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Design and Analysis of Parison Blow Molding Using Adaptive Mesh

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Abstract: Blow Molding is one of the most versatile and economical process available for molding hollow materials. When polyethylene is stretched, it exhibits strain-hardening properties, which are temperature, pressure, velocity and strain-rate dependent. In this paper, preform is made by extrusion and forced between two halves by pressurization. This process includes isothermal and transient flow of Newtonian fluid in complex geometries simultaneous with structuring and solidification. A time dependent problem is defined and setting material properties and boundaries condition for bottle blow molding. Numerical data available in POLYDATA for a time dependent problem using ANSYS POLYFLOW were applied. Results display in form contours associated with different variables at different time steps and good agreement with the bottle thickness profile is observed. In this paper, the analysis of the stretch-blow molding (SBM) process of polyethylene terephthalate (PET), parison plastic bottles is studied by the finite element method (FEM). A hyper elastic constitutive behavior was calibrated using material data available in literature in variant high temperatures and strain rates and was used in the numerical simulation. Hydrostatic pressure with convention heat transfer has been used instead of a blowing process. Comparisons of numerical results with experimental observations demonstrate that the model can predict an overall trend of thickness distribution. Through the study, it becomes clear that the proposed model is applicable for simulating the stretch-blow molding process of PET bottles, and is capable of offering helpful knowledge in the production of bottles and the design of an optimum preform.
Keywords: Parison, stretched blow molding, polyethylene terephthalate (Pet), finite element method.

I. INTRODUCTION

Extrusion blow molding (EBM) is used to produce hollow parts. In the process, a molten tube, or parison, is extruded into a mold cavity and injected with compressed air; the parison expands outward, forming a hollow article in the shape of the cavity. Traditionally, rubberlike hollow parts could only be achieved through the injection molding of thermo set rubber (TR). However, the invention of thermoplastic elastomers (TPEs) that can be extrusion blow molded, allows rubber-like articles to be produced cost effectively and with significant advantages.

A. Injection Blow Molding

Typically, injection blow molding is suited to production of products that are light (<100 gm/<.22lb), usually ready for immediate use directly out of the mold, they require very little finishing. However, compared to extrusion blow molding, tooling costs on a cavity-to-cavity basis are higher, since blow molds, core rods and injection molds are all necessary to the process. As a result of the relatively high tooling costs, injection blow molding is typically used for large production runs.

B. Extrusion Blow Molding

Extruder operation with a stationary mold is the simplest possible blow molding arrangement. The stationary mold is located directly below the crosshead die that extrudes the parison between the mold halves. There may be several molds if more than one parison is extruded simultaneously. Air is blown into the mold usually through the core in the die or through a mandrel (blow stick) inserted from below. In intermittent extrusion blow molding the extruder screw operation is halted when the parison has reached the desired length.

II. LITERATURE REVIEW

Blow molding is a manufacturing process by which hollow plastic parts are formed.
In general, there are three main types of blow molding; Extrusion Blow Molding, Injection Blow molding, and Stretch Blow Molding. Molding is the process of manufacturing by shaping pliable raw material using a rigid frame or model called a mold Injection blow molding

Injection blow molding is a two stage processes since the parison is produced in a separate operation. In the first process molten plastic is injected into a heated preform mold around a hollow mandrel blow tube or core rod. This is similar to insert injection molding. The workpiece for the second, blow molding, process is the preform-mandrel assembly. The preformed parison is placed in a larger mold cavity for blow molding. Between the preform production and blow molding processes a heated preform may be héld in a temperature conditioning stage or a cooled preform re-heated. After blow molding the part is stripped from the core rod at an ejection station Injection The injection blow molding machine is based on an extruder barrel and screw assembly which melts the polymer. The molten polymer is fed into a manifold where itis injected through nozzles into a hollow, heated preform mould. The preform mould forms the external shape and is clamped around a mandrel (the core rod) which forms the internal shape of the preform. The preform consists of a fully formed bottle/jar neckwith a thick tube of polymer attached, which will form the body [Oxford EngineeredMaterials Corporation].

Step 2: Blowing

The preform mould opens and the core rod is rotated and clamped into thehollow, chilled blow mould. Thecore rod opens and allows compressed air into thepreform, which inflates it to the finished article shape

Ejection After a cooling period the blow mould opens and the core rod is rotated to the ejection position. The finished article is stripped off the core rod and leak-tested priorto packing. The preform and blow mould can have many cavities, typically three to sixteen depending on the article size and the required output. There are three sets of core rods, which allow concurrent preform injection, blow molding and ejection [Oxford Engineered Materials Corporation]. Mold Design.

