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VISCOELASTIC SIMULATION OF PET STRETCH/BLOW MOLDING

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INTRODUCTION

The performance of PET bottles produced by the stretch/blow molding process (see Figure 1) is determined both by operating conditions and by material properties.

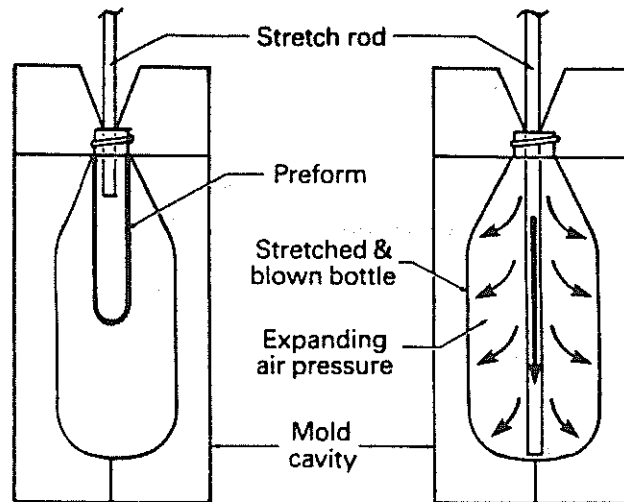


Figure 1 Description of stretch/blow molding process

Experiments have been performed on an industrial stretch/blow molding machine with a well instrumented mold. Different parameters have been recorded such as the blowing pressure, the force exerted on the rod and its displacement. Preliminary computations, performed assuming a newtonian behavior for the polymer, have shown the importance of viscoelastic effects by comparing the measured force versus time and the numerical one (Schmidt et al, 1992). In this paper, the stretch/blow molding of a viscoelastic fluid (Oldroyd B constitutive equation) has been implemented using an axisymmetric volumic finite element code. The numerical results have been compared to analytical calculations in simple blow molding configurations. Finally, the influence of several material parameters has been studied.

NUMERICAL RESOLUTION

An updated-lagrangian finite element algorithm based on a splitting technique and a fixed point method has been set up. At each time step, two linear sub-systems are successively solved. The first sub-system deals with a newtonian fluid flow (Stokes equations) perturbed by a known pseudo-body force expressing fluid elasticity. The second sub-system permits to determine the viscoelastic components of the extra-stress tensor for a known velocity field.

VALIDATION TEST

A quasi-analytic solution may be obtained for the stretch/blow molding of a tube of uniform thickness (see Figure 2) and compared to the finite element computation results. The initial thickness of the tube e_0 is 3.75 mm; its initial length L_0 125 mm. The constant velocity V_0 is 400 mm/s. The constant pressure ΔP is 0.1 MPa. Figure 3 shows an excellent agreement between the quasi-analytic and the numerical stretching force as a function of time.

