COMSOL CONFERENCE 2015 BOSTON

Assessment of Squeeze-off Location for Small Diameter Polyethylene (PE) Pipe and Tubing

O. Lever, E. Lever
Gas Technology Institute, Energy Delivery & Utilization, Des Plaines, IL, USA

Introduction: Squeeze-off of PE pipes is a common method that is used to stop gas flow for repairs or emergency shutoff. A model of this procedure was created in COMSOL Multiphysics to determine if the current 12-inch minimum distance of squeeze-off from a fitting can be reduced.

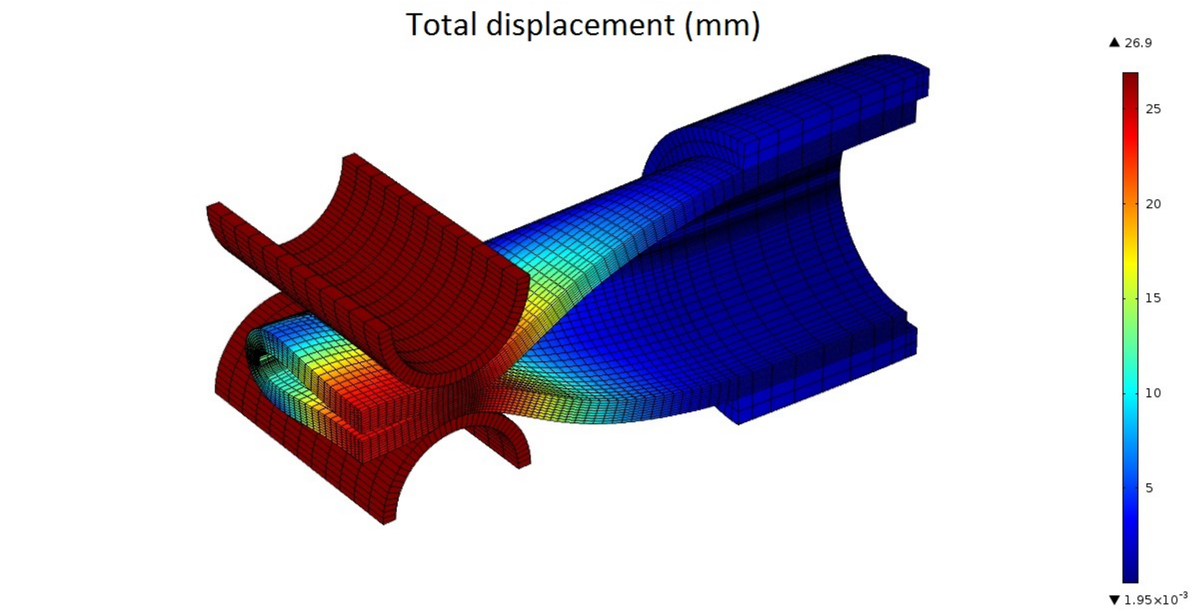

Figure 1. Pipe squeeze-off model

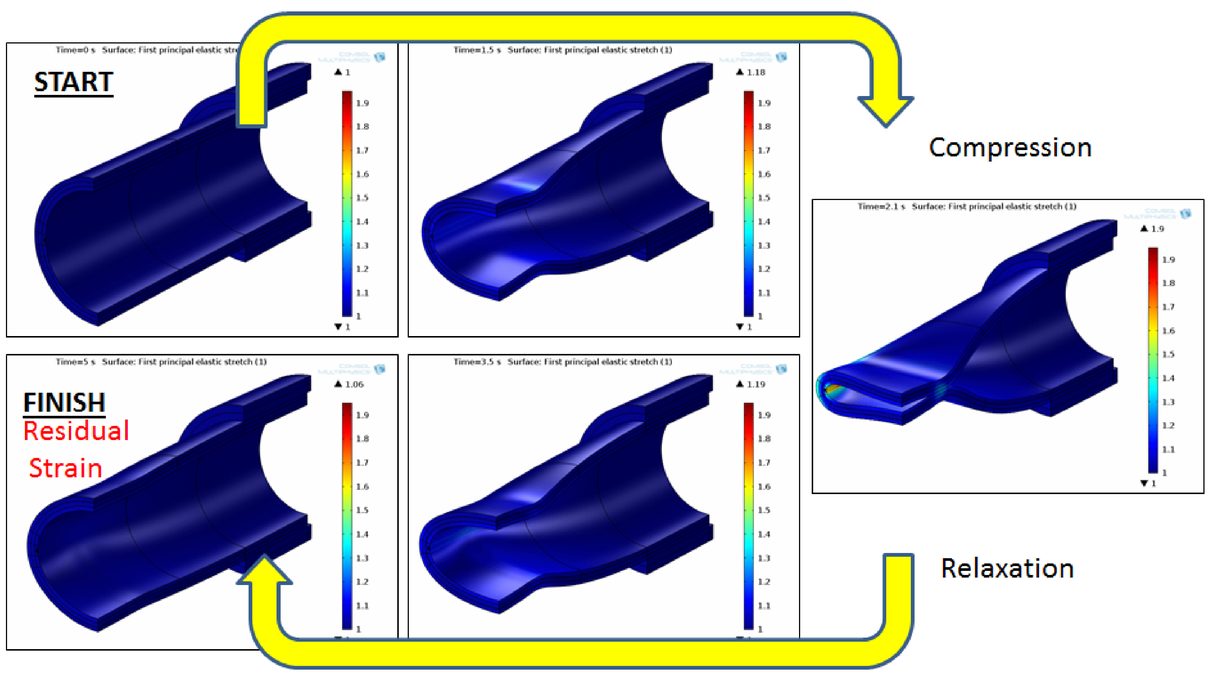

Figure 2. Squeeze-off simulation sequence

