



SELECTED ASPECTS OF VIRTUAL PROTOTYPING THE BLOWING PREFORM PROCESS IN THE ANSYS-POLYFLOW SOFTWARE

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Abstract

Technological processes of blowing the polymer preform occupy a prominent position among the widely understood blowing technology side extrusion blow molding or direct injection blow molding. Efficient design of a structural preform for a specific final polymer product needs to give its geometric form suitable thickness distribution in the different peripheral sites under consideration of the preform and the appropriate temperature field adapted to the blow ratio and the final geometry of the product or user requirements. Often it is a time consuming task in the absence of adequate knowledge about the blowing process phenomenality in general-purpose software Ansys–Polyflow. This may result in the occurrence of different errors in the numerical calculations. In a virtual design of Polyflow environment is possible to check whether a particular geometry application specific blowing preform parameters and their impact on the final form of a product.

Keywords: *blowing preform, virtual prototyping, Ansys-Polyflow simulation, blowing abnormalities*

1. Introduction

Blow molding of polymers is one of the main processes of plastics processing. For blow molding technologies include, in particular: extrusion blow molding (EBM), injection blow molding (IBM), injection stretch blow molding (ISBM) and 3D blow molding (3DBM). Injection blow molding is the third largest share of these four technologies [1]. The products formed in the injection blow molding technology, compared to the extrusion blow molding, are formed without the technological wastes (flashes). For complete implementation of the process involves the following steps: injection a molten plastic into the mold cavity to form a parison with a given geometry, the stabilization of heat to a certain temperature blow molding processing, transfer preform to blow cavity, blowing with compressed air, cooling and eject a product of the form [2].

Nowadays, due to the increasing need to market the blowing products relating in particular to minimize material and energy requirements [8] on the unit implementation plastics process, it is necessary to take into account modern and advanced computer aided (CA) tools – computer simulations. In the present case concerns software dedicated to computer aided blowing materials such as: Polyflow, Abaqus, BlowView, Simblow, B-Sim, etc. Often, the carry out these tasks in a virtual environment requires a broad knowledge of polymer processing such as: polymer rheology, knowledge processing technology, the design principles and current realities of technological machines. However, it should be noted that thanks to advanced CA and technology tools of

machinery and equipment was possible in the past 30 years reduce bottle weight: for extrusion blowing product – average of about 100%, and the injection blow bottles with about 30% [9].

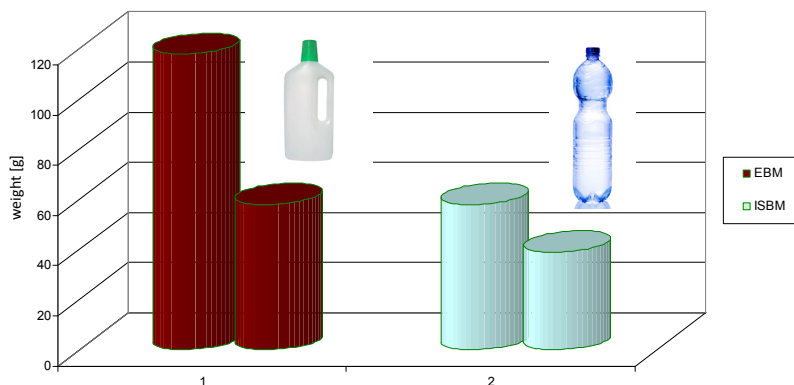


Fig. 1. Reducing the weight of the blowing product over the last thirty years, for example, bottles made in the EB and ISB technology [9]

2. Outline of Polyflow design simulation

Outline of simulation design using CAE software to the design blowing process involves several consecutive stages. The most important and advanced step of virtual modeling and design is environment of Polydata module.

The first step necessary for the simulation is to create or import the geometry of the test piece of software CAD3D. For this purpose is using a module Design Modeler. In the realized task used in surface models without thickness attribute. Then, in the module ANSYS Meshing, applied to the model, finite element mesh and determines the characteristics and parameters. There are several possible choices in the types of networks in this module: automatic, square (Fig. 2a), triangular (Fig. 2b), mixed referred to as a square – triangle (Fig. 2c).

