

7th OpenFOAM Workshop
Center of Smart Interfaces,
Technische Universität Darmstadt,
Germany
24-28 June, 2012



Incorporating Tool Deformation in the Design of Extrusion Dies for Complex Hollow Profiles

M.R. Moosavi ^{*‡}, N.D. Gonçalves, A Gaspar-Cunha., O.S. Carneiro and J.M. Nóbrega

Institute for Polymers and Composites / I3N, University of Minho, Campus de Azurém
4800-058 Guimarães, Portugal

June 24-28, 2012

Profile Extrusion Dies, Complex Hollow Profiles, Computer Aided Design, Fluid Structure Interaction

Thermoplastic profiles are widely used in a large range of application fields, like medical, building, automotive, electric and electronic, among others. Typically, these profiles have constant cross-section, being produced by extrusion. In order to fully exploit their potentialities and due to the high degree of geometrical flexibility given by thermoplastics, the profiles have usually complex cross-section geometry, designed to fulfil the needs of a specific application. Common examples employed to illustrate these facts are the window frames or the medical catheters, which usually comprise intricate cross section geometries.

There are many variables and phenomena involved in the design stage. Therefore, die design is usually strongly dependent on the designer's experience, being more an art than a science [1]. The development of adequate computational fluid dynamics (CFD) codes, allowed achieving significant improvements in the die design procedures. As a consequence, nowadays this trial-and-error design approach is being transformed from an experimental to a numerical based operation [2-4].

The complexity of the die design problem increases when small and complex cross sections are involved, as happens frequently for medical catheters, since the interaction between the forming tools and the polymer melt promotes the deformation of the first, mainly due to the high pressure gradients involved and the relatively weakness of the (very thin) mandrels that shape the hollow lumens, see Figure 1. These conditions promote deformations in the weakest parts of the die, thus modifying the flow channel geometry. Consequently, to obtain accurate results, the CFD tools employed to aid the design of this type of dies must be able to predict the above mentioned deformation of the flow channel, i.e., they must incorporate the usual designated Fluid Structure Interaction (FSI) [5].

[‡] Corresponding Author: M. R. Moosavi (moosavi@yahoo.com)

Typically, in FSI algorithms, the initial flow field variables (pressure and velocity distribution) are computed assuming an non-deformed flow channel, being the computed pressure gradients used to predict the deformation promoted in the flow channel, which is then employed to compute the new flow field variables. The process is repeated until convergence is achieved [5].

The main purpose of this research project is to employ OpenFOAM to model this process, considering the FSI issues. Due the complex behaviour of the material involved (Viscoelastic) some additional features have to be implemented in the code.

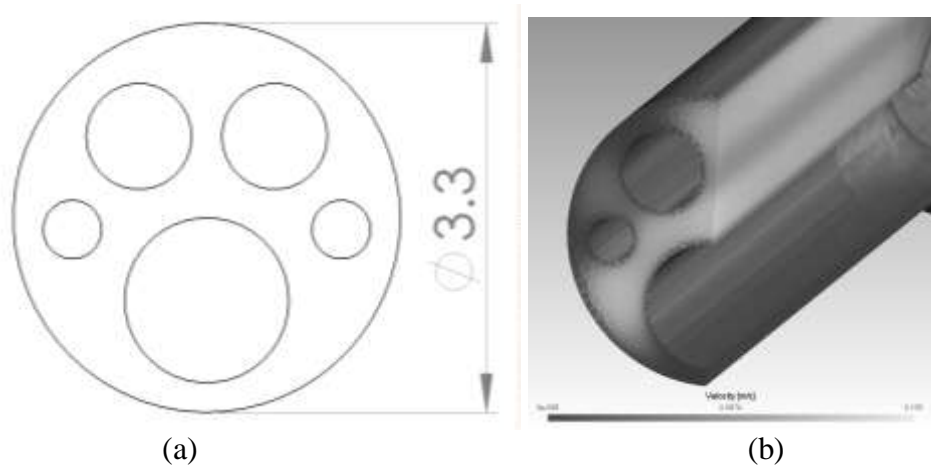


Figure 1 – Extrusion of a catheter (a) Cross section geometry (dimensions in mm), (b) velocity distribution computed in the flow channel (half of the geometry due to symmetry)

ACKNOWLEDGMENTS

The authors gratefully acknowledge funding by FEDER via Fundação para a Ciência e Tecnologia through projects FCOMP-01-0124-FEDER-015126 (Ref.^a. FCT PTDC/EMEMFE/113988/2009), FCOMP-01-0124-FEDER-010190 (Ref.^a. FCT PTDC/EME-FME/102729/2008) and PEst-C/CTM/LA0025/2011 (Strategic Project - LA 25 – 2011-2012). N.D. Gonçalves and M.R. Moosavi would also like to acknowledge FCT for the funding by of, respectively, the PhD grant FCT - SFRH/BD43632/2008 and the Post-doctoral grant FCT-SFRH/ BPD/ 77467/ 2011.

REFERENCES

- [1] Gogos, C.G., Tadmor Z. Principles of Polymer Processing, Wiley-Interscience, New Jersey, 2006.
- [2] Nóbrega, J.M., Carneiro, O.S., Oliveira, P.J., Pinho, F.T. (2003) Flow Balancing in Extrusion Dies for Thermoplastic Profiles. Part I: Automatic Design. International Polymer Processing XVIII, 298-306.
- [3] Nóbrega, J.M., Computer Aided Design of Forming Tools for the Production of Thermoplastic Profiles. Guimarães: Universidade do Minho, 2004. PhD Thesis;
- [4] Nóbrega, J.M., Carneiro, O.S., Pinho, F.T., Oliveira, P.J. (2004) Flow Balancing in Extrusion Dies for Thermoplastic Profiles. Part III: Experimental Assessment. International Polymer Processing 19 , 225-235.
- [5] Valette, R., B. Vergnes, and T. Coupez, Fluid structure interaction techniques for extrusion and mixing processes. NUMIFORM '07: Materials Processing and Design: Modeling, Simulation and Applications, Pts I and II, 2007. 908: p. 319-324.