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Optimization of an Extrusion Process for Non-Newtonian high-viscous Fluids with Wall Slip and Shear Thinning Effect

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COMSOL Conference, Rotterdam, October 2013

COMSOL CONFERENCE ROTTERDAM2013

Agenda:

Visco-plastic materials

Measurement of material parameters

Simulation of the flow in a forming die

Conclusions

Examples of visco-plastic materials

Silly putty

Heavy clay

Technical ceramics

Noodles, ketchup, food

Aluminum

Blood

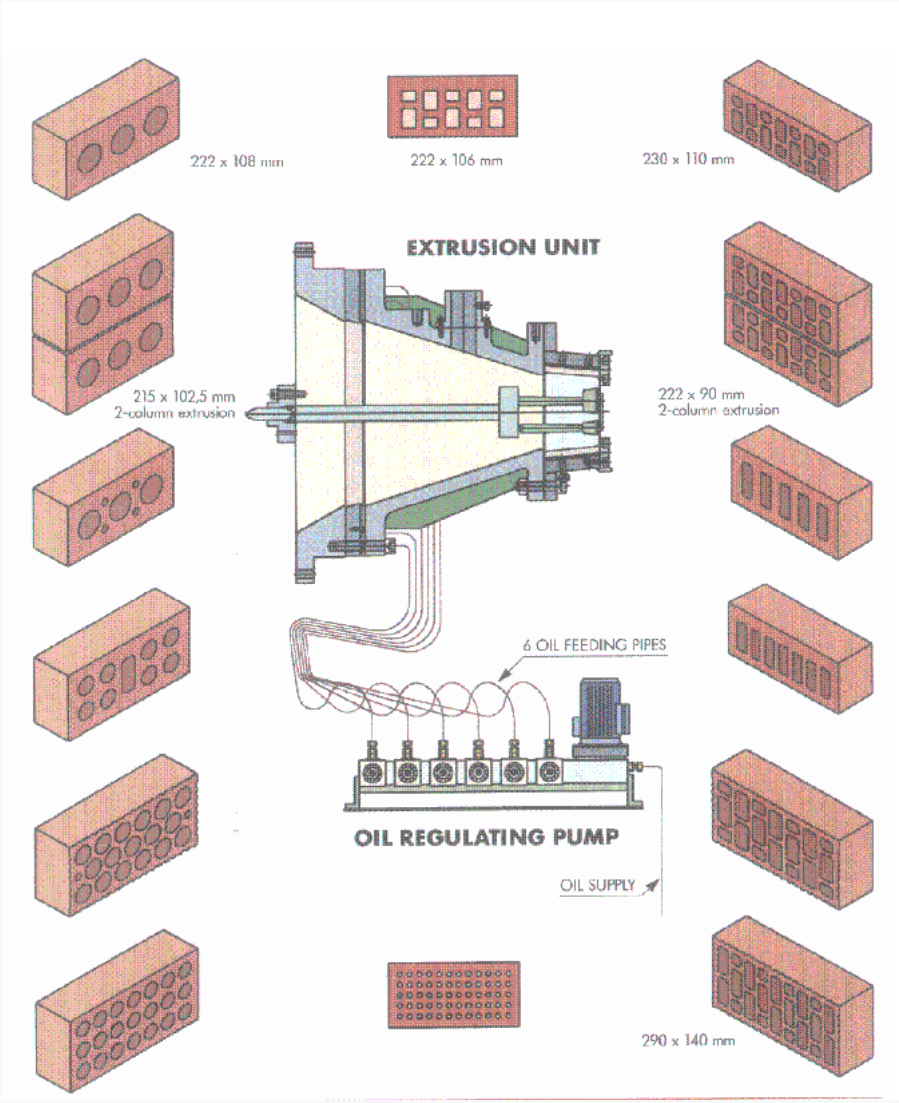
Plastics

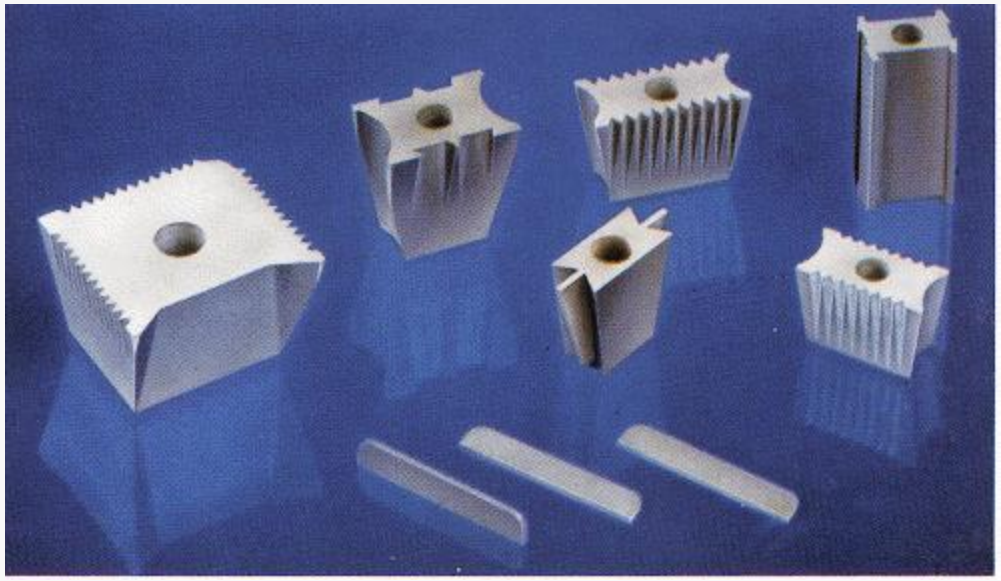
Rubber

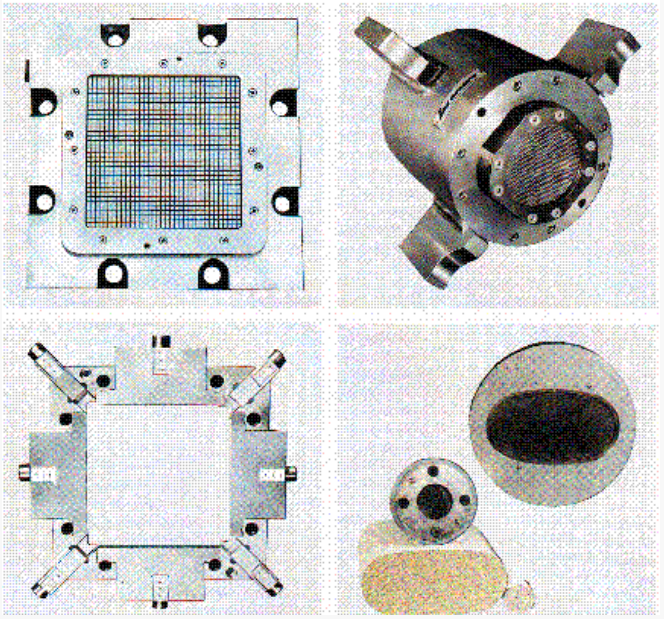
Polymers

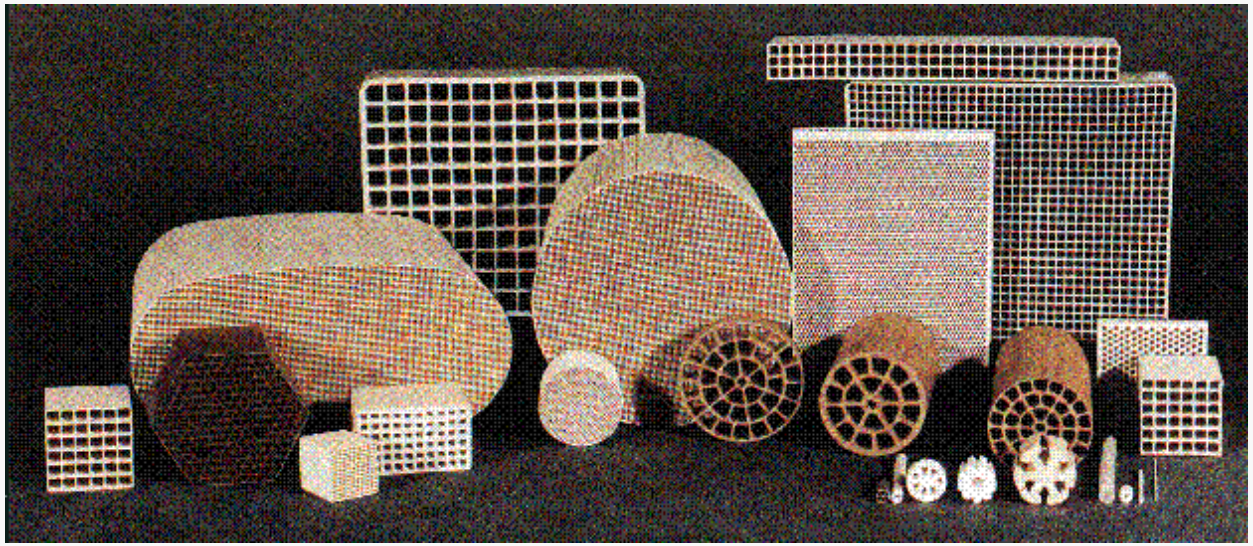
.....

