve a specific distribution of the final container wall thickness, which is then used by the mathematical Polyflow solver to optimization an initial profile of the parison, for example, on its length (Vertical Wall Distribution System).

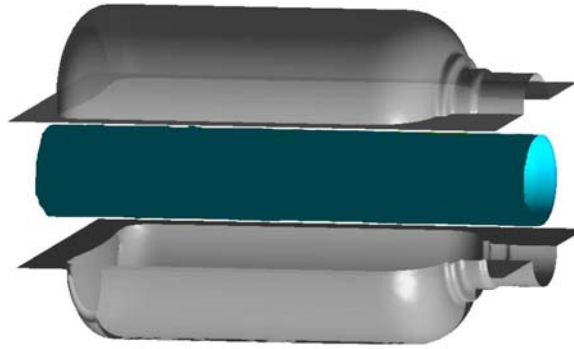
It is usually so that the largest thinning is formed at the corners in blowing product [3]. Using a larger parison thickness makes thinned areas are thicker, but too much plastic (which is not needed) is located in other place of the product. Ultimately, the parison of variable thickness allows obtaining the greatest wall thickness distribution ratio of the bottle. It also allows, for example, reduce the amount of plastic waste from about 20 to 40% (depending on the geometrical characteristics of the blowing product: oval, rectangular, 'sharp' corners, handle, etc.), thus making the product lighter and more economical in production. It should be further noted that carrying out a series of successive Polyflow optimization (number 3÷4) gives the best results [4].

It should be mentioned that the available methods to control the parison thickness distribution systems (also possible to use in the Polyflow simulation), include: Vertical Wall Distribution System (VWDS), Static Flexible Deformable Ring (SFDR), Partial Wall Distribution System, (PWDS) [6], Three Dimensional Wall Distribution System (3DWDS).

## 3. Realized task

The realized tasks aims to make the bottle wall thickness measurements obtained under real production conditions, and computer simulation. Also, the goal is assumed to propose an optimized thickness distribution of extrudate parison to obtain a product with more uniform wall thickness over the entire surface of the bottle. Considered bottles capacity is 150 ml.

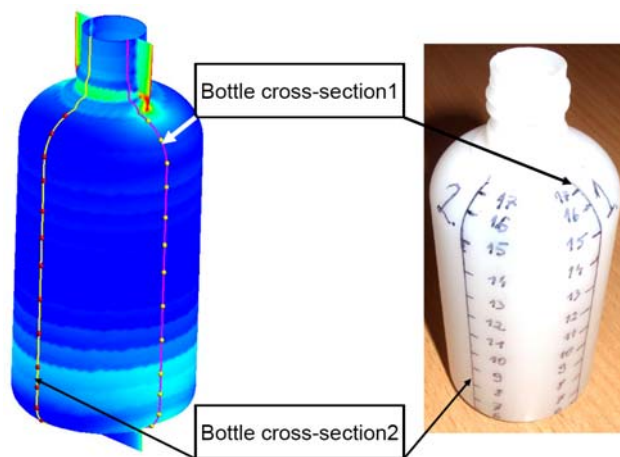
In the engagement on the blowing simulation software Ansys-Polyflow, first prepared a virtual model of the cavity and parison (Fig. 1). Due to lack of die land geometry and parameters of the extrusion head, computer simulations have been limited to the closing stage of the parison in the mold and its blow. On the basis of traces of the upper and lower 'tail' waste bottles obtained under real conditions and the initial simulation, establish the initial diameter of the parison,  $d = 24\text{mm}$ . On the other hand, knowing that the die land of the head gap is 2 mm, it was assumed that the initial thickness of the parison is  $g = 2,3\text{ mm}$ .



*Fig. 1. Virtual model of the cavity and parison*

In the next stage of the geometric model has been imported into the program Ansys Polyflow, which successively applied FEM mesh for the cavity and parison, specified boundary conditions, blowing conditions, contact conditions for the parison and mold, mold closing conditions, plastics HDPE properties, running computational module, to obtain the thickness distribution of the bottle, read the results from the simulation.

Also for fifteen selected bottles received in terms of real production grid points was applied in two sections for each of the bottles. One of the sections was placed at a distance of 3 mm from the parting line, while the second was applied in the plane turned 90 degrees from the parting plane. Moreover this some points were measure in Polyflow environment (Fig. 2).



