Simulation Of Blow Molding Of Polyethylene Bottle Using Ansys Polyflow

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Abstract - *Blow Molding is one of the most versatile and economical process available for molding hollow materials. 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. ANSYS Polyflow software is used extensively to design and optimize processes such as extrusion, thermoforming, blow molding, glass forming, fiber drawing and concrete shaping.*

ANSYS Polyflow software shall be used to predict the blow molding behavior on the effect 34 mm diameter parison the final wall thickness distribution and stress contour occurred. Polyethylene (PE) ASTM D4101 shall be used as the parison materials and aluminum as mould material. PE has excellent moisture resistance, low density, good fatigue resistance, high flexural strength and good impact strength.
This project consists of the blow molded part of 100ml medicine bottle. The objective is to optimize a blow molding process such as to achieve the required thicknesses with material economy. The problem deals with the cavity filling stage of the molding process that encompasses bending and its effect with change in wall thickness and designs; and studying the hoop stiffness of different bottle designs were the secondary focus here.

Key Words: blow molding; ANSYS Polyflow software; parison; bottle designs; Polypropylene; hoop stiffness; hollow materials; preform.

1. INTRODUCTION

In today's competitive foundry industry, manufacturers are aiming for reliable products with characteristics such as light weight, high-quality parts, defect-free output and minimal lead time, all at the lower level of investment. One of the obstacles of its emergence as a major product on the market is the added cost of fabrication and a large uniform thickness distribution. Blow molding technologies will be used in these studies for the improving the quality of plastic products for the replacement of conventional blow molding techniques. Blow techniques have many advantages over that conventional blow molding such as higher part quality in more uniform wall thickness distribution, maintained the mechanical properties, lower regrind content and lower flash weight. The temperature control, blow pressure, time control, thermal properties and die design is a important variable that need to be consider in production to has a better final products . Packaging is an important step of the production process that involves delivery of the final product to end users. In particular, materials used in beverage packaging that deals with carbonated and non-carbonated drinks has shifted from glass and Aluminum to high performance polymers such as polyethylene (PE) owing to their superior mechanical properties, ease of manufacturing and low cost. For example, one can readily see the melt temperature is suggestive of the lower cost in manufacturing since glass has the highest of the three and polymers the lowest. Even with the lower cost to process PE, the industry has evolved to further expand the gap. One of the greatest pushes in this area is called "light weighting," where unnecessary material is designed out of the package, saving weight. Light weighting not only reduces the material usage but also minimizes impact on the environment; this has been a driving force behind substantial research in this area. For design optimization, it is critical to evaluate the structural performance of bottles under different loading conditions. Injection stretch blow molding is a manufacturing process of PE that yields non-uniform thickness and material properties along the length of the bottle. Understanding the behaviour of PE, observing the changes in non-uniform thickness and material distribution are also key factors in assessing the design and structural performance.

1.1 PROBLEM DEFINITION

ANSYS Polyflow software shall be used to predict the blow molding behaviour on the effect 34 mm dia parisonon the final wall thickness distribution and stress contour occurred. Polypropylene (PE) ASTM D4101 shall be used as the parison materials and aluminium as mould material. PE has excellent moisture resistance, low density, good fatigue resistance, high flexural strength and good impact strength [1, 2]. The PE property is shown in Table 1.

The graphical sketch of bottle is referred the design according by M/S Shirsh Technosolutions Pvt. Ltd. .The design cavity should meet the equation 1 and 2 requirements.

Blow ratio equation for one cavity mould halves (M, 2009)

Cavity–Cavity Blow Ratio = W>D (1)

Blow ratio equation for 2 cavity mould halves

Cavity – Core Blow Ratio = W>2D (2)

w=diameter and a depth, d=radius (2:1)

Table -1: Properties of Polyethylene

Properties	Values
Temperature, T	190°c
Viscosity, µ	100000 Pa.s
Density,	0.906 g/ cm^3
Gravity, g	-9.81g/cm^2
Pressure, p	0.9Mpa
Yield stress	25Mpa
Thermal Coefficient of expansion	100-150 x 10^{-6}
Melting point (recommended)	210C-240C
Elastic modulus	840MPa
Tensile Strength	32MPa

The preliminary parison is of uniform thickness 3 mm with initial mean diameter 34 mm and length 120 mm, blowing pressure, p is 2.0 MPa and density is 2.7g/cc.