Heavy clay industry



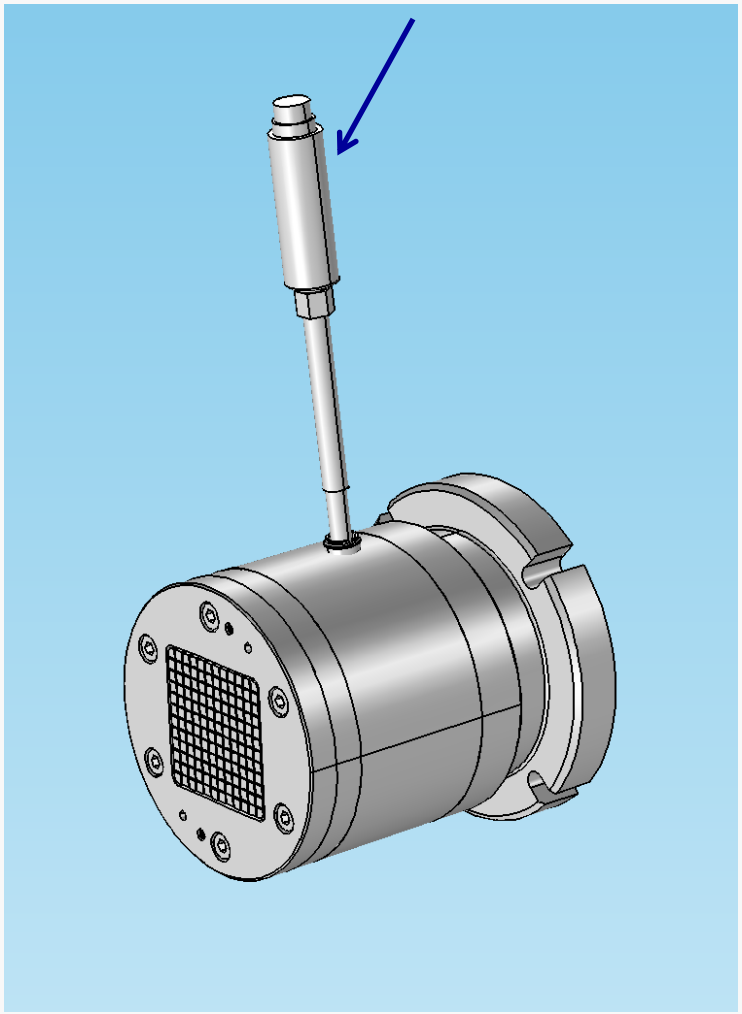




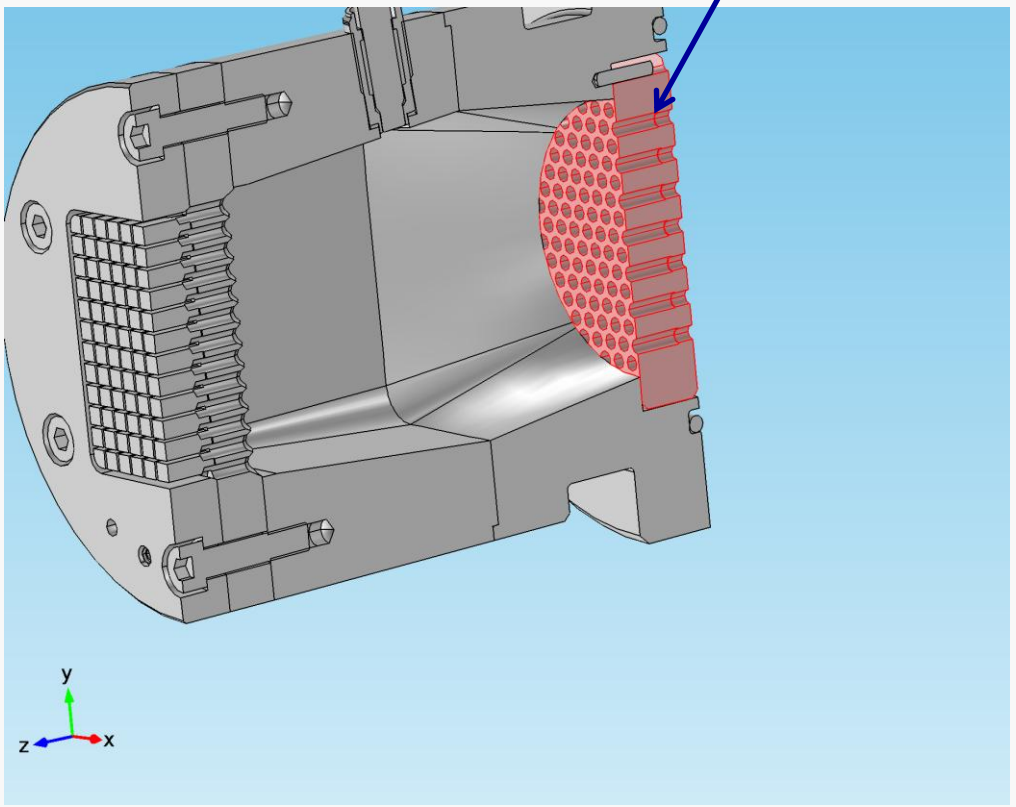


Die with pressure head

Pressure sensor