*Fig. 2. Bottle cross section: (on the left) virtual model, (on the right) real model of 150 ml HDPE container*

With the help of a measuring device the Magna-Mike 8500 (Hall Effect thickness gage), were measured wall thicknesses of bottles, at the designated points of measurement. The results were averaged for each section and included in the research protocol, and the results are shown in Fig. 3–4 (line – wall thickness results of real bottle). This results comparison with Polyflow outcome (see line – wall thickness results for Polyflow simulation).

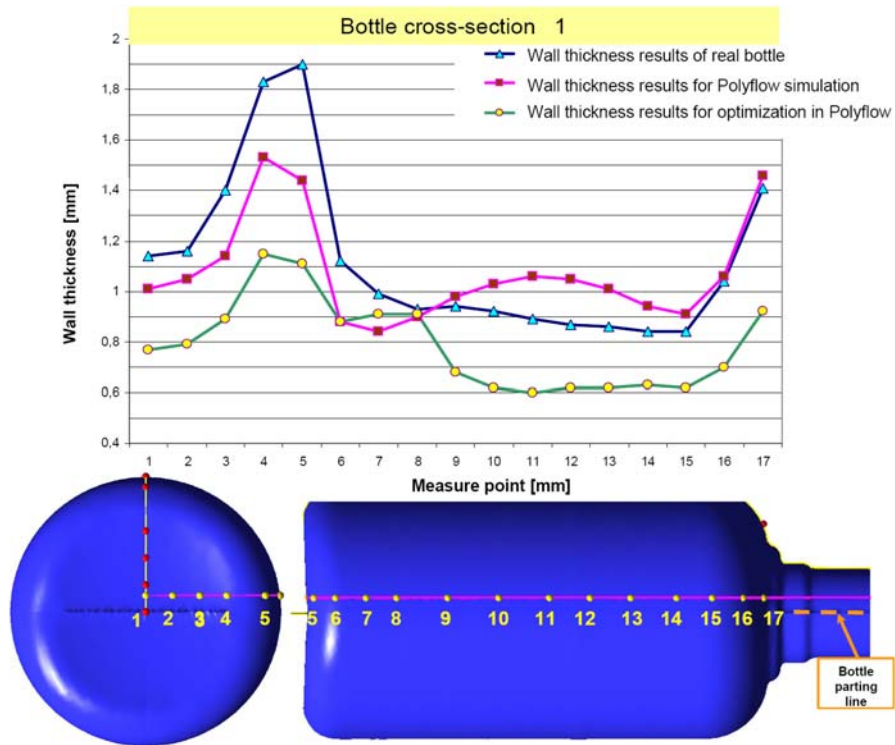


Fig. 3. Comparison part thickness distribution along the measurement line in cross section 1

Additionally, in order to obtain a more uniform wall thickness distribution in the bottles were realized Polyflow simulations to optimize the initial parison thickness distribution (Fig. 5) in the axial direction (method VWDS), to obtain the bottle of the assumed thickness of 0.6 mm (in the entire volume of the bottle).