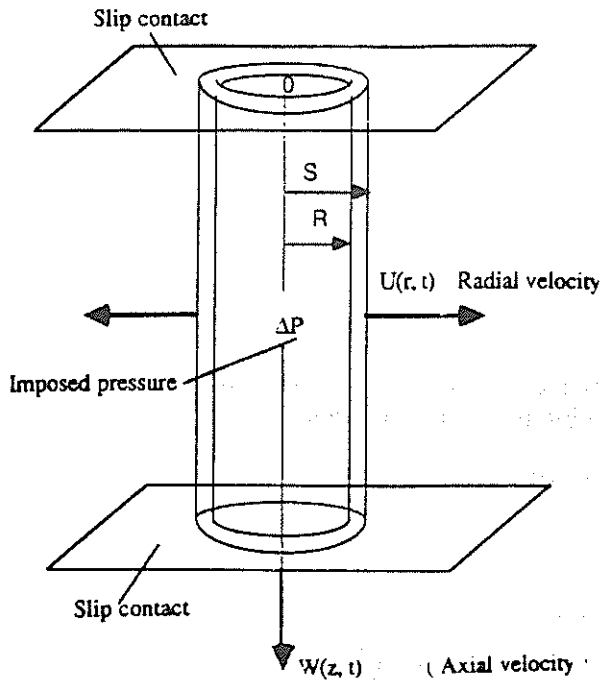


Figure 2 Validation test

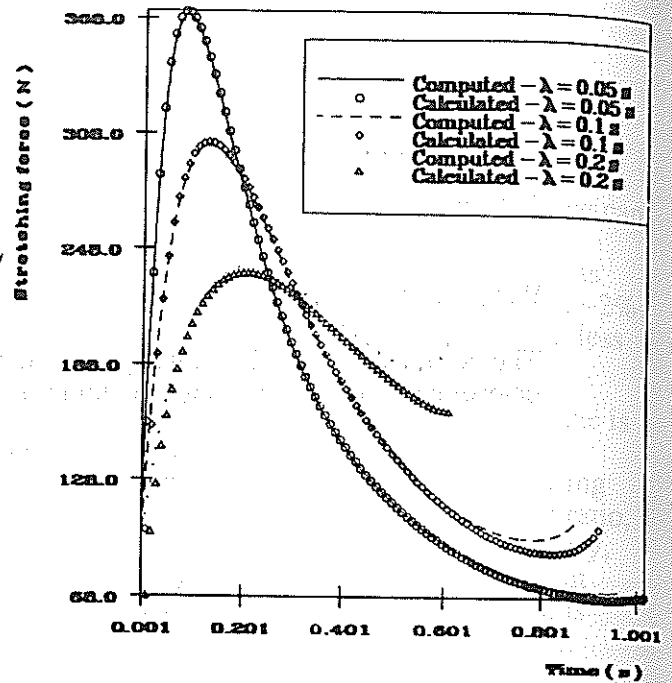


Figure 3 Stretching force versus time

APPLICATION TO THE SIMULATION OF THE STRETCH/BLOW MOLDING PROCESS

As a preliminary result, Figure 4 shows intermediate shapes from the initial preform to final bottle which were obtained in the case of Oldroyd B constitutive equation.

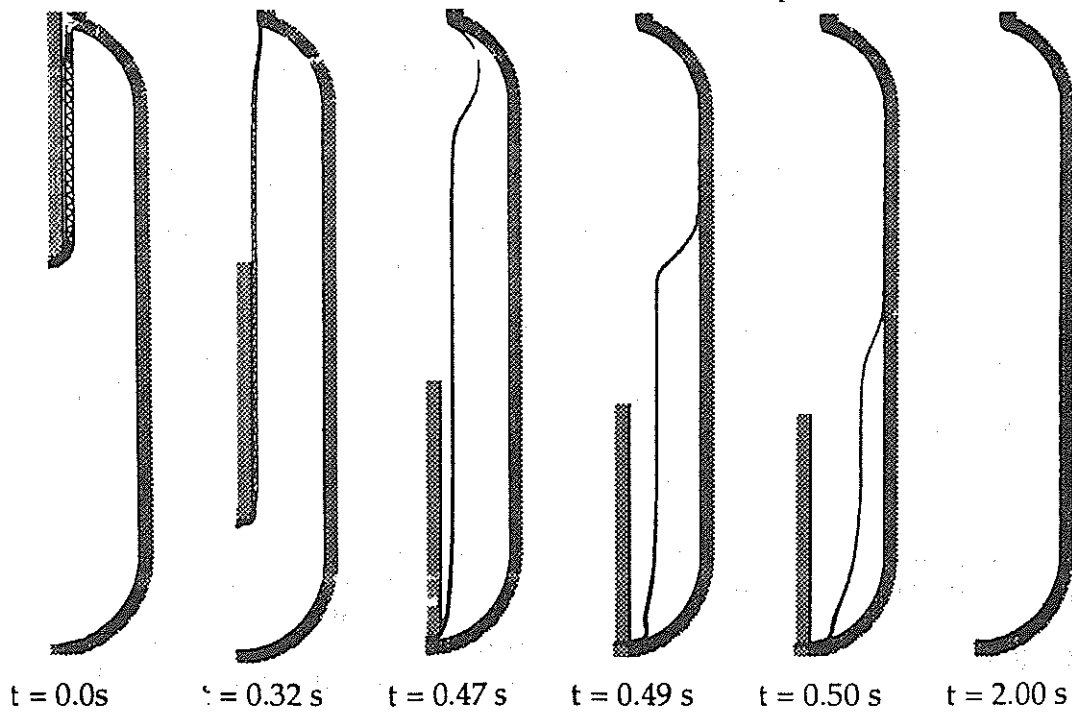


Figure 4 Intermediate bottle shapes

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Schmidt F. M., Agassant J. F., Bellet M. and Denis G., "Numerical Simulation of Polyester Stretch/Blow Molding Process", Numiform 92, Proc. 4th Int. Conf. on Numerical Methods in Industrial Forming Processes, Balkema, pp. 383-388, September 1992