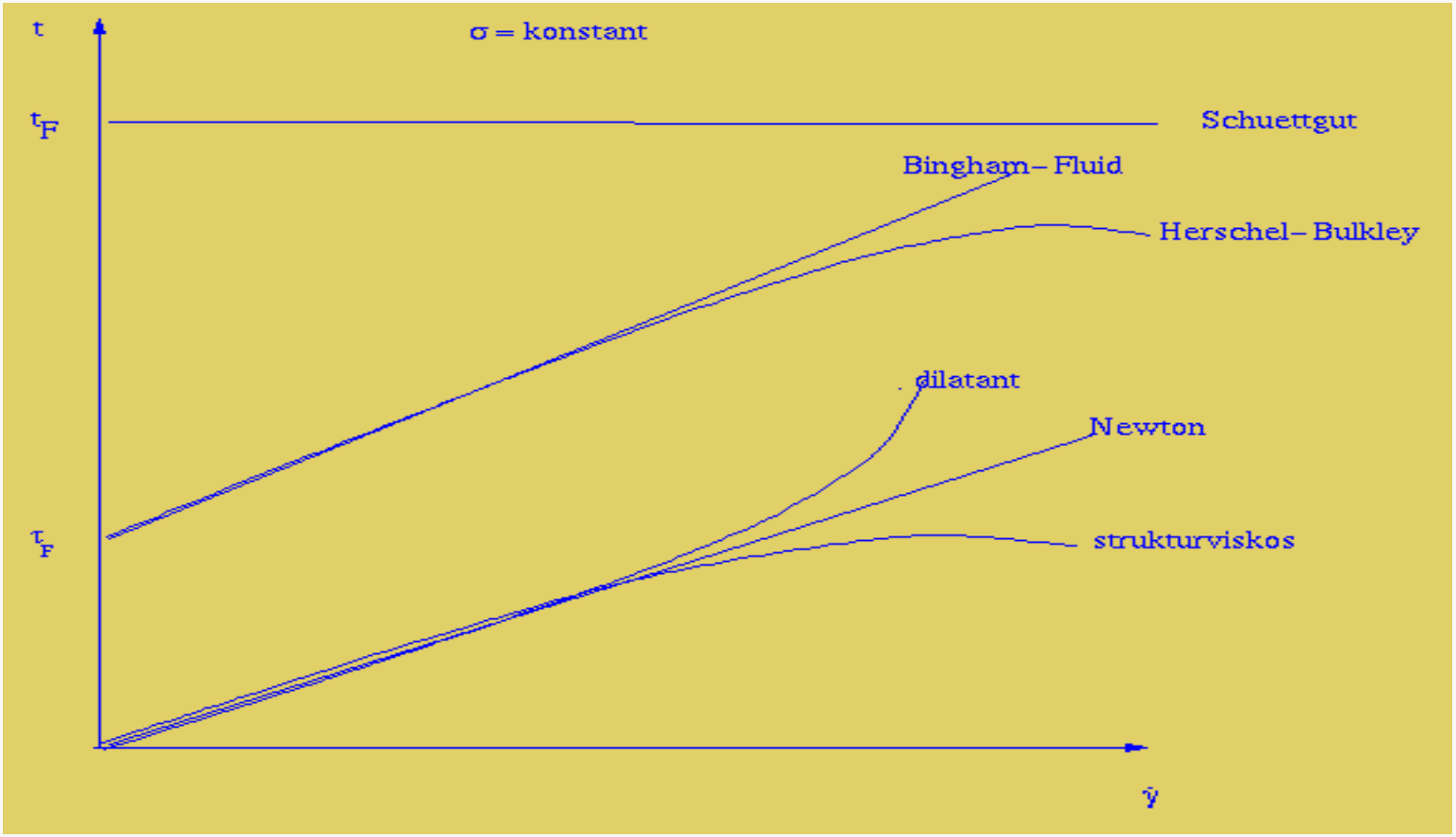


strainer



Bingham-Fluid: yield stress

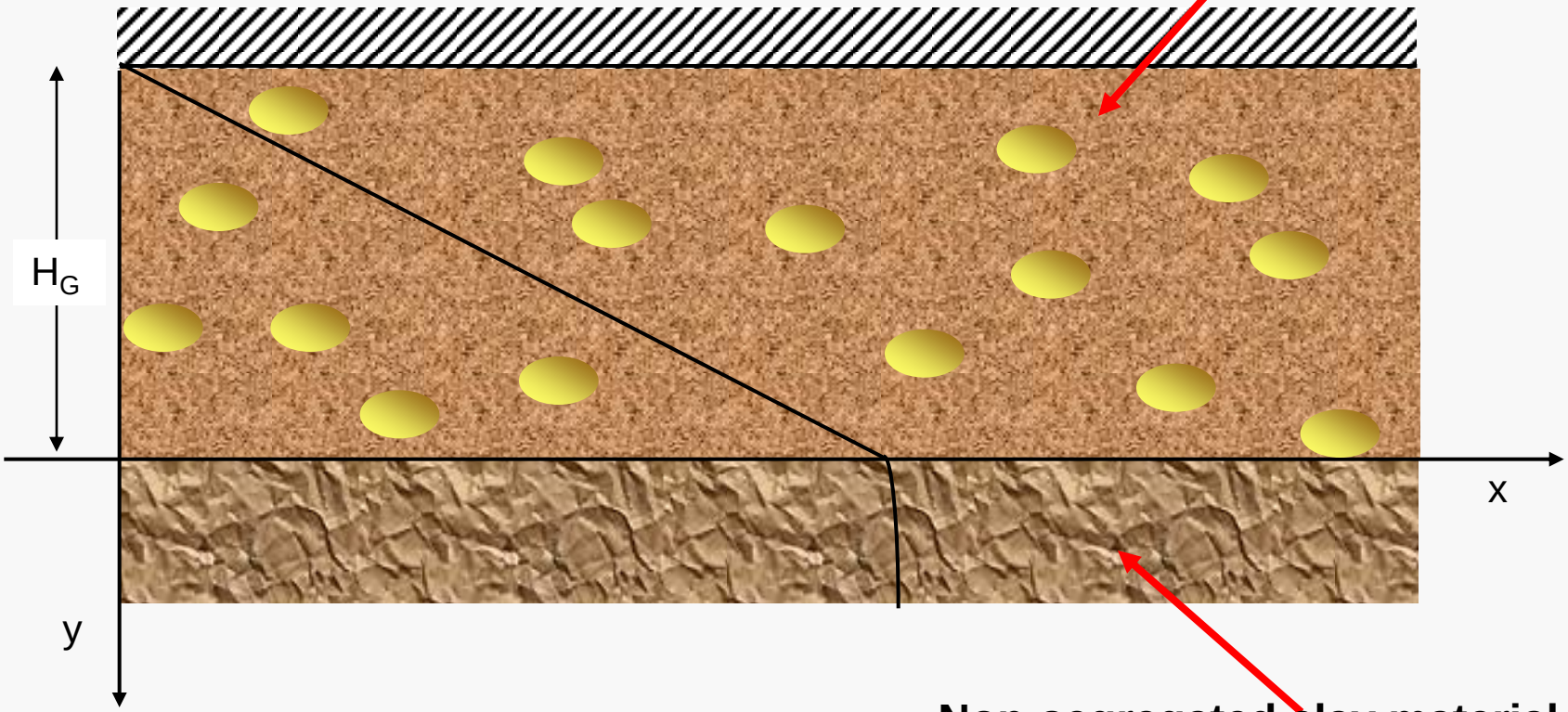
$$\tau = \eta\dot{\gamma} + \tau_F, \quad \tau \geq \tau_F$$