III. MATERIALS

Mould construction costs are an important factor in the calculation, particularly in the case of large containers, complicated parts and multiple moulds. All these considerations taken together culminate in the demand for a low-cost, technically suitable mould which can be constructed quickly and has a long life. In addition to construction materials, properties and costs, it is very important to take into account the particular production process for which the mould is to be used. Thus, in selecting the construction material, not only mould size, i.e. cavity volume or mounting platen dimensions, but also the lengths of the runs are decisive factors.

Plastic	Recommended Temperature	
	($^{\circ}$C)	($^{\circ}$F)
Polyacetates	80-100	176-212
Polyamides	20-40	68-104
Polyethylenes and PVCs	15-30	59-86
Polycarbonates	50-70	122-158
Polymethyl methacrylates	40-60	104-140
Polypropylenes	30-60	86-140
Polystyrenes	40-65	104-149

IV. DESIGN BY ANALYSIS

In this study, ANSYS Polyflow software was used to predict the blow molding behavior. 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 Techno solutions 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 behavior of plastic during the process and the wall thickness distribution and stress contour results can be viewed in 3-D graphic at result stage.

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The thickness of the fluid parison is much smaller than the other two dimensions of the bottle, which allows for the use of the membrane (shell) element, which is suited for the analysis of 3D blow molding simulations. It is important to remember when preparing the surface mesh, that the mesh elements on the mold should not be the same order of magnitude as the expected final local thickness. The use of the membrane element is presently restricted to time-dependent flows and is combined with Lagrangian representation. That is, each mesh node is a material point.

The finite element mesh and the boundary conditions are displayed in, a full 3D finite element is built for both the mold and the parison. Only a surface mesh is needed for both the mold and the parison, but the most important aspect remains the proper description of the inner mold surfaces that will shape the bottle.

The parison has the following material properties in SI units:

Height = 0.276 m

Radius = 0.0225 m

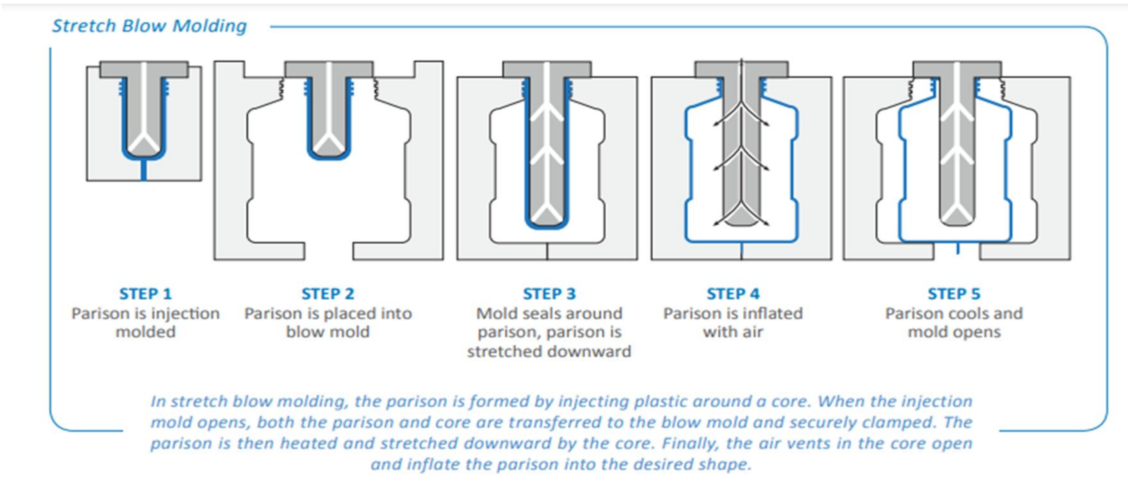
Initial thickness = 0.003 m

Model: shell model, Gen. Newtonian isothermal

Viscosity = 104 Pas

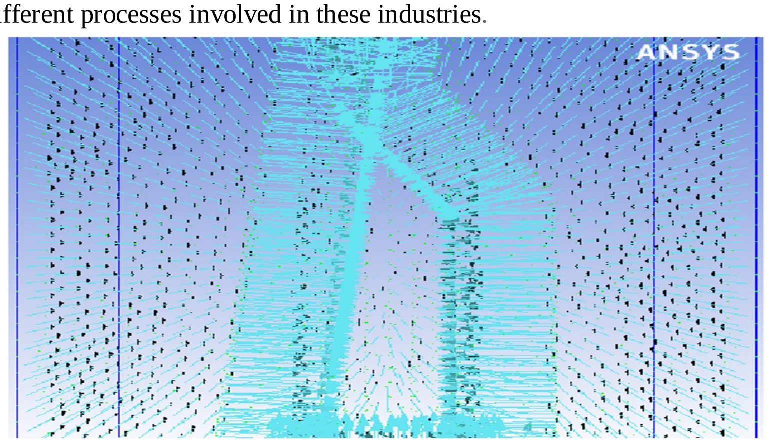
Density = 900 kg/m3

Inertial terms taken into account



V. ANSYS POLYFLOW

Ansys POLYFLOW is the unchallenged finite element CFD solver for complex non-Newtonian rheology including viscoelastic flow. The different direct coupled solvers using the finite element technique ensure robust convergence to address the complex physics of flows encountered in polymer processing and glass forming. The ILU and iterative solvers provide more aggressive solution techniques for large simulations involving less complex flow physics. Advanced techniques to deal with deforming mesh, complex motion of solid parts (intermeshing screws) and detection of contact between free surface and molds are available to accurately simulate the many different processes involved in these industries.