Computational Methods: To simulate the large deformations encountered in PE pipe squeeze-off, COMSOL's Nonlinear Structural Mechanics Module was used together with a custom nonlinear viscoelastic-plastic constitutive model[1] using the Ordinary Differential Equations (ODE) functionality. The constitutive model captures the large-strain behavior and of PE in tension and compression, and at a wide range of operating temperatures.

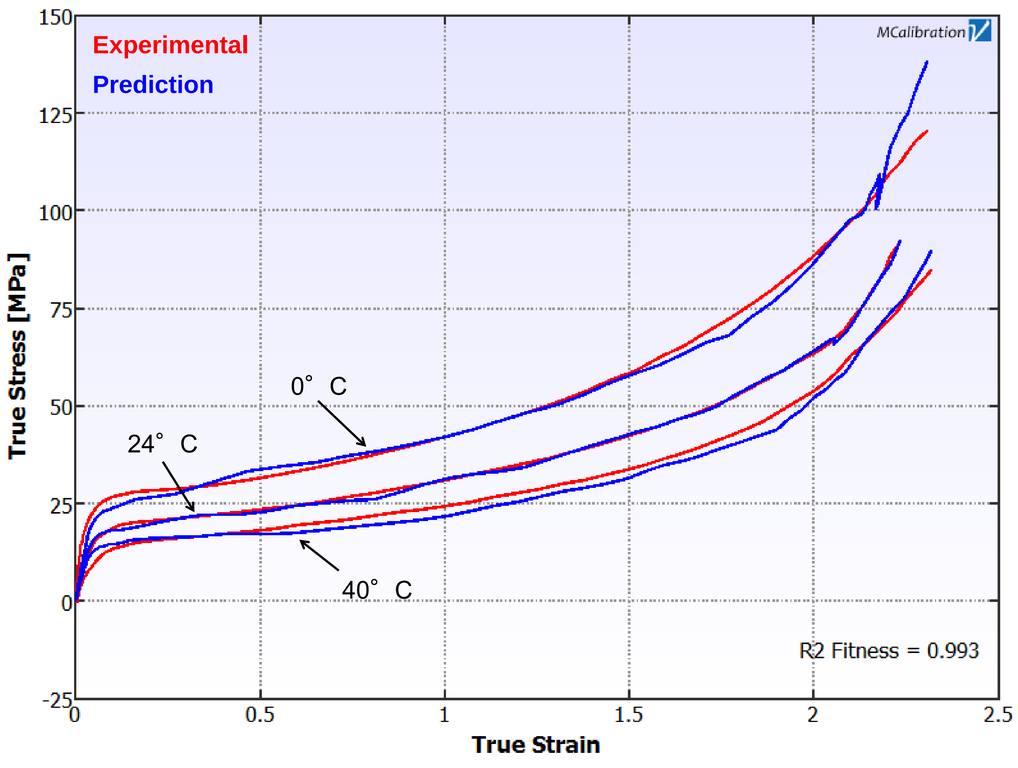

Figure 3. Custom PE model capturing large tensile strains, at different temperatures

Special attention was given to meshing to allow for convergence of the model at time steps where very high deformations occurred.

