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ANSYS-POLYFLOW SOFTWARE USE TO SELECT THE PARISON DIAMETER AND ITS THICKNES DISTRIBUTION IN BLOWING EXTRUSION

Karol Pepliński, Arkadiusz Mozer

University of Technology and Life Sciences
ul. S. Kaliskiego 7, 85-789 Bydgoszcz, Poland
tel.: +48 52 3408224, fax: +48 52 3408222
e-mail: karolpep@utp.edu.pl

Abstract

The blowing extrusion in mould is one of the most widely used techniques for the production hollow plastic product example: bottle, cosmetics container, fuel tanks etc. A significant factor in the design stage of new blowing product is the selection initial parison shape in order to obtain the best distribution of final wall thickness in bottle. In this case using Ansys-Polyflow software is very helpful. This paper presents the blowing container Polyflow simulation with high-density polyethylene (Borealis, BS 2541) under isothermal and non-isothermal conditions. In the present work was showed the impact of the initial parison diameter and their geometry distribution onto final wall thickness in the sample container. This series of numerical simulation with parison optimization was showed that initial parison diameter and geometry have crucial importance for uniform final wall thickness distribution and minimal bottle mass. Eleventh cases of blowing parison were considered. Initial parison diameter was 14 mm and final 34 mm (step 2 mm). Optimizing the thirty milimeters diameter parison profile thickness for allowed to eliminate excessive thinning in the corners of container wall and get minimal container weight. An established criterion for a minimum wall thickness (1 mm) in the final product was achieved.

Keywords: *blowing extrusion, non-isothermal conditions, optimization the parison profile thickness, Ansys-Polyflow simulation, minimal container weight*

1. Introduction

One of the areas of technique characterized the last three decades the dynamic development is the containers manufacturing technology using plastics. Result of this development is to significantly increase the production quantity of containers, including large blowing parts [13]. Already in 2000, the number of blown bottles to beverage industry in the world has exceeded 10 billion units [10]. Currently, this number is much higher. In 2008 in Europe processed 60 million tones of plastics, including up to 38% in the production of packaging [15]. These data show that the manufacturing of packaging technology, in particular extrusion blow molding process, is an important direction of development of polymer processing. Blowing extrusion in the mold are the basic plastics processing methods used to manufacturing packaging polymer, such as: beverages, cosmetics, chemical products or more complex structures such as tanks for liquid fuels [11].

In order to maintain the required mechanical properties and the criterion of a minimum plastic consumption for blowing product requires close monitoring in many aspects. One of the final aspect is the ending wall thickness distribution in the product which depends primarily on the geometry and thickness distribution of the parison or pre-container [2,7]. Typically in industrial conditions required distribution of parison thickness is obtained by the trial and error method. However, this process is tedious and its results largely depend on the experience of workers. Moreover, the time and cost of obtaining satisfactory results is usually very high. Helpful solution is to use CAE software Ansys-Polyflow. The software makes it possible to determine the behavior of the plastics during the process, identify areas where there may be the biggest container wall thinning, which reduce the mechanical properties of the product and ultimately to suggest the appropriate geometry and parison thickness distribution in order to obtain a product of given parameters [3–5].

This article is a continuation of the research presented in [10], where for a given parison geometry were done two simulations under isothermal conditions, including one optimization of initial parison profile thickness.

2. Research aims

The information contained in the literature [1,6,8,9,12] shows that there are not possible to obtain extrusion blowing products with a uniform wall thickness distribution on the basis of parison with constant thickness. Additionally parison diameter influence on final product feature. In this case, the selection of parison diameter and wall thickness distribution was to be the most equitable form. It is not possible to do intuitively, but it can be done with available Polyflow software.

The aim of this paper is to stage a series of CAE simulations of blowing parison in non-isothermal conditions. The final effect will be to find parison diameter and geometry, providing the product of a minimum wall thickness 1 mm, while consuming minimal plastics to final product. Also determine the impact temperature distribution along the variable thickness parison on the final bottle thickness is taken into account. Simulations are carried out using Ansys-Polyflow 12.1 software.