Wall slip

$$\dot{\gamma} = \frac{U_G}{H_G} \quad \tau_W = f(\tau_G, ku_W)$$

Low viscosity lubricating film



Non-segregated clay material

PSM developped for visco-plastic materials

4 characteristic parameters

expansion flow rheometer

$yield\ \ stress\ \tau_F$

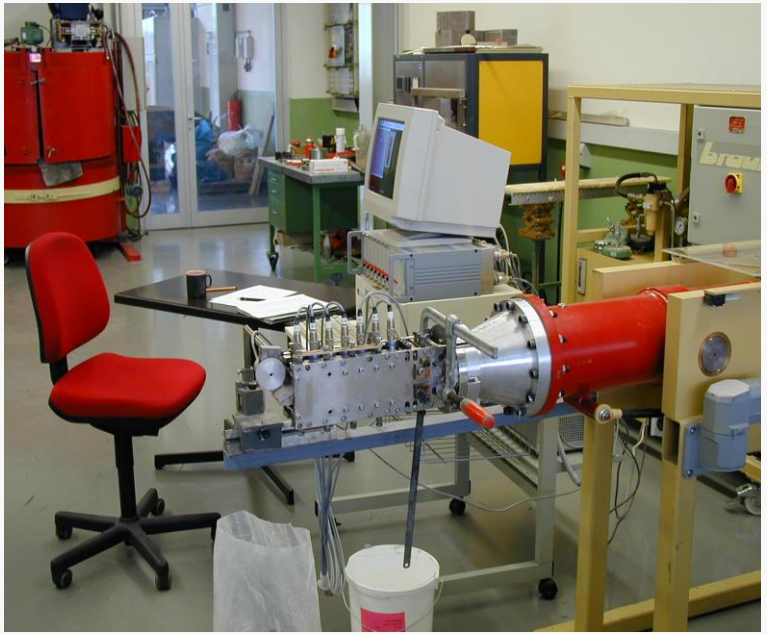
$Bingham-viscosity\ \eta_B$

$wall\ slip\ stress\ \tau_G$

$wall\ \ factor\ \ k$

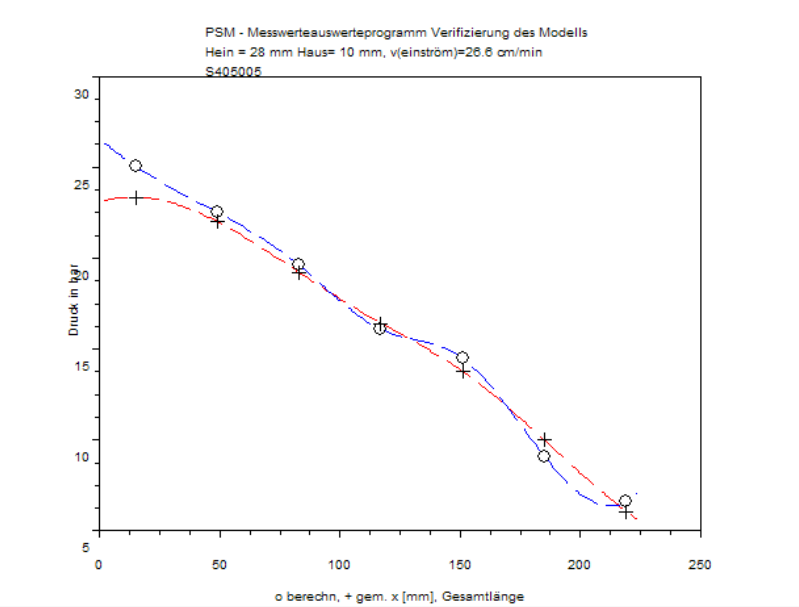
Measurement of material parameters

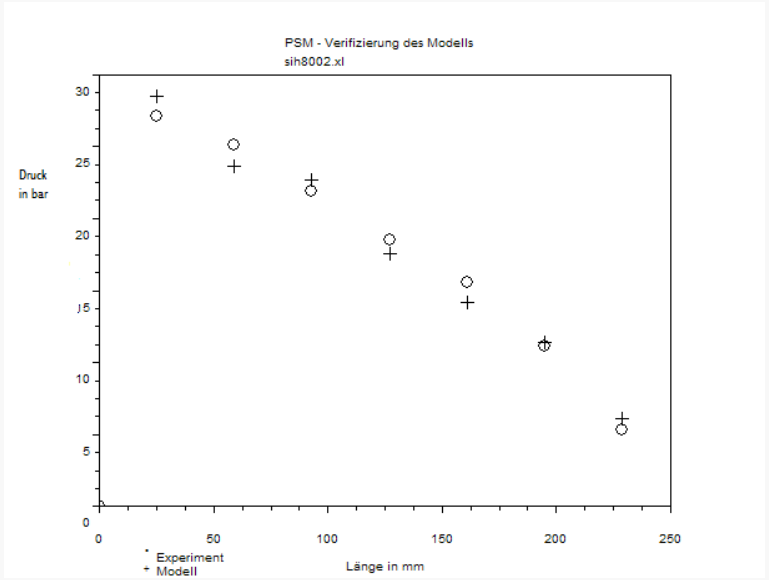