In Any-Sys We Create A New Mold

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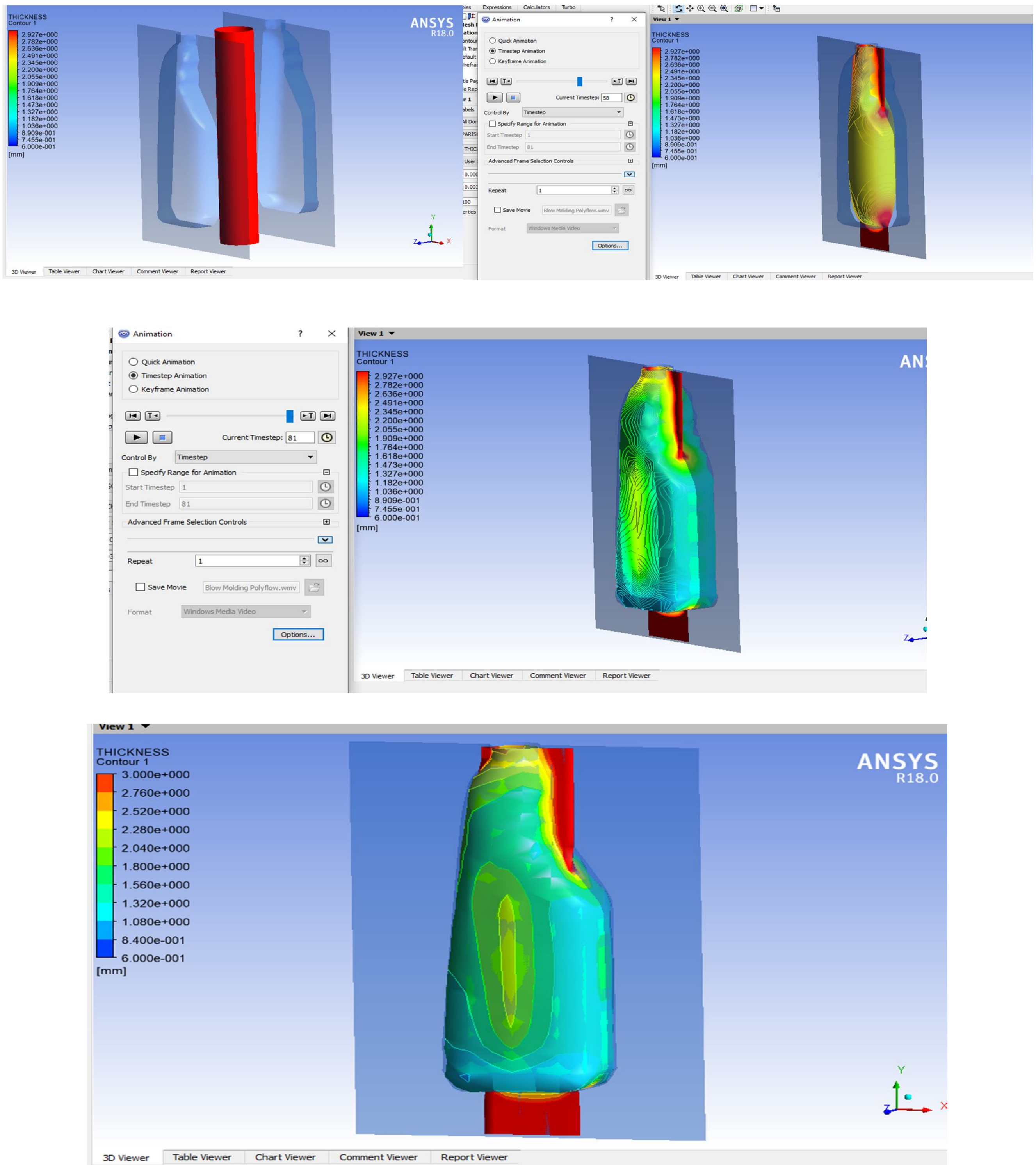
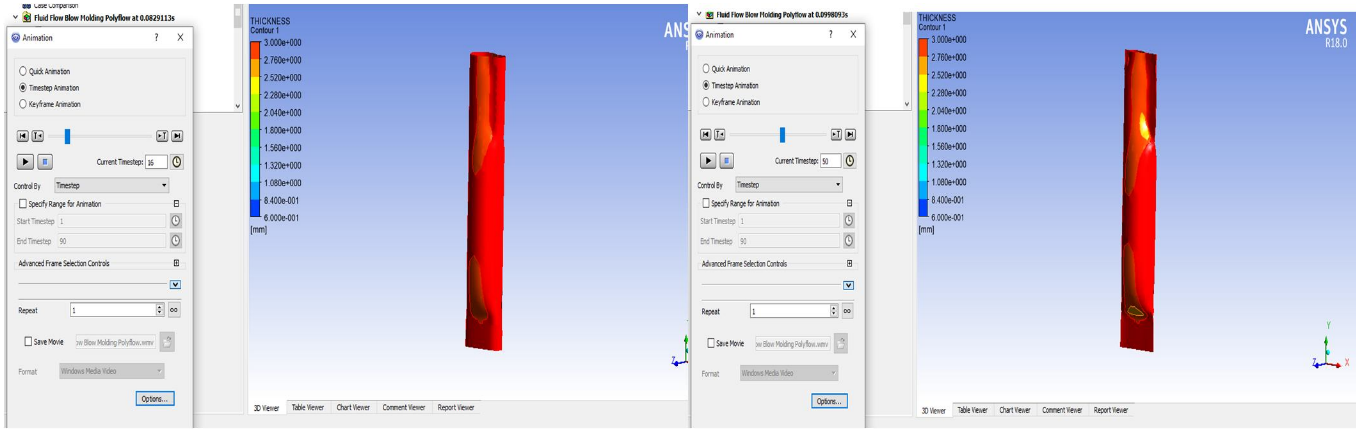
VI. RESULTS

The entire time-dependent calculation has been completed after few time steps. As requested, after successful steps, a pair of result files is created. Intermediate results are displayed, where we show the preform shape during inflation; contour lines of the axial coordinate are also displayed, and identify material lines. The final thickness distribution is at the end; all points of the preform have entered into contact with the mold. The bottle is shaped. We see that the thickness is important at the neck, whilst it may be considered as insufficient at the edge.