3. Process description

The object considered in the Polyflow simulation is axially symmetric bottle, whose shape and dimensions are discussed in the publication [10]. Due to the complexity of the modeling process, blowing in the environment Polyflow, assumptions and methodology of the procedure was described in general terms. Figure 1 illustrated the initial configuration of extruded parison and mold cavity position adopted for the simulation run. It was assumed that the parison material is extruded, while the mold is still open. Both halves of the mold are located $s = 36$ mm to each other (Fig. 1 a,b). Parison height is $H = 154$ mm and initial thickness is $g = 2$ mm. Diameters in following simulations changed every $d = 2$ mm to $D = 14 \div 34$ mm. Material used in the simulations is high density polyethylene HDPE, which have a temperature of $T = 190\ ^{o}$C, viscosity $\mu = 6622$ Pa•s and density $\rho = 0.96$ g/cm³ [14]. Due to the symmetry of the analyzed container, blow simulations can be carried out for the geometry quarter (Fig. 1c). This significantly cut down the time of calculation. The mold and parison model has been imposed on the finite element mesh in ANSYS Meshing module. The run of the whole process starts with the closure of the mold, where the final stage of closing the parison and plastic is welded only in at the bottom or top and bottom parts. It depends on the diameter of the parison. The two mold halves are moving with a velocity $v = 50$ mm/s, and the final welding of parison is followed with slow motion mold. Then blowing pressure is accompanied with a value of $p = 0.9$ MPa and running until the bottles is blown. Total time blowing process simulation is 1 second. More data on the assumptions for the simulation are contained in table 1.

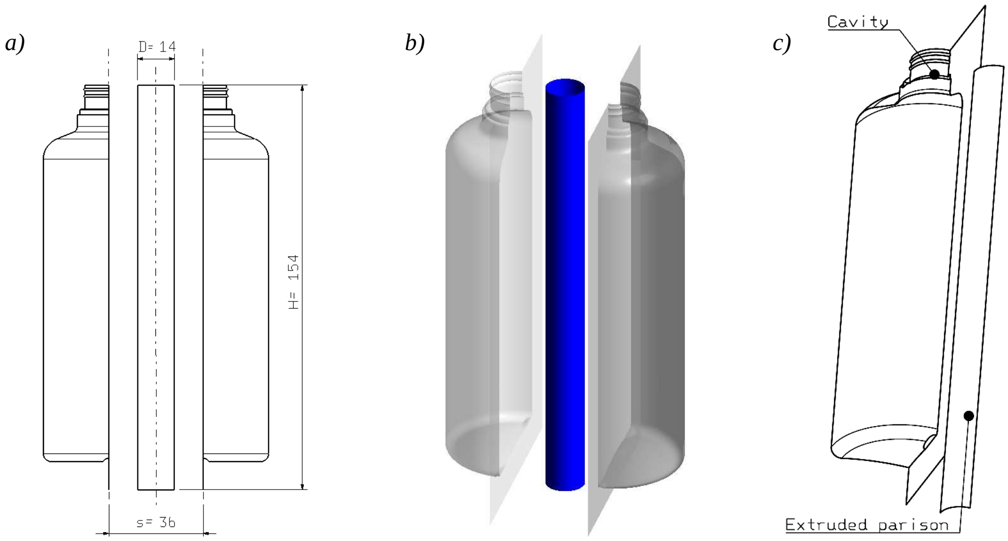

Fig. 1. Considered model: a) mold and parison position, b) CAD model, c) quarter of the mold and parison

4. Simulation results and their analyses

Realized simulations generated series of results, which the selected part is presented below. Figure 2 shows a comparison the distribution of thickness bottles obtained from the parison with a diameter 14 mm in isothermal and non-isothermal conditions, along a given line of measurement. Performed simulations for the initial constant parison thickness with and without taking into account non-isothermal conditions showed no significant differences in the value of the bottle wall thickness distribution. Significant differences were not observed also for the optimized parison, but there is a visible improvement the distribution of wall thickness in bottom area of container compared to the constant initial thickness of parison.