Screw extruder

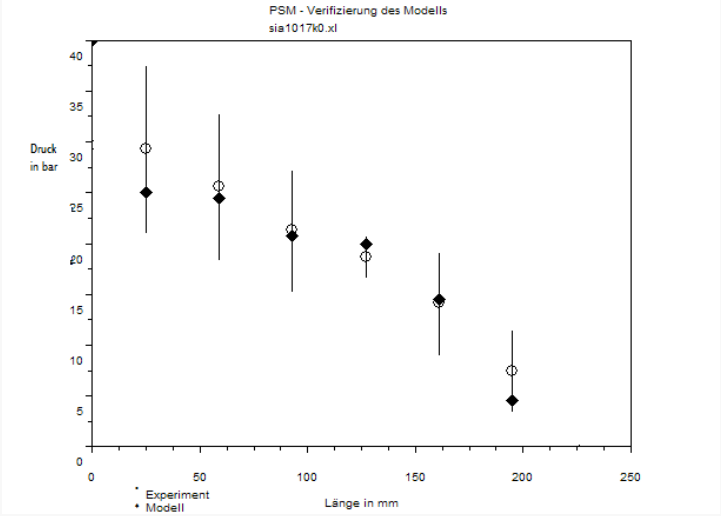


Piston extruder

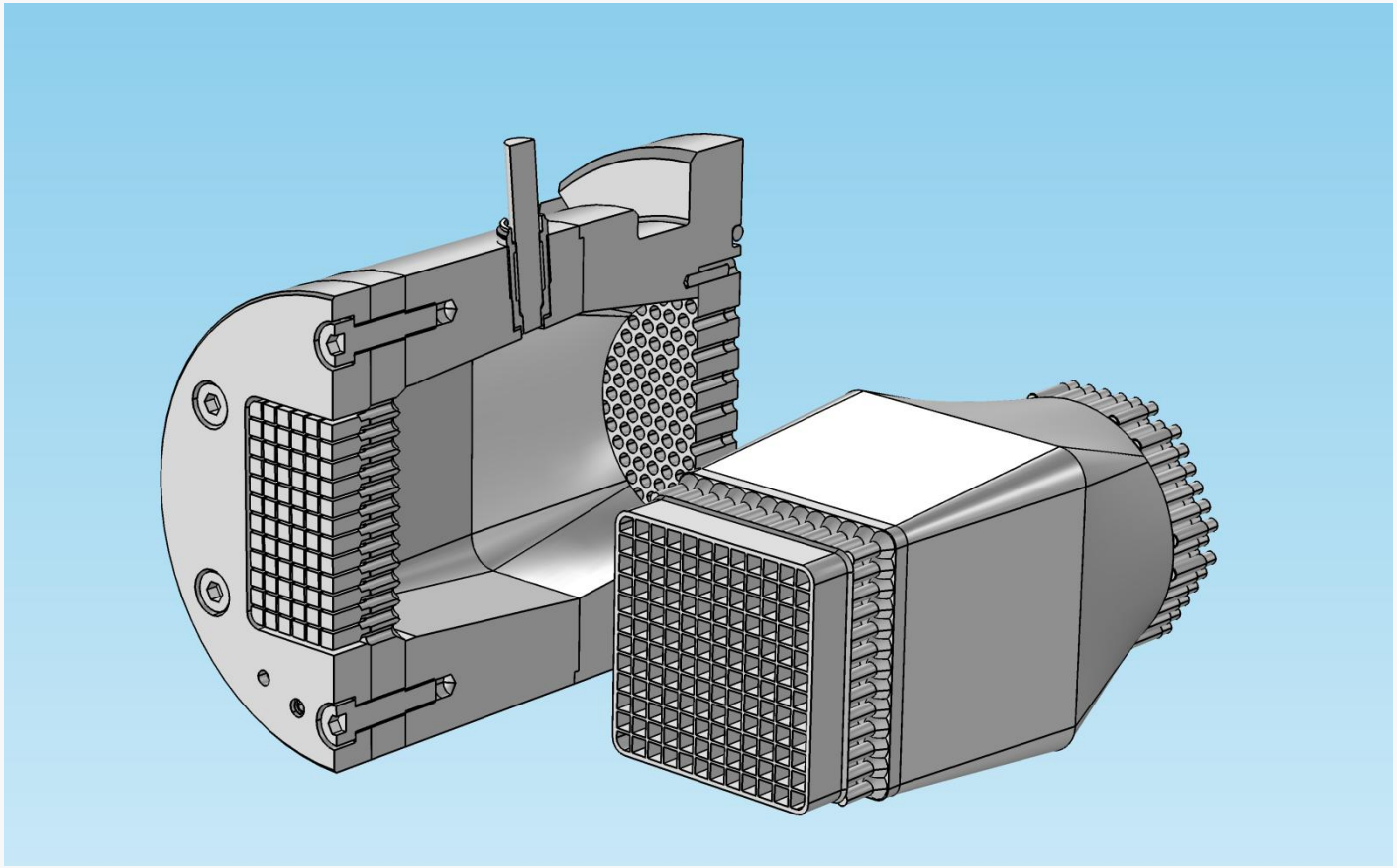
Reliabilty of the material modell, PSM

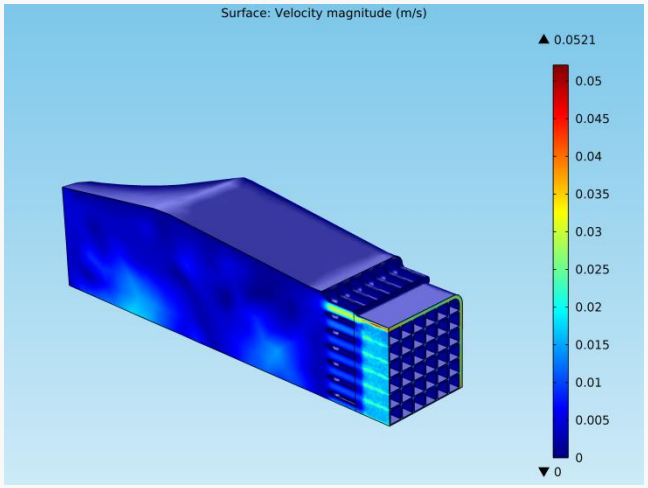




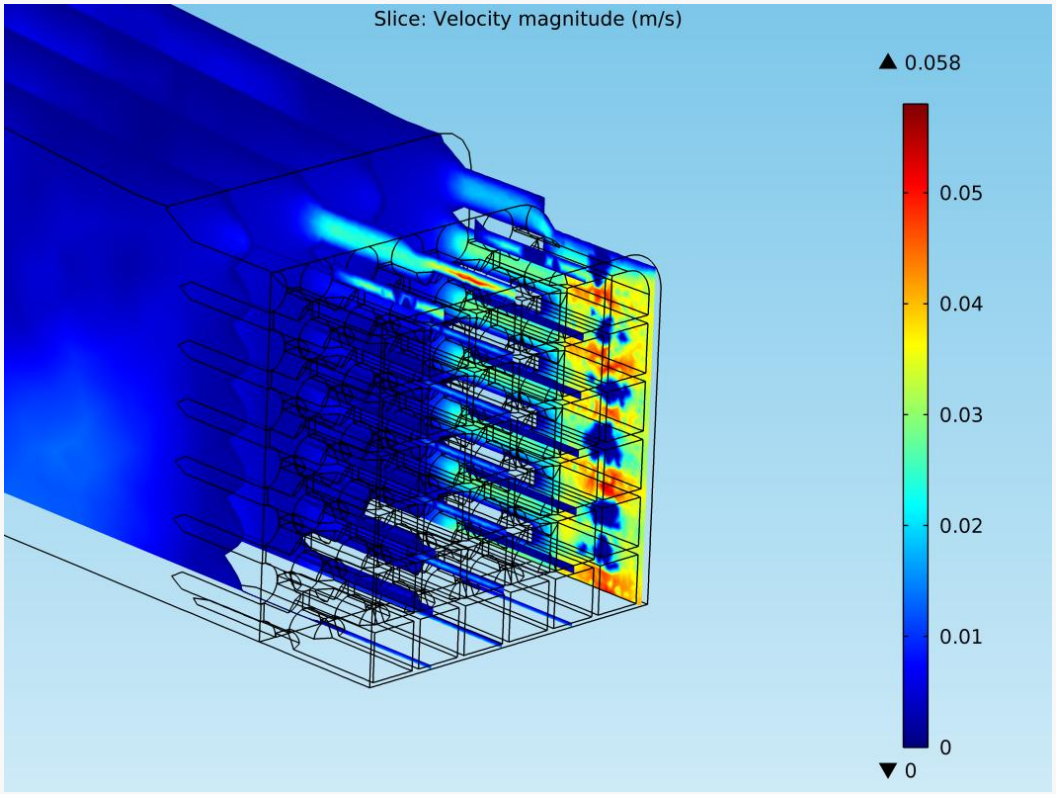