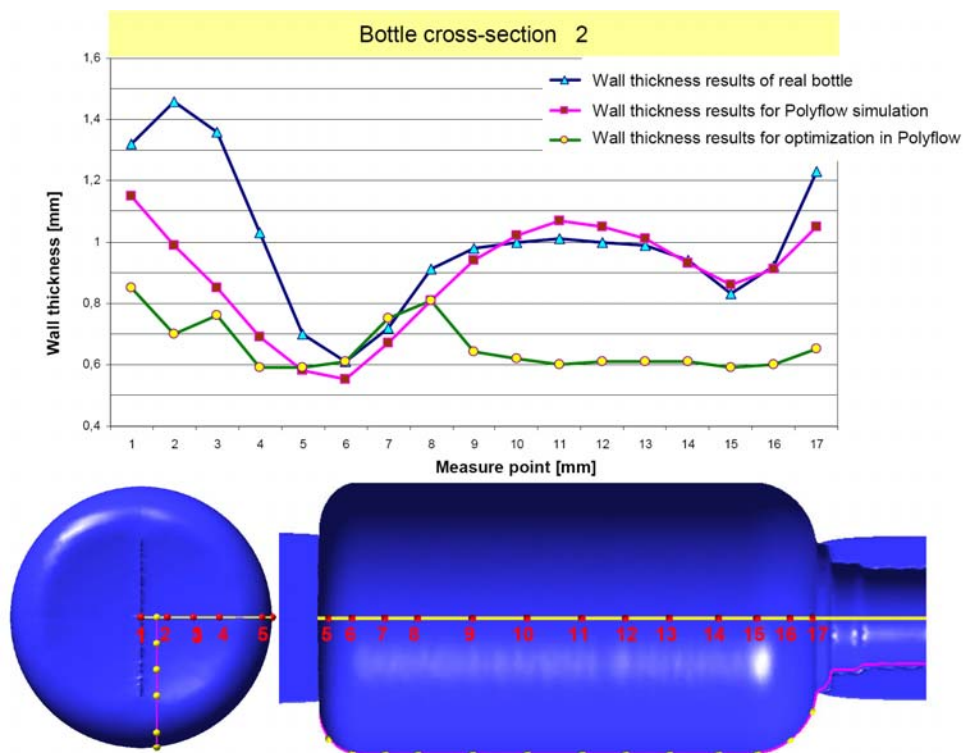


Fig. 4. Comparison part thickness distribution along the measurement line in cross section 2

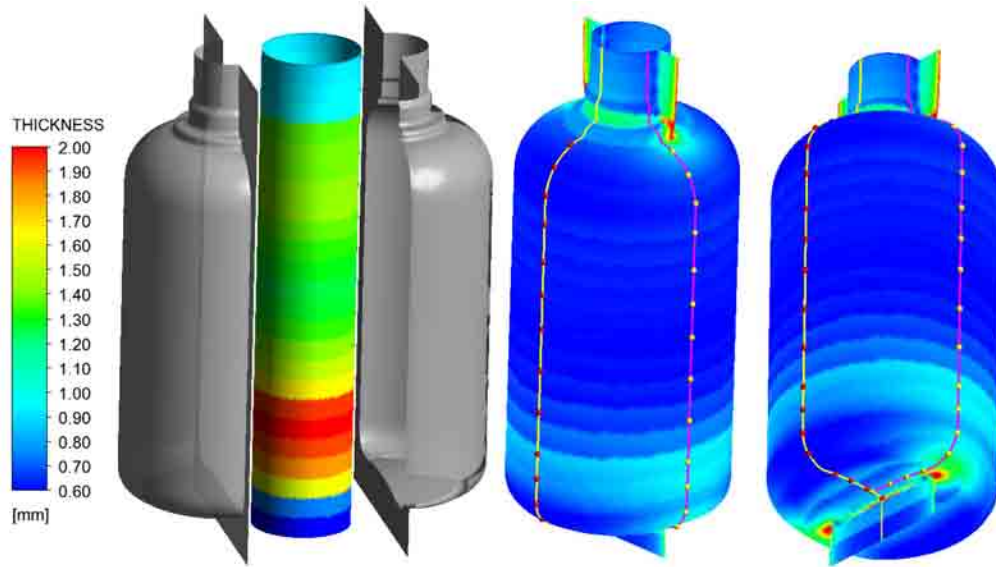


Fig. 5. Final part thickness distribution for optimized parison diameter 24 mm: (on the left) optimized parison thickness distribution, (on the right) visible final bottle wall thickness distribution after realized task

#### 4. Final consideration and summary

Comparing the thickness distributions of products obtained in the first section and second, we can conclude that the results of measurements and simulations of actual bottles are mostly close to each other, but especially in bottom zone of the bottle (points 1-6) are greater discrepancies. The resulting differences may result from the inability to simulate the plastic flow in pinch off section when mold close, which in real life takes place, to ensure adequate strength weld line bottom of the bottle. It should also be noted that the simulation assumes a certain initial diameter and thickness of the parison, which may differ from reality.

Implemented to optimize the simulation can be a kind of guideline for changing the geometric of extrudate parison to achieve greater uniformity of real bottle wall thickness distribution. This determination can be more helpful for more complex geometry of blowing product.

For increased confidence (accuracy) of the simulation results, further work on such simulation of polymer flow through the die head and land length, take a picture of real parison and measure its diameter, and comparison with simulations.

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