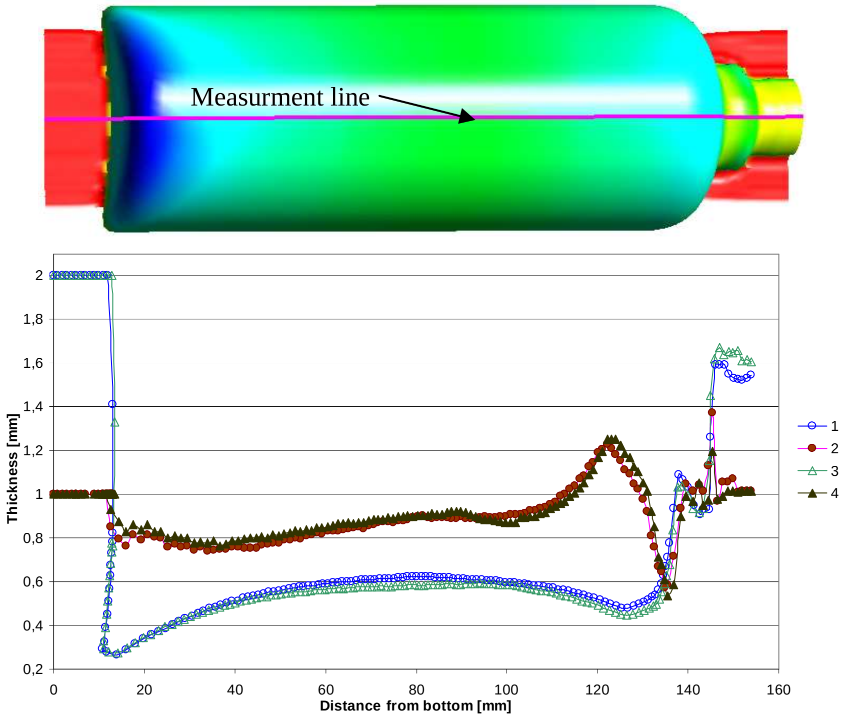

Fig. 2. Comparison part thickness distribution along the measurement line: 1 – initial part thickness under isothermal conditions, 2 – optimized part thickness under isothermal conditions, 3 – initial part thickness under non-isothermal conditions, 4 – optimized part thickness under non-isothermal conditions

As a result of simulation research for exploration in diameter and profile parison thickness satisfies the posed conditions (minimum thickness of wall container is 1 mm at the smallest consumption plastic for the bottle) was obtained in a large number of results. Selected summary is shown in table 1. It is visible percentage distribution of wall thickness obtained for selected diameters of parison, and also gained bottle weight. The posed condition – minimum thickness of wall container 1 mm – fulfill only the simulations with number 12, 15 i 18, for which the initial distribution of parison thickness has been obtained by simulation optimization. Of the three cases, the smallest mass consumption of plastic for blow product obtained for the case of 12 (weight is 27.31 g). Analyzing the obtained results it can observe some dependence. With the increase parison diameter, the percentage bottle wall thickness of less than 1 mm, progressively decrease in subsequent simulations (1 const., 2–3 opty.). In turn, reverse trends reveal the results obtained by weight of bottles, whose value increases in subsequent simulations (1 const, 2-3 opty.), except that the diameters of (30, 32 and 34) mm. An exception may arise from the relationship between the parison diameter and the material waste obtained in the upper and lower zone of the bottle and also minimization the product thickness in these areas through optimizing simulation, where instead parison with a thickness of 2 mm in the lower zone of waste is a minimum thickness of 1 mm.

Tab. 1. Summary of the results obtained for the simulation for the variable diameters of parison: D = 14, 20, 26, 30 and 34 mm, where: const – initial constant thickness of parison g = 2 mm, 2 (opty.) – the first simulation using the optimized parison, 3 (opty.) – second simulation using the optimized parison