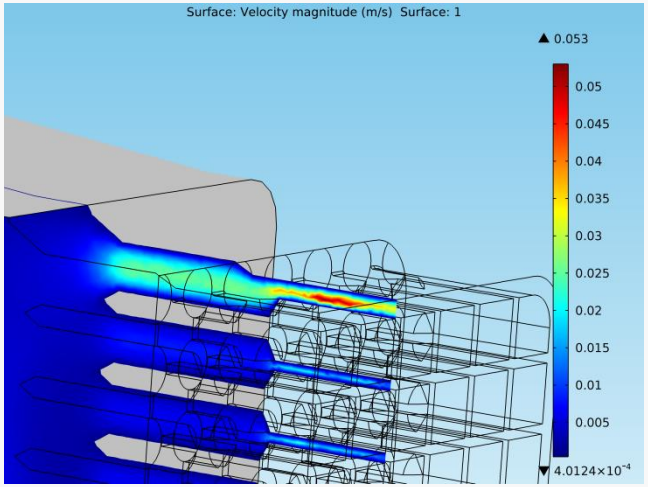
Die with pressure head and fluid volume



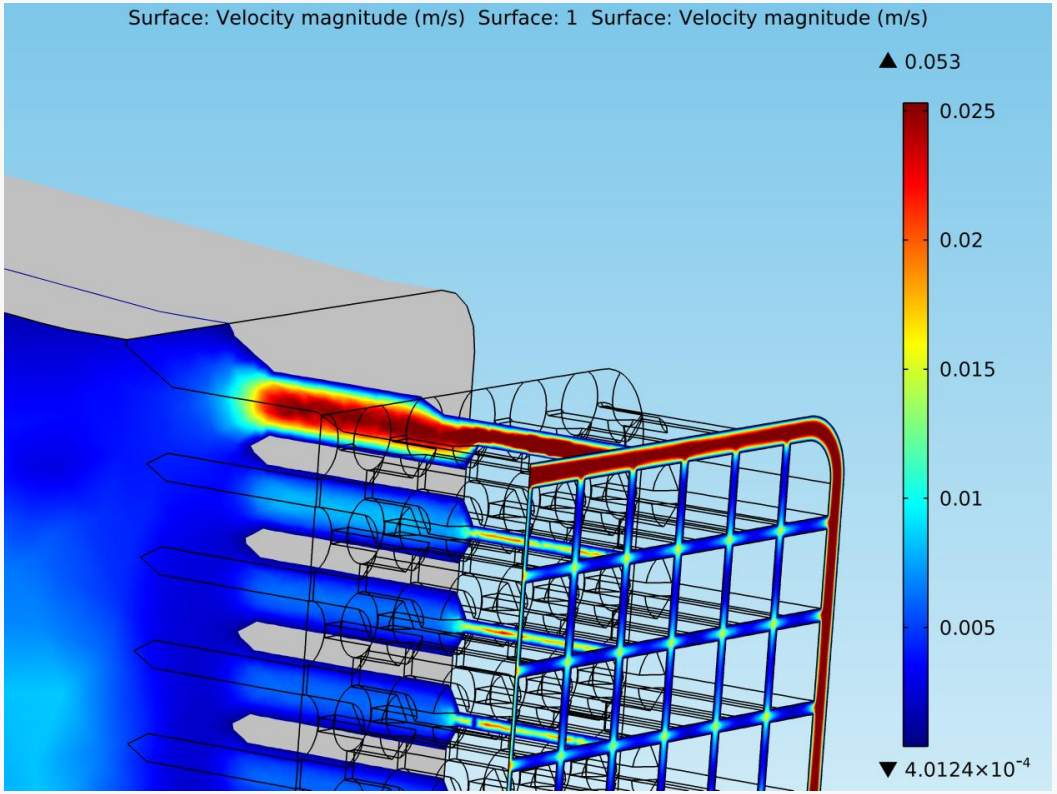


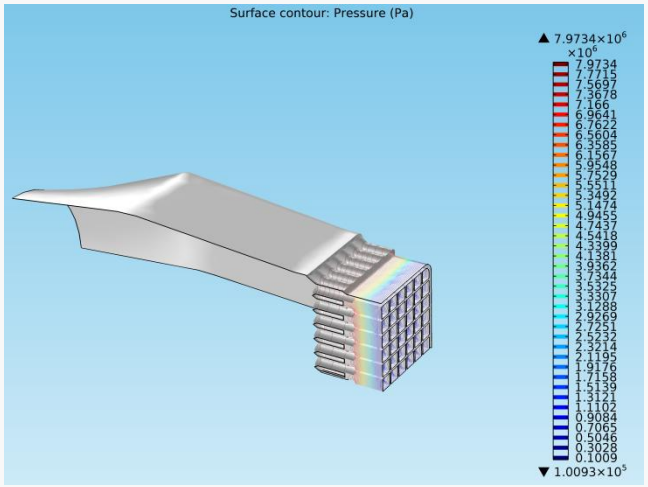
Velocity profile



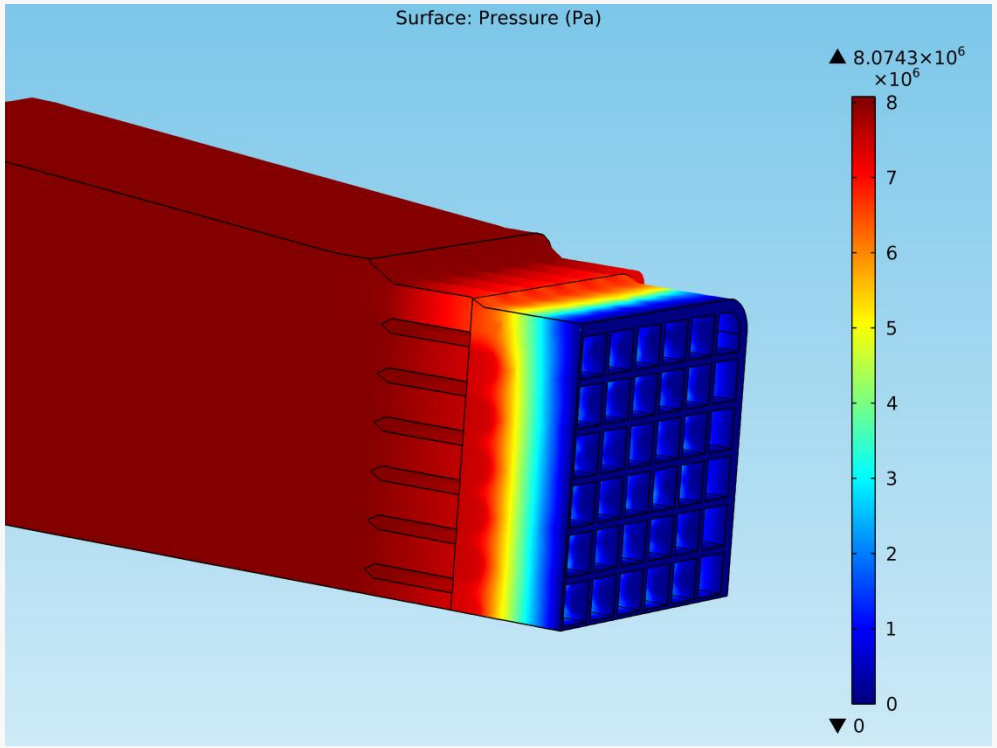