The blow molded part is 100ml medicine bottle. Its various sections can be divided into 3 parts viz. mouth, body & base. Mouth is the top narrow portion of the bottle which assists in controlled pouring of liquid. Mouth is the thickest (2.5-3 mm) part of the bottle for further specified purposes such as, incorporate threads for cap, rigidity during bottling (filling liquid at packaging centre) and to avoid buckling/crippling of neck due to stacking/dropping. Body is the storage volume with least/optimum thickness (0.5-0.7 mm) to hold liquid against hydrostatic pressure and also the bottling pressure. Base has medium thickness (1.2-1.7) with concave shape to give rigidity during bottling and to avoid warping after blow moulding process. Its concavity also serves for good stability. Thus, we have to optimize a blow molding process such as to achieve the required thicknesses with material economy keeping in mind.

Assessing the design features of the bottle; studying the bottle subjected to bending and its effect with change in wall thickness and designs; and studying the hoop stiffness of different bottle designs were the secondary focus here. Apart from that, stability (structural performance) of light weighting of bottles by thickness values shall be determined.

This problem analyzes a blow molding simulation for a 3D bottle. The problem deals with the cavity filling stage of the molding process and it is assumed that a parison has been positioned inside the mold. The contact between the fixed mold and the parison is considered.

A large pressure is applied to the parison, which enters the mold and eventually takes its shape. The operating conditions is accounted for a low pressure drop at the entrance, low material waste, and slow cooling to avoid premature solidification of the preform.

The domain for the problem is divided into two subdomains: one for the fluid parison (subdomain 1) and the other for the mold (subdomain 2). Incompressibility and momentum equations are solved in subdomain 1 (the fluid parison). Parison will eventually come into contact with the mold, and its position is calculated as a part of the solution. The fluid parison has a density of 0.906 g/cm3and a viscosity of 100000Pa.s Inertia terms and the effects of gravity will be included in the calculation.

2. DESIGN BY ANALYSIS

In this study, ANSYS Polyflow software was used to predict the blow molding behaviour. This chapter gives the CFD (Computational Fluid Dynamics) of the PE bottle. In order to analyze the thickness of the bottle formed, Finite Element Analysis (FEA) was performed using ANSYS Polyflow and the data generated was quantified using Simple Digitizer. The simulation task is divided into five stages. First, the 3D models of the mould and parison shape circular cross section was developed at geometry stage. The visual of model is formed in one half of the mould. The graphical of bottle is sketch referred the design according by M/s Shirsh Technosolutions Pvt. Ltd. . The diameter of the bottle is 41mm and overall height is 106mm. The simulation starts with the generation of mesh and the value of element size was set to 2mm. The mesh is done to divide the geometry into cells or control surfaces. Next, the simulation parameter and specific materials for the mould and parison was set up. Table 2 shows the assumption parameters were considered in this simulation. Next step was set up the condition of analysis for operating at setup stage. Lastly, the behaviour of plastic during the process and the wall thickness distribution and stress contour results can be viewed in 3-D graphic at result stage.

Table 1: The parameter input for simulation

Input	Data
Element size	2 mm
Viscosity	100000Pa.s
Density	0.906g/cm^3
Gravity	-9.81 m/s^2
Slipping coefficient	1e+09
Penalty coefficient	1e+09
Inner free surface	-2e06
Initial time value	0
Upper time value	1.0000000e-01
Initial value of time step	1.0000000e-03
Max value of time step	1.0000000-e07
Tolerance	1.0000000e-02
Max number of Successful step	200
Number of step	4

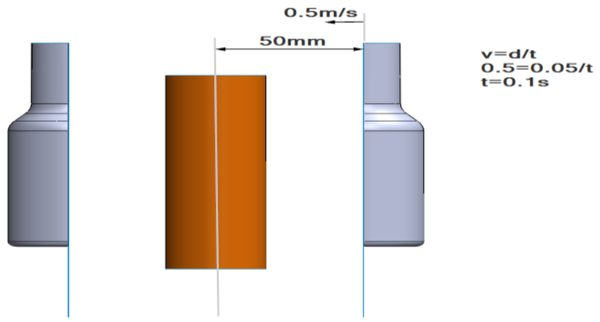


Fig-1: Mold for syrup bottle container showing parison geometry

Steps in Injection Blow molding analysis using polyflow:

1. Launch ANSYS Workbench.

2. Create an ANSYS Fluid Flow - Blow Molding (Polyflow) analysis system in ANSYS Workbench.
3. Import and edit geometry using ANSYS Design Modeler.
4. Create a computational mesh for the geometry using the ANSYS Meshing application.
5. Fed Data in to Polydata setup of polyflow program for the die motion rate and materials and operation conditions.
6. Calculate a solution using ANSYS Polyflow.
7. View the initial results and create an output parameter for the thickness variation in CFD-Post.
8. Generate results of thickness variation for iterative design points.

The parison has the following material properties in SI units:

- Model: shell model, Gen. Newtonian isothermal
- Viscosity = 10^5 Pa.s
- Density = 906 kg/m^3

From a geometric point of view, the initial parison has the following dimensions are: height = 120mm, radius = 34mm, initial thickness = 3 mm

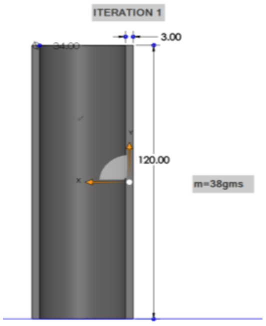


Fig -2: Initial Parison Dimensions

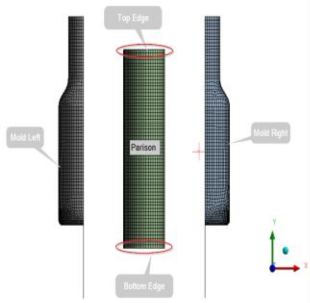
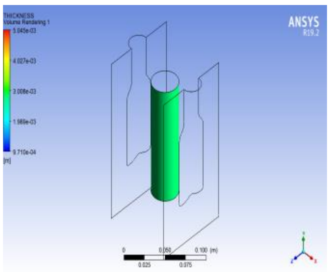


Fig-3: Finite Element sub domains and Boundary set

The two halves of the mold moved into contact with the parison, where it became pinched, and a pressure was applied to the parison. This blew the parison into the mold where it assumed the shape of the mold, which was a bottle in this case. The output in terms as thickness at various time, can be seen as shown in following figures.



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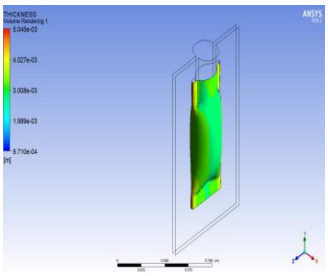

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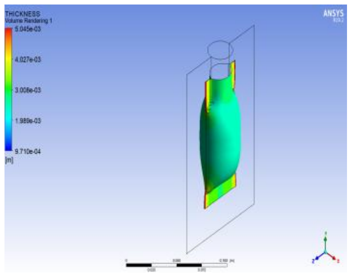

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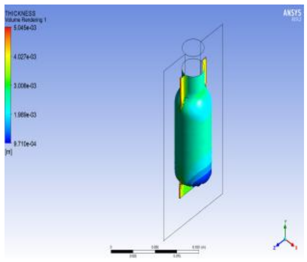

Time=1s

3. CONCLUSIONS

Above sections figure shows the results of wall distribution thickness at the surface contour on the bottle obtained from parison diameter from initial time from 0 sec until the blowing process finished at time 1sec. Dark blue depicted the region is too thin and can be acceptable for safety reasons and yellow and red colour depicted the region can be economically attractive. The wall thinning influenced to the mechanical properties of the product. The wall thickness on red region was more thick compare to blue region was thinner because the forces on the upper of the bottle is too high to maintain the bottle strength. It is decreasing the thickness slowly until the uniformly surface along the bottle. At the bottom of bottle the thickness become high because it wants to support the density of the bottle when the water was insert into the bottle.

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