Any-Sys Poly Flow with Die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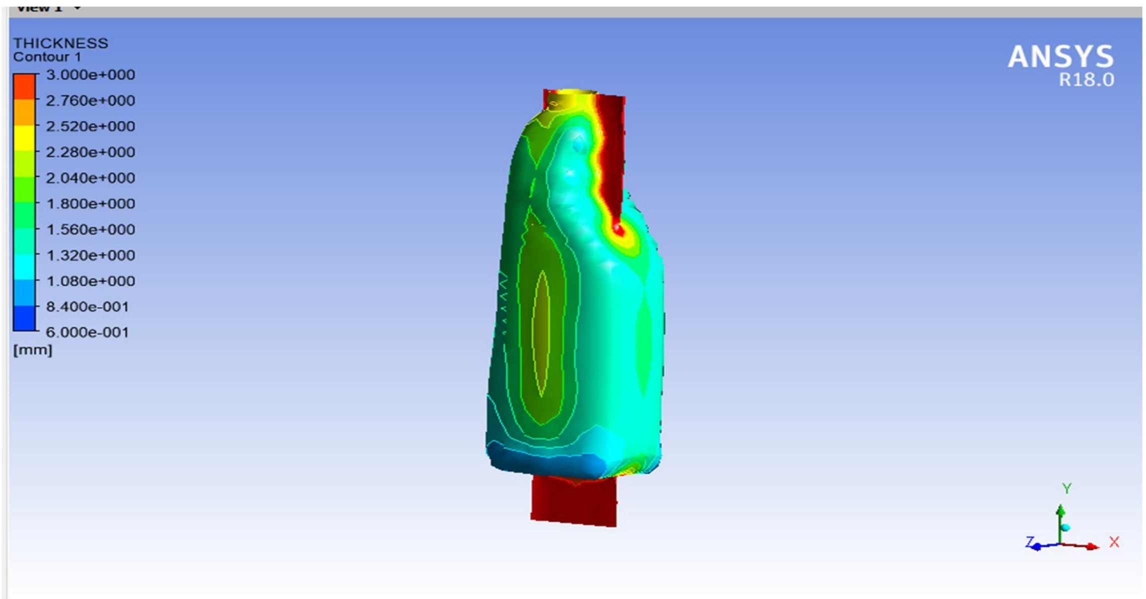
Animation
THICKNESS
Contour 1
Fluid Flow Blow Molding Polyflow at 0.0998093s
ANSYS
R18.0


