Stresses and Deformations After Extrusion Die Exit

M. Kostic (www.kostic.niu.edu/extrusion) 12/16/2003

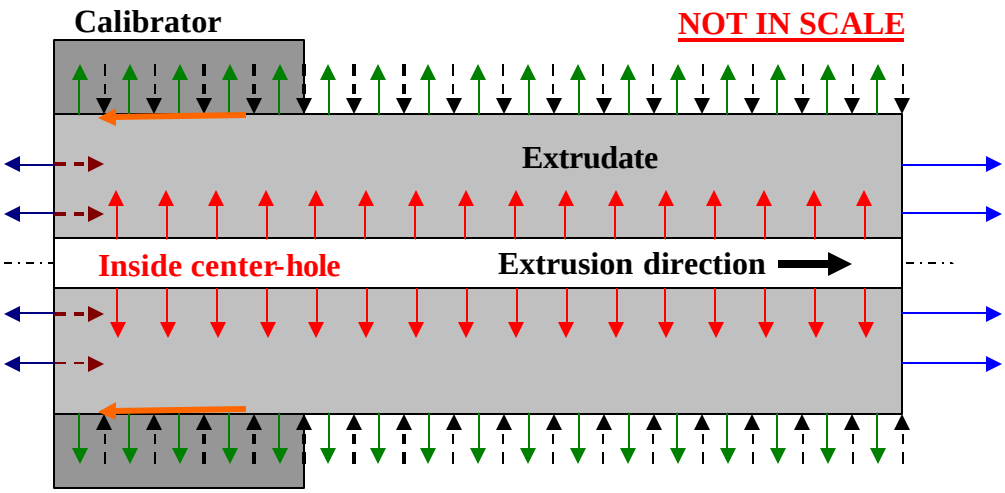
Why some final extrudate profiles are larger than the corresponding calibrator profile, if it is expected to be otherwise?

Extrusion is also a very complex mechanical-deformation and thermal-shrinkage process after the die-exit, including solidification, where competing and non-uniform stresses shape and finalize the extrudate profile (see the illustration below).

Usually, the final extrudate profile is somwhat smaller than the calibrator profile due to puling *Poisson* effect (transverse shrinkage) and thermal (cooling) transverse shrinkage. During extrusion in Fermilab of the 10x20mm rectangular profile with a 1mm center-hole, using a 10.5x21mm calibrator profile, we obtained enlarged (istead of reduced) final extrudate of about 11x22mm. I challanged several of my collaborators to speculate on the reasons for this unusual outcome and obtained different feedback.

I hypothesize that the transverse (cross-sectional) enlargment is due to transverse stretching of vacuuming and Nitrogen (inside-hole) pressure stresses (see sketch below), which in this particular case (magnitude of these stresses) outcompeted shrinkage due to axial puling and thermal cooling, among others.

I propose to verify this hypothesis experimentally. I also propose to systematically investigate influence of all mechanical-deformation and thermal-shrinkage forces (or ruling them out) by varying the corresponding extrusion-process parameters within possible ranges. Modeling and simulation of stress and temperature fields within and after calibrator should complement experimental investigation.



LEGEND (color coded stresses/deformations on the extrudate):

- **Pulling/stretching**
- **Friction in calibrator**
- **Pulling/stretching (if calibrator is starved)**
- **Pushing/compressing (if calibrator is staffed)**
- **Nitrogen transverse stretching**
- **Vacuum transverse stretching**
- **Thermal (cooling) transverse shrinkage**

NOTE: Deformations due to *Poisson* effect are not depicted