Journal of Polish CIMAC
Gdansk University of Technology
The Faculty of Ocean Engineering and Ship Technology

SIMULATION OF BLOWING PREFORM AND OPTIMIZATION THEIR THICKNESS DISTRIBUTION FOR FINAL TARGET SHAPE OF IN CONTAINER

Karol Pepliński, Artur Kubielski

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

Abstract

Injection blow molding is a manufacturing process widely used to produce thin thermoplastic parts and it is best suited to smaller containers ranging in capacity from 1 ml to about 1.5 liters, typically for medical, pharmaceutical, and personal care application [3]. In this paper was presented numerical simulation of the inflation phase of an injection blow molding process under which a polymer preform is deformed into a mould under the action of applied pressure. Two cases of blowing preform were considered: for blowing pressure 4MPa and 2MPa. Simulation starts with constant thickness preform geometry. There has been excessive difference of thickness distribution (about 0,6÷1,6mm) in the bottle after forming. On this basis, was made optimization of the preform profile geometry to remove thickness differences. It was assumption one optimization step to obtain final thickness distribution about 0.3mm and next to optimization steps to obtain hypothetical thickness about 0.1 mm. Noted was a significant effect of the initial preform thickness distribution on the final desirable wall thickness distribution (0.3 mm or 0.1mm) in the considered container. The Ansys Polyflow procedure of optimizing the preform thickness distribution allowed eliminating excessive differences in injection blow molding container.

Keywords: *injection blow molding, Ansys Polyflow simulation, optimization preform geometry*

1. Introduction

In the last 35 years plastics manufacturing technology grow rapidly. The result of this development is a significant increase manufacturing of different product, example injection blowing bottle. According to statistic data, in 2010, Europe processed 46,6 million tons of plastics. The demand of packaging producers accounted for 39% of European market for plastics processing [8]. These data show that the manufacturing of packaging technology, in particular injection blow molding process, is a vital direction of progress of polymer processing. Blowing techniques have some of the greatest opportunities for the manufacturing hollow product example for cosmetics, childes and pharmaceutics [2]. Blowing containers can be produce by popular following resins [3]: HDPE, LDPE, PS, ABS, PP, PVC, PET and polycarbonate.

One of the most important key components during the production of these methods is appropriate selection of technological parameters of processing, as well as initial geometrical features of preform (thickness distribution), to provide positive functional characteristics of final products. Classically in industrial situation required distribution of preform thickness is obtained by the trial and error method. However, this process is monotonous, time dependent and cost of obtaining satisfactory results is usually very high. A good course of action for the proper selection of perform geometric features is the use of computer-aided processing of polymeric materials such as Ansys-Polyflow.

This article is a continuation of the blowing simulation task presented in [5, 6], but here for the first time will be presented blowing preform with is situated in injection blow molding technology.

2. Description injection blowing molding process and simulation task

The injection molding process produces a molded part called a preform. This method is preferred over extrusion blow molding for making small parts that require high production volumes and closer quality dimensions. Injection blow molding consists of injecting a thermoplastic material into a cavity and around a core rod producing a hollow test tube (preform). The preform can be injection molded in a profiled shape that corresponds to the requirements of the blow mold form. The molded preform still on the core rod is transferred to the blow mould. The mould is clamped around the preform and air is blown to shape of the cavity. The preform is injected onto a support pin or core, which forms a neck with threads to their required dimensions. The preform is then blown against the cavity wall to its final shape [2, 3, 4].

The information contained in the literature position [1, 2] shows that there are not possible to obtain injection blowing products with a uniform wall thickness distribution on the basis of preform with constant thickness. Additionally preform diameter and geometry influence on final product feature.

Computer-aided design can give many useful facts. One of this is reduce plastics consumption for final bottle. Excessive thick of the bottle wall is not desirable. One of the assumptions of bottle design stage is uniform thickness of final bottle which was brief foredesign. Ansys-Polyflow can eliminate trial and error stage and help minimize the time and energy using for starting and realizing production stage. One of the most important element of the injection blow molding process is initial state of perform (geometry and temperature distribution). Each final shape of container should have preform with individual range of geometry and plastics processing parameters. Improper selection of perform geometric features may result in lack of a precise blow mold mapping, poor distribution of wall thickness, or too little of the final strength of the product. Ansys Polyflow software allows determining the appropriate distribution of wall thickness in preform by realizing the blowing simulation.

The aim of this study was to simulate blowing preforms for the real model deodorants roll-on (Fig. 1) using different blowing pressures and optimization perform test for final wall thickness distribution of bottle. Much more information about Polyflow applications was described in previous author publications [5, 6].

The aim of this paper is to stage two series of CAE simulations of blowing preform for different blowing pressures and some optimization stages for preform geometry: first task include changing geometry for final uniform container distribution about 0.3 mm and second for the 0.1 mm. The final effect will be to find preform geometry, providing the product about these values.

Fig. 1. Considered real roll-on bottle geometry

3. Process description

The study object to realizing simulation stages was draft on the CAD system (surface model), but the geometry was be simplification to shape seeing on Fig. 2. Preform height is 90 mm and their diameter is d_1=20 mm. Height of container is 93 mm. The hoop ratio (HR) [3] in our analyzed object has average value HR=1,2÷1,5. For the standard injection blow molding process preform height should be similar to the height of container but always little shorter [2]. For the study model assumed only a "quarter-object", because it was symmetrical about two planes perpendicular to each other. The initial thickness of the preform was g = 2 mm. The material for perform is PEHD, which have a temperature of T = 120 °C, viscosity μ = 7350 Pa•s and density ρ = 0.96 g/cm^3 at the moment of blowing stage. On the first stages of simulation value of blowing pressure was 4 MPa (Fig. 3-4) and for the second stage: 2 MPa (Fig. 5b,d).

The simulation blowing time for standard power computer depended on grid layouts, which on this item were about 65 thousand MES elements. For the corresponding grid (about 215 thousand elements) a container calculations are taking too long to be able to be carried out to the end (within 18 hours converted just 15 simulation steps by the program with about 250 expected).

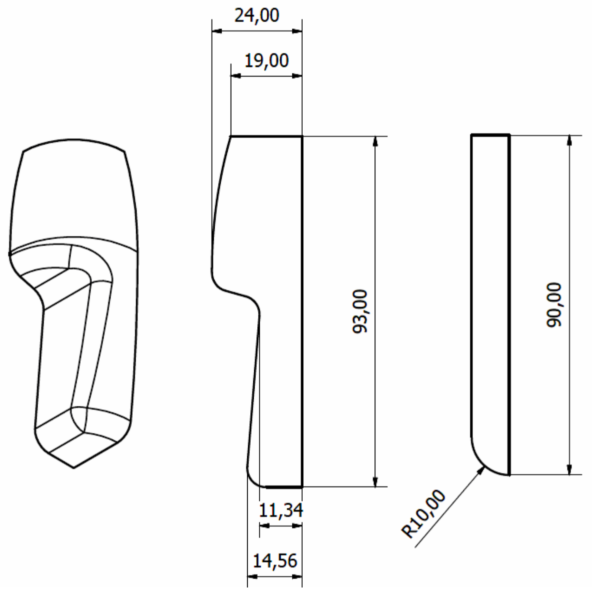

Fig. 2. Simplification bottle CAD geometry conmtainer model (left) and initial preform shape (right) with dimensions

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 container obtained from the preform with constant thickness. It was observed non-uniform thickness distribution (Fig. 3b). Excessive thickness can cause some minimal deformation of container in this place. Also it can generate so long cycle time in cooling process and unnecessary consumption of energy using. Preform with different initial geometry (Fig. 3c) help obtain final container with much more uniform thickness distribution (Fig. 3d).

First of all, showing the perform wall thickness distribution and final bottle for subsequent optimization steps for the first (Fig. 3b) and second (Fig. 4a). Each perform optimization step (first and next second) changes the form of perform geometry. The program adjusts the preform so that the largest possible part of the final container surface has reached the desired thickness. Already the first optimization allows reducing the consumption of polymer material. The greatest preform thickness are on the place when the blowing time is longer and depend on blowing ratio and bottle geometry.

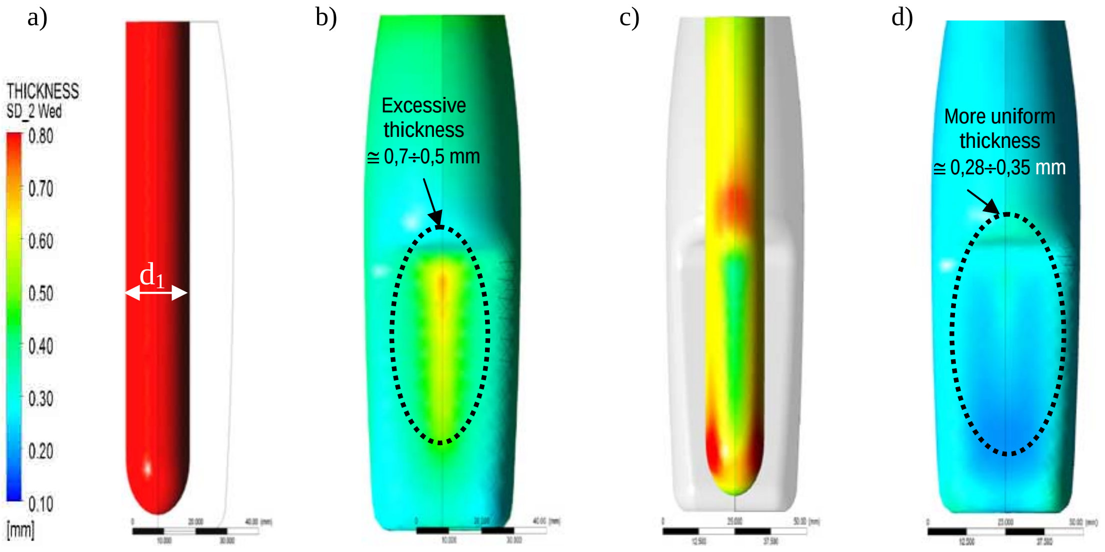

Fig. 3. Comparison part thickness distribution as a result of different perform geometry for optimization assumption 0,3 mm: a) perform with constant thickness geometry g=2, b) container with non-uniform thickness, c) perform with optimized thickness geometry g=0,8÷0,45mm, d) container with much more uniform thickness distribution g=0,28÷0,35mm

For final desirable final hypothetical wall thickness distribution about 0,1 mm it was realized two stage of preform optimization (Fig. 4). It can be seen that each steps give different preform geometry and final wall thickness distribution in container. For the first optimization average wall thickness is (0,20÷0,29mm). After second optimization the container has a thickness value (0,1÷0,25) near to desirable, but still it is not uniform. In this situation it can be positive reaction to tray change diameter geometry of preform d_2= 1,5d_1 or realized third stage of optimization. But this can be done in the future research.

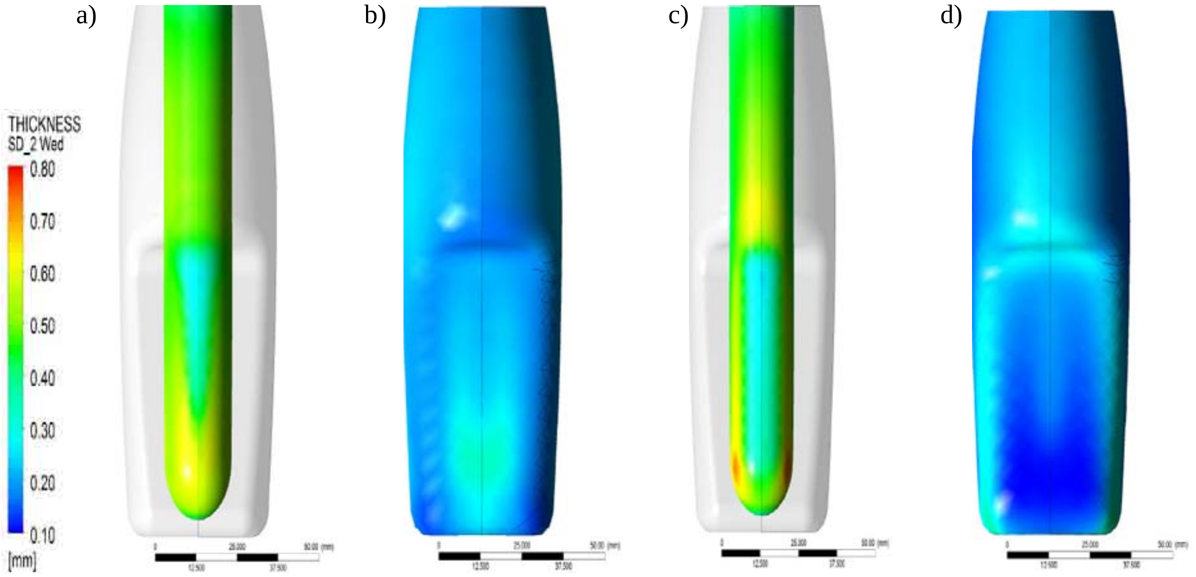

Fig.4. Contrast part thickness distribution as a result of different evaluation perform geometry for optimization assumption 0,1 mm: a) perform in the first optimization stage, b) container as an effect of first preform optimization, c) perform in the second optimization stage, d) container as an effect of first preform optimization