Name	Parison diameter [mm]	Type of simulation	Percentage distribution of bottle wall thickness [%]			Weight [g]
			Above 1 mm	Belowe 1 mm	Equal 1 mm	
1	14	1 (const)	17,14	80,44	2,42	13
2	14	2 (opty.)	30,03	58,26	11,71	20,96
3	14	3 (opty.)	41,98	28,18	29,84	22,53
4	20	1 (const)	21,5	77,32	1,18	18,58
5	20	2 (opty.)	34,88	47,84	17,28	23,29
6	20	3 (opty.)	33,9	8,36	57,74	24,69
7	26	1 (const)	39,51	27,35	33,14	24,15
8	26	2 (opty.)	39,76	14,88	45,36	24,83
9	26	3 (opty.)	38,65	1,47	59,78	25,14
10	30	1 (const)	80,6	11,42	7,98	27,87
11	30	2 (opty.)	44,49	3,39	52,12	27,45
12	30	3 (opty.)	44,41	0	55,59	27,31
13	32	1 (const)	85,63	7,57	6,8	29,73
14	32	2 (opty.)	46,48	3,02	50,5	29,14
15	32	3 (opty.)	45,27	0	54,73	29,07
16	34	1 (const)	88,62	6,34	5,04	31,58
17	34	2 (opty.)	52,75	2,86	44,39	30,32
18	34	3 (opty.)	52,07	0	47,93	30,28

Figure 3 summarizes the results of selected simulation blowing plastic parison with diameters 14 and 30 mm. Simulations were carried out in non-isothermal conditions for a parison with a constant thickness and optimized. It is noticeable here resolution to improve the distribution of bottle thickness after the optimization for parison diameter of 30 mm. Graphical display blowing container for two diameters is shown in Figure 4. For parison diameter 30 mm achieved the most desirable distribution of wall thickness in the final container. It was noted, however, double-wall thickening at the bottom of the container in the parting line (Fig. 4d).

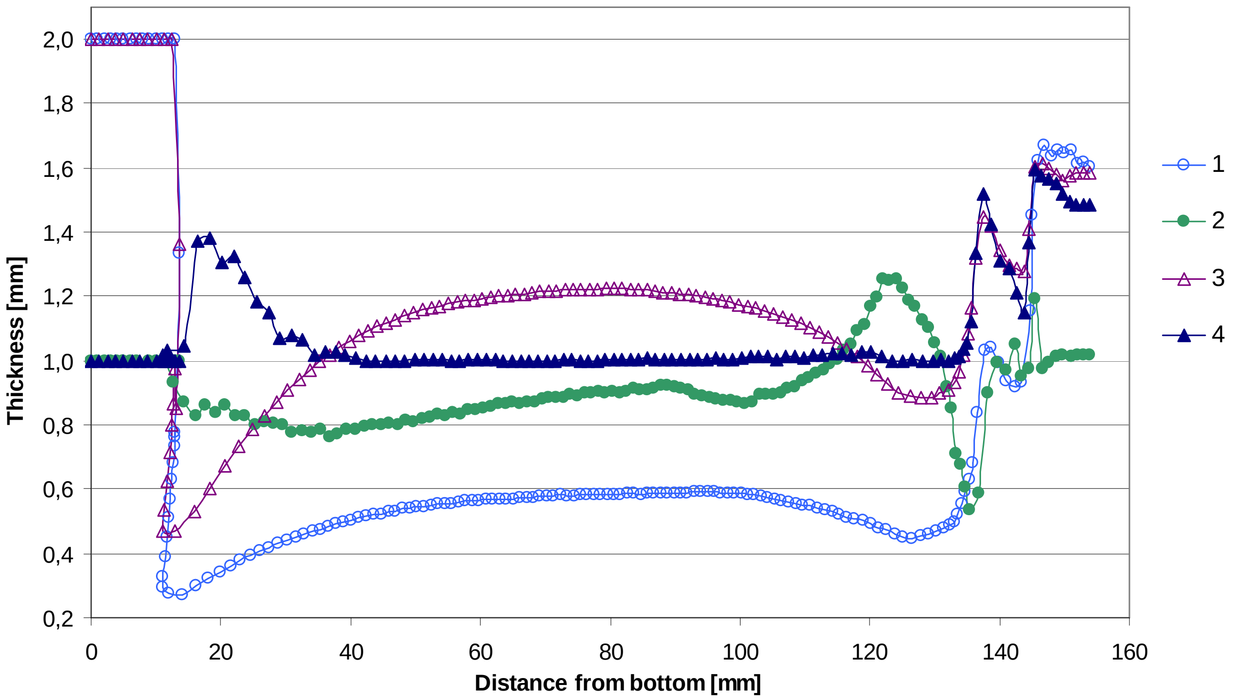

Fig. 3. Comparison part thickness distribution along the measurement line for three cases: 1 – parison with diameter 14 mm, 2 – optimized parison with diameter 14 mm, 3 – parison with diameter 30 mm, 4 – optimized parison with diameter 30 mm