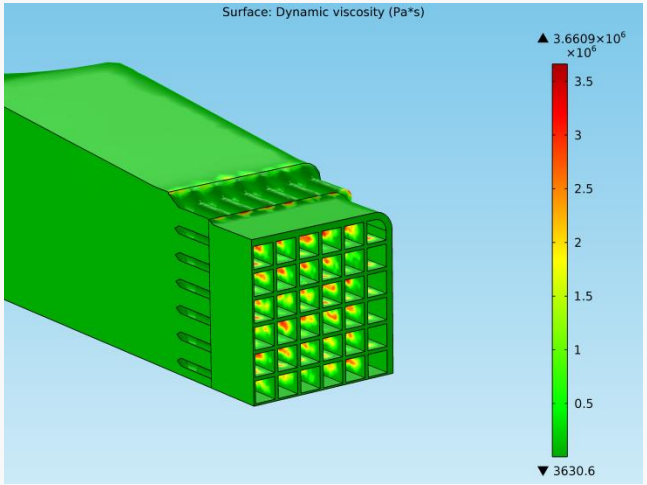
Velocity profile



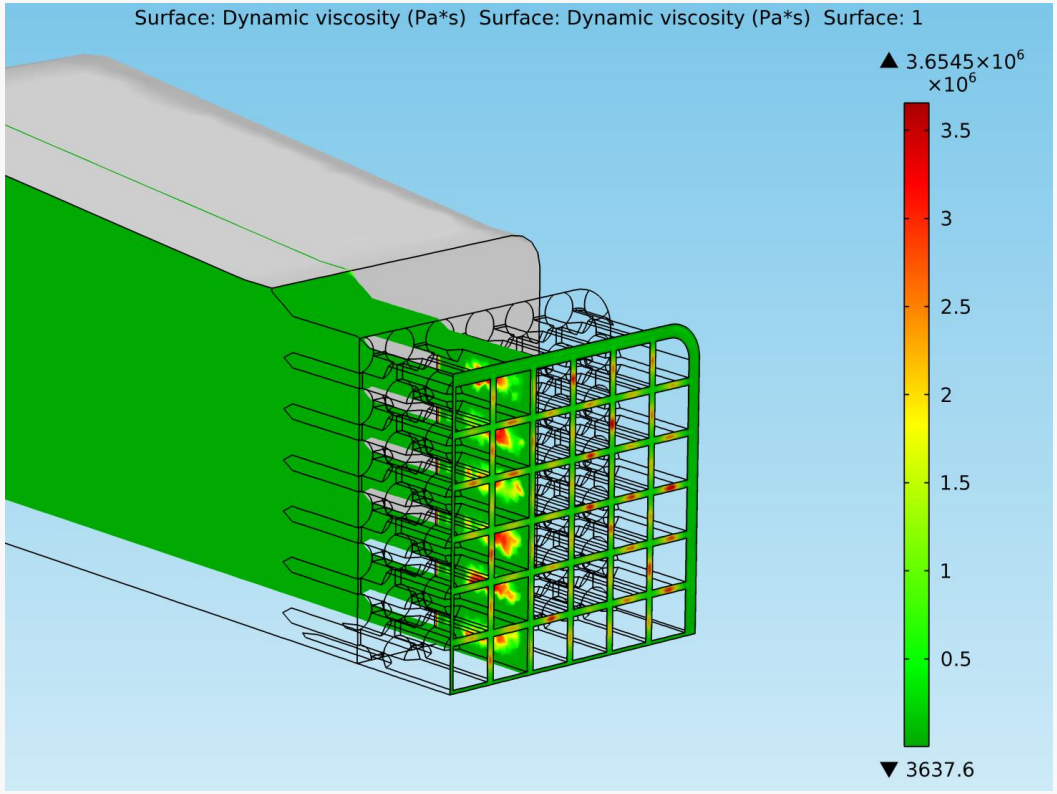


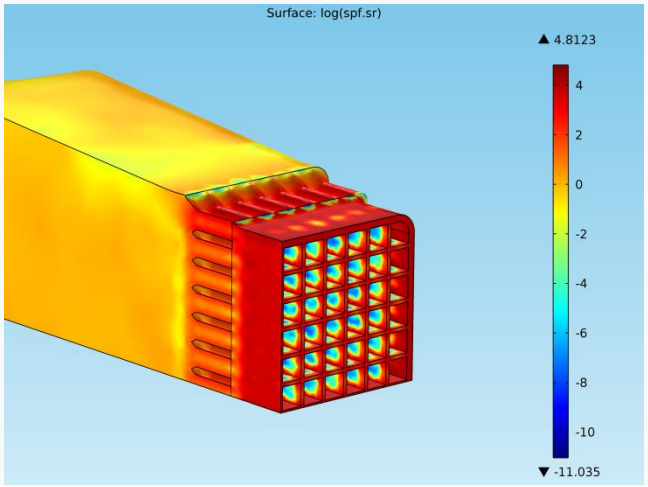
Pressure profile



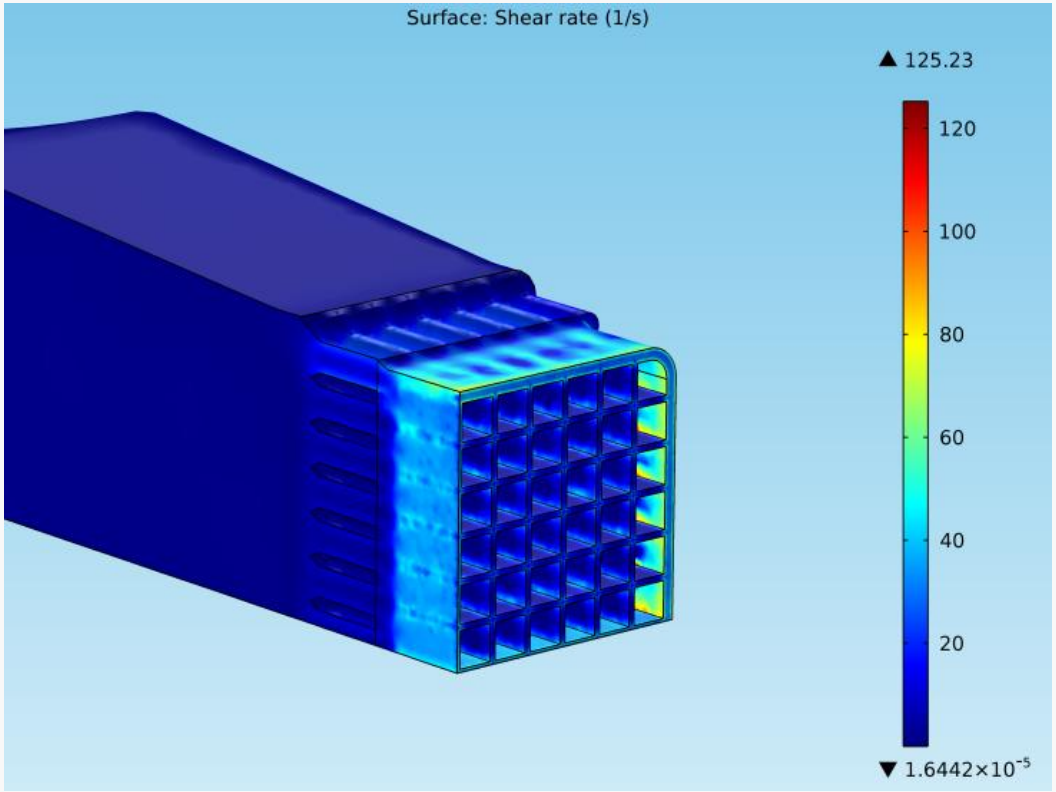


Viscosity profile

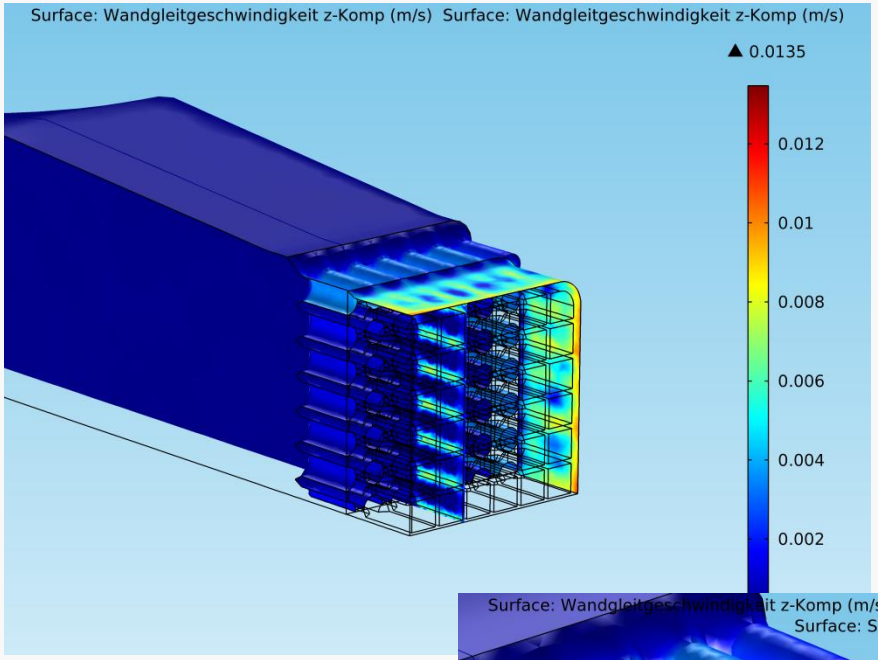