THICKNESS
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1.080e+000
8.400e-001
6.000e-001
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ANSYS
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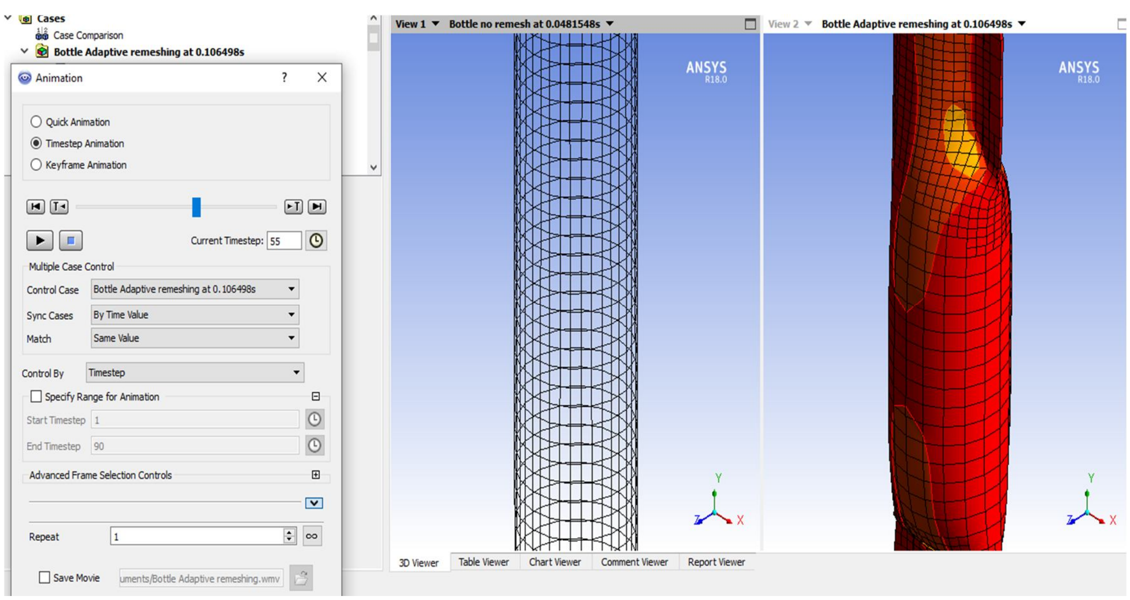
Cases
Case Comparison
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Animation
Quick Animation
Timestep Animation
Keyframe Animation
Current Timestep: 55
Multiple Case Control
Control Case
Bottle Adaptive remeshing at 0.106498s
Sync Cases
By Time Value
Match
Same Value
Control By
Timestep
Specify Range for Animation
Start Timestep
End Timestep
Advanced Frame Selection Controls
Repeat
Save Movie
View 1
Bottle no remesh at 0.0481548s
View 2
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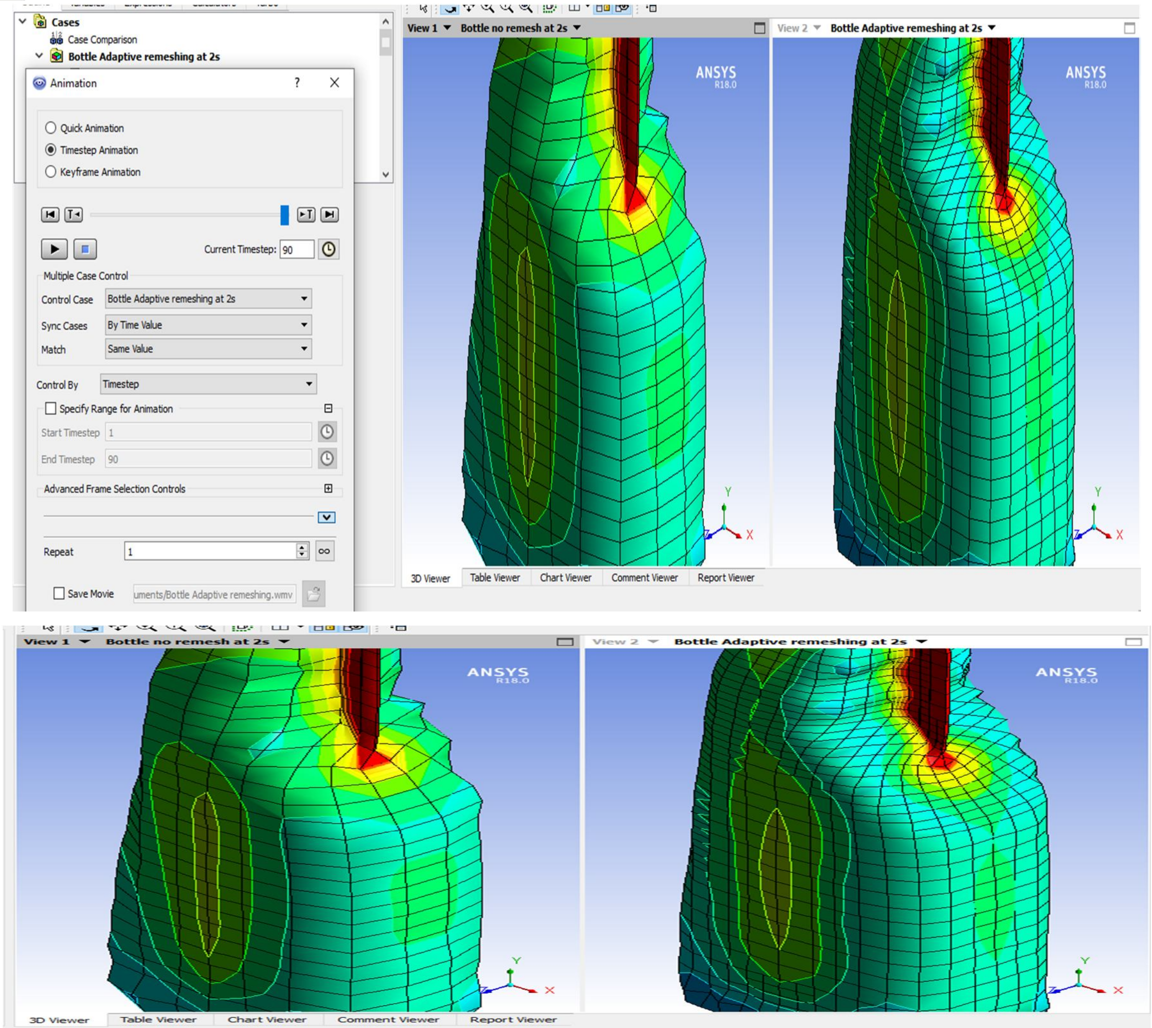
R18.0
3D Viewer
Table Viewer
Chart Viewer
Comment Viewer
Report Viewer



Adaptive Mesh Geometry

VII. CONCLUSION

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 2 sec. Dark blue depicted the region is too thin and can be acceptable for safety reasons and yellow and red color 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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