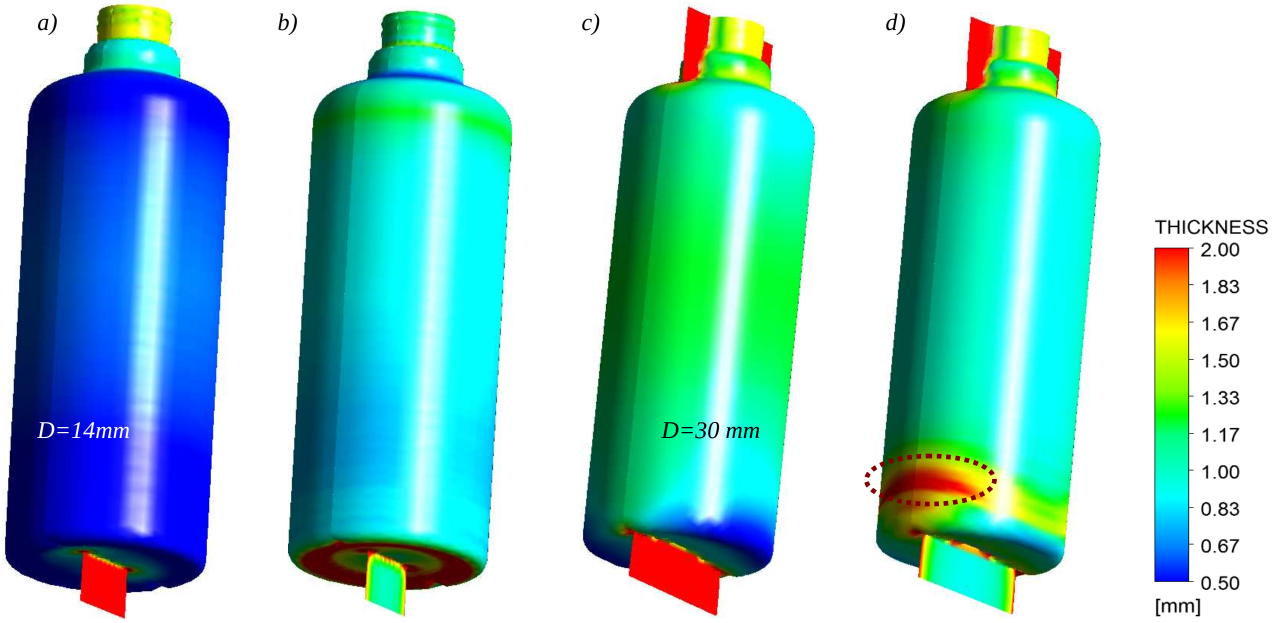

Fig. 4. Final part thickness distribution for parison with diameter 14 and 30 mm a) c) before optimizing, b) d) after optimizing

5. Final consideration and summary

For test cases most thin wall was observed in the final product of the edge bottle areas and the bottom, which is associated with the longest time parison wall deformation in these areas, also the largest plastic stretching in circumferential and longitudinal directions. It follows from this that the bottle wall thickness depends primarily on the shape and dimensions of the cavity mould and varying degrees of individual areas stretching of parison and at different times of contact parison with the mold. Because that the shape of cavity mold is limited desired shape of the product, adjusting the final thickness profile of the container is only possible by obtaining appropriate parison thickness profile.

Performed blow molding simulation in the Polyflow environment allow creations container with improved performance characteristics, obtained as a result of a more even wall thicknes distribution in the container. This is possible due to the selection of the proper parison diameter and their profile thickness. Polyflow simulation allows for minimizing the consumption of plastic on the product while retaining some structural assumptions such as the minimum wall thickness of container. Simulation could even be much more effective for blowing products with complex geometry.

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