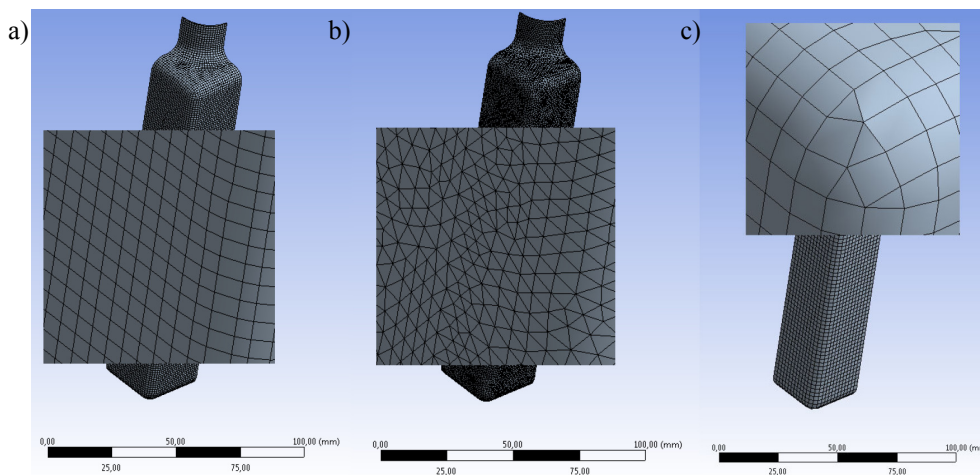


Fig. 2. Types of finite element mesh: a) square grid, b) triangular mesh, c) net mixed

Type of selected grid has a significant impact on the accuracy of reproduction the object surface during the implementation of numerical calculations for blowing preform. The basic parameters of the grid depend on its type. Typically, the accuracy of numerical calculations depends on degree of the net density. There is also the possibility to use different grids for each object (preform – mold).

Thanks to Face Sizing option can be determined various parameters of the grid for each of the

planes of a single object, which can significantly control the accuracy of the location of the grid, the appropriate density and time calculations. Another important option that is available in the ANSYS Meshing module is optional Virtual Topology. It enables connect the surface with a common edge. The operation to remove the division edge of the surface changes the distribution grid. Its use generally results in an increase in the number of finite elements used to create the grid (maximum increase in the number of finite element simulation during realizing task exceeded 40%). This option is shown in Figure 3 This module also defines the boundary conditions in the consideration issues.

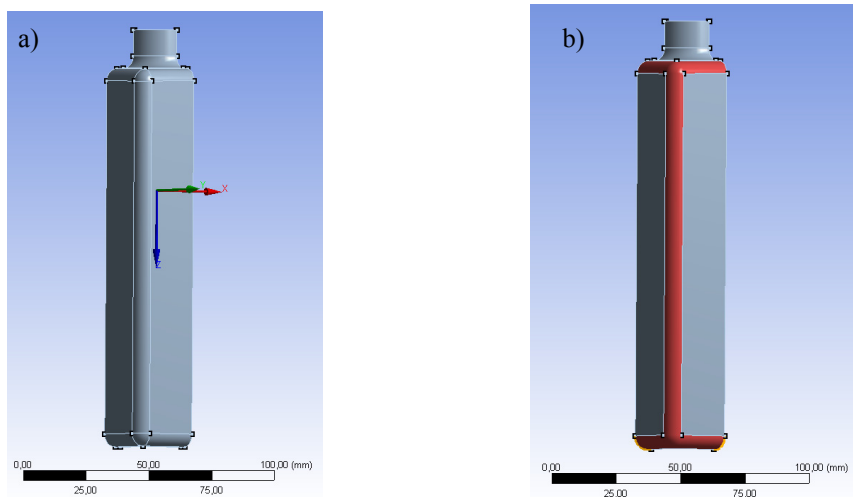


Fig. 3. Virtual Topology option: a) detail before using Virtual Topology, b) detail after use of this option