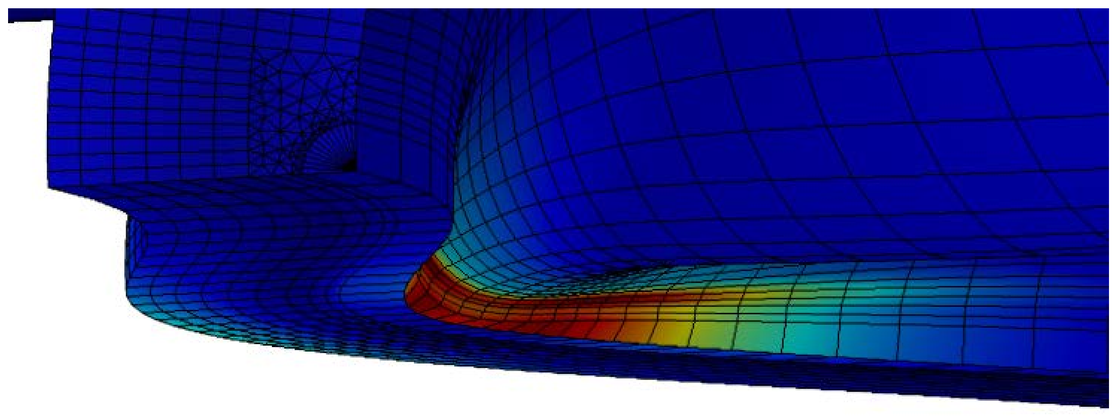

Figure 4. Deformation prior to complete squeeze-off, showing crease

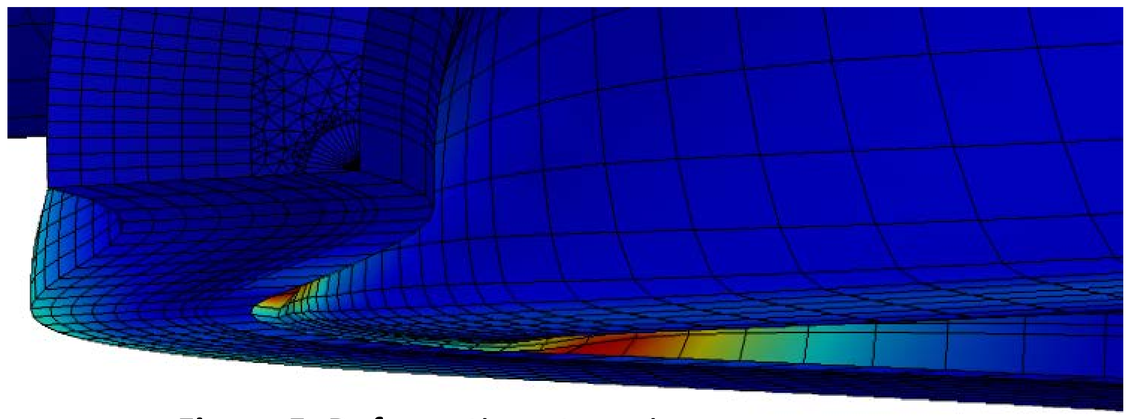

Figure 5. Deformation at maximum squeeze

Results: The simulation indicated that squeeze-offs of small diameter pipe performed at distances of three (3) pipe diameters from a fused coupling, do not induce strains larger than industry accepted strains for bent pipes.

Table 1: Maximum First Principal strain at vicinity of coupling edge

Pipe Configuration	1/2" IPS DR11	1/2" IPS DR11	1/2" IPS DR11	2" IPS DR11	2" IPS DR11	2" IPS DR17.6
Offset	12-inch	3xOD	2.5xOD	12-inch	3xOD	2.5xOD
Distance [in]	17.500	18.250	22.500	22.000	27.000	31.450
Pipe Strain [%]	0.38	0.92	1.06	1.19	1.26	1.46
Coupling Strain [%]	0.40	1.26	1.47	0.61	0.66	1.73

Table 2. Industry accepted Strains for bent pipe[2]

Pipe Dimension Ratio (DR)	Pipe Bend Radius	Max Strain [%]
7, 7.3 , 9	20 x Pipe OD	2.5
11, 13.5	25 x Pipe OD	2
17, 21	27 x Pipe OD	1.85

Conclusions: The simulations results indicated that squeeze-off of small diameter pipe at distances of three (3) pipe diameters from a fused joint are viable and empirical testing is ongoing to verify this indication.
Future work is planned to further calibrate and verify the PE constitutive model by carefully measuring and datalogging pipe deformation and compression loads during squeeze-offs and installation of pipe reinforcement clamps.

References:
1. Elabbasi N, Bergstrom J, Constitutive Modeling of Polyethylene in COMSOL Multiphysics, COMSOL Conference 2015, Newton MA.
2. *Handbook of PE Pipe*, 2nd Edition, Plastics Pipe Institute. http://plasticpipe.org/publications/pe_handbook.html