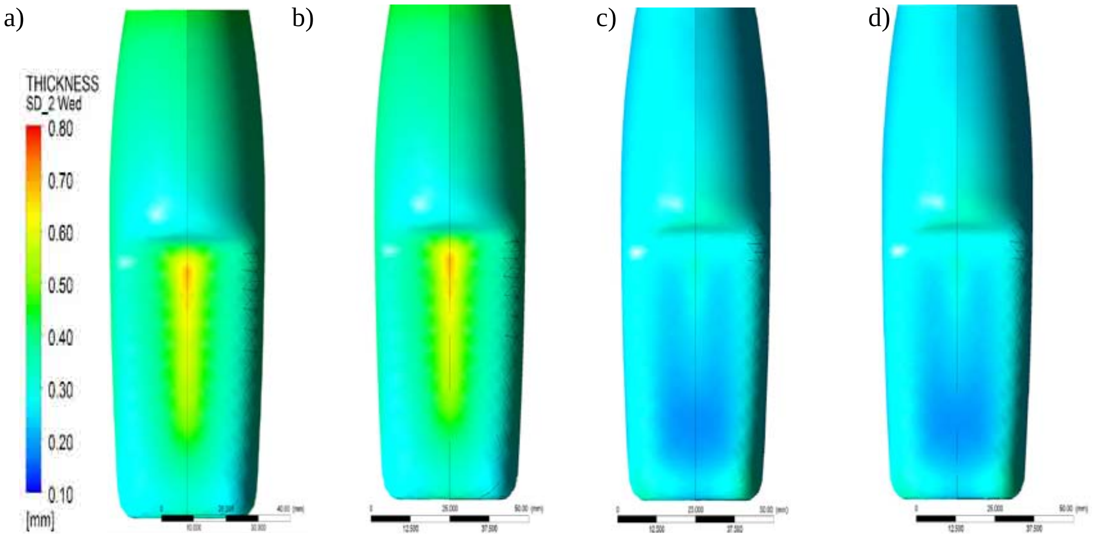

Fig.5. Compare of part thickness distribution as a function of different blowing pressure: a-b) container as a result of constant initial preform geometry and blowing pressure 4MPa and 2MPa, c-d) container as a result of optimization initial preform geometry and blowing pressure 4MPa and 2MPa

Finally, it should be added that the software also allows the presentation of a given stage of blowing in a certain time moment, as illustrated on the Fig. 6.

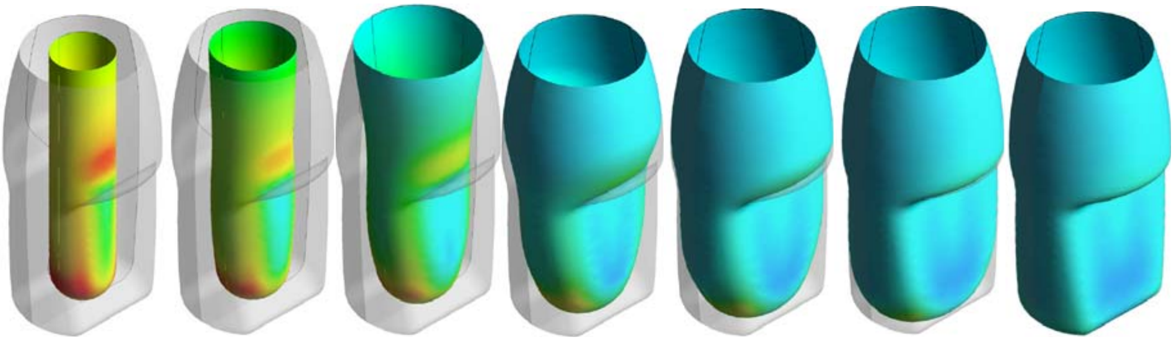

Fig. 6. Simulation stages during preform blowing in different time stages

5. Final consideration and summary

An optimization technique for injection blow molded products was made in Ansys Polyflow software. It was shown that the technique could be useful to design the preform wall thickness distribution such that the final product was at a target thickness. Research has allowed optimizing the geometry shape of the preform to the desired shape of the container. It was obtain the distribution of wall thickness, which helped achieve the goals of research (wall thickness product - WTP g_1 = 0.3 mm and g_2 = 0.1 mm). This thickness assumptions in the optimization simulation stages can have different value, ex. g_i= 0.5 mm. It is only dependent on author assumption.

Software Ansys Polyflow, enables to carry numerical experiment in the range of phenomena modeling during the injection blowing process. By steering wall thickness distribution on initial preform it is possible to get the more profitable wall thickness distribution of formed containers. Especially in the case of complex geometry in blowing product we have new opportunity of applying the technology of blowing forming. Numerical analyses can reduce energy consumption during injection and cooling stage as an effect of more uniform thickness distribution of final container.

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