Polydata module represents the next stage of design simulation. It is introduced in the material parameters (such as: viscosity, density, heat capacity, etc.), blow-molding processing conditions (pressure and blowing time, preform temperature and wall thickness) and flow conditions (the type of flow, the type of liquid polymer used in the simulation). Introduced the parameter values associated with the same simulation, among others: its duration, the maximum number of steps. Adaptive Meshing option available in Polydata module allows inherent thickening grid in sensitive areas during the implementation of numerical calculations. Typically, the connection surfaces are arranged relative to each other at a small angle or a small radial passage. By using this option, the grid can be compacted as much as 16 times. The use of auxiliary tasks as a postprocessor allows for batch files for the next steps (simulation) optimization. The optimization can be carried out in terms of the volume of the bottle, the weight, the temperature distribution or preform distribution thickness. Following the establishment of the relationship and specific processing conditions for the object, it can proceed for numerical computations in a module Solution.

The final step is to present the results of the simulation. Visual presentation is made possible by the use of CFD Post module. The module allows you to present selected individual calculation steps in the form of color objects. Results can also be displayed as graphs. This module allows the simultaneous presentation of the results of different parameters.

3. Selected errors in the design and implementation of simulation

Simulations of improper conduct are a significant problem in the design of polymer processing and associated with relatively large waste of time, even last twice as long as simulations programmed in the right way. It should be noted, however, that the wrong course of simulation calculations can be seen even after a small number of steps, others become apparent only after several steps. It is worth mentioning that during the complex process of optimization problems

blowing and difficult to predict outcomes, it is not easy to choose the right strategy in dealing with the simulations carried out. One way to quickly selecting the mistake is to monitor the simulation, but this requires the user to sacrifice a significant amount of time during several hours of calculations.

The most common mistakes made by users include incorrectly described the boundary conditions (Fig. 4), incorrectly selected processing parameters such as the range of process temperature, the blowing pressure setpoint value and the incorrectly chosen finite element mesh. Sample preform geometry with inadequately described boundary conditions, it is not blown only gradually flattened and deformed into one of the walls. The breakthroughs around sharp corners of the mold (Fig. 4d) are formed in the absence of sufficient quantities of material. The wall thickness is determined by the program as a negative.

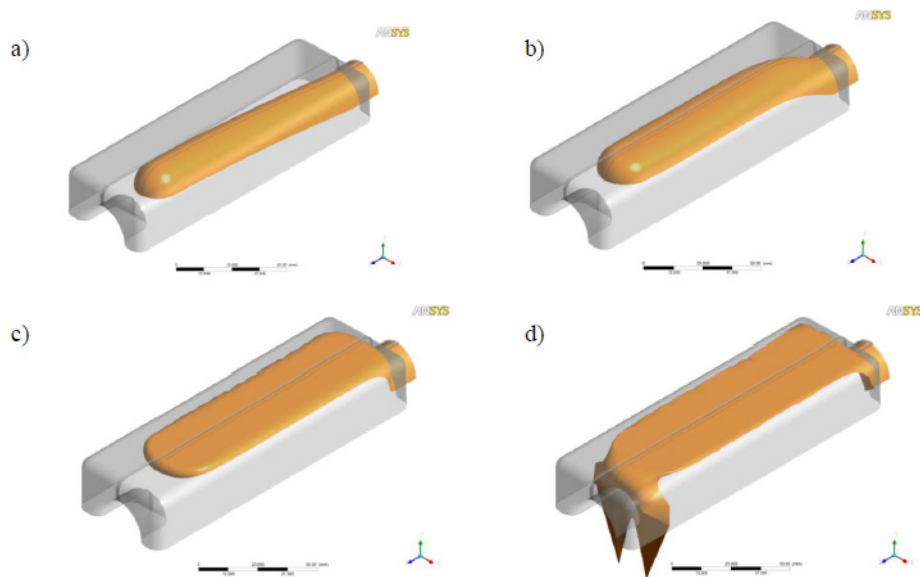


Fig. 4. Errors associated with the inappropriate selection of the boundary conditions: a), b), c), d) - improperly running blow process stages

If you specify the wrong temperature range processing in conjunction with preform thickness occurs of irregularities blow the wall. Area with the lowest temperature of 91°C (Figure 5, indicated by the field - blue) is simultaneously the zone with significantly increased wall thickness, thickening is more than six times as compared to the zone at a temperature of 120°C. Thickening and the much lower temperature caused a much slower blowing (stretching) of the area, resulting in each other superposition and penetration of the two layers of the stretched material, and an error simulation (Fig. 5).

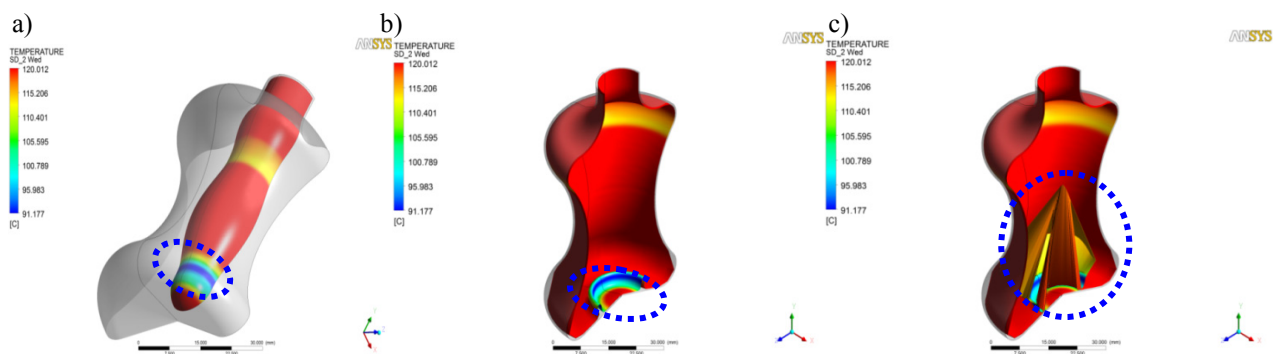


Fig. 5. Improperly selected interval processing temperature range blowing preform: a) preform during the initial blowing to the area of reduced temperature, b) the beginning of the visible improper preform blowing, c) the penetration of thin layers of material in the border area of low and high temperature fields

4. Summary

Virtual prototyping of blowing preform process often requires an amendment at the stage of the finite element mesh or modifying certain boundary conditions, material properties or conditions associated with the process window of blow molding processing: temperature, pressure, etc. Also, as soon as possible in order to identify design errors and accuracy of the simulation running should monitor the course of the calculations in the module CFD Post, and not only upon completion of the calculation. Many other correct blowing simulation results are presented in previous publications [3-8]. It should be noted that despite the difficulties during the implementation of virtual prototyping blowing process, should use this tool because of the opportunity to test a specific geometry or application specific blowing preform parameters and their impact on the final form of a product beyond the typical industrial conditions.

Literature

- [1] Kutz M., *Applied plastics engineering handbook*, 1st ed., pp. 280 – 284, Elsevier 2011
- [2] Belcher S.L., *Practical guide to injection blow molding*, Taylor & Francis Group, 2007.
- [3] Pepliński K., Mozer A., *Ansys Polyflow software use to optimize the sheet thickness distribution in thermoforming process*, Journal of Polish CIMAC, 6, Gdańsk 2011.
- [4] Pepliński K., Mozer A., *Design of extrusion die for plastic profile using Ansys Polyflow software*, Journal of Polish CIMAC, 6, Gdańsk 2011.
- [5] Pepliński, K., Bieliński, M., *Polyflow software use to optimize the parison thickness in blowing extrusion*, Journal of Polish CIMAC, 4, Gdańsk 2009.
- [6] Pepliński K., Mozer A., *Ansys-Polyflow software use to select the parison diameter and its thickness distribution in blowing extrusion*, Journal of Polish CIMAC, 5, Gdańsk 2010.
- [7] Pepliński, K., Bieliński, M., *Processing and functional properties of the containers prepared by blowing extrusion in variable processing conditions, and evaluation of yield and quality of the process*, Polimery, 54, nr 6, pp. 448–456, 2009.
- [8] Pepliński, K., *Select technical aspect of energy using and management in injection molding process*, Journal of Polish CIMAC, 6, Gdańsk 2011.
- [9] Metwall H., *Virtual prototyping for the blow molding industry*, Ansys U.S.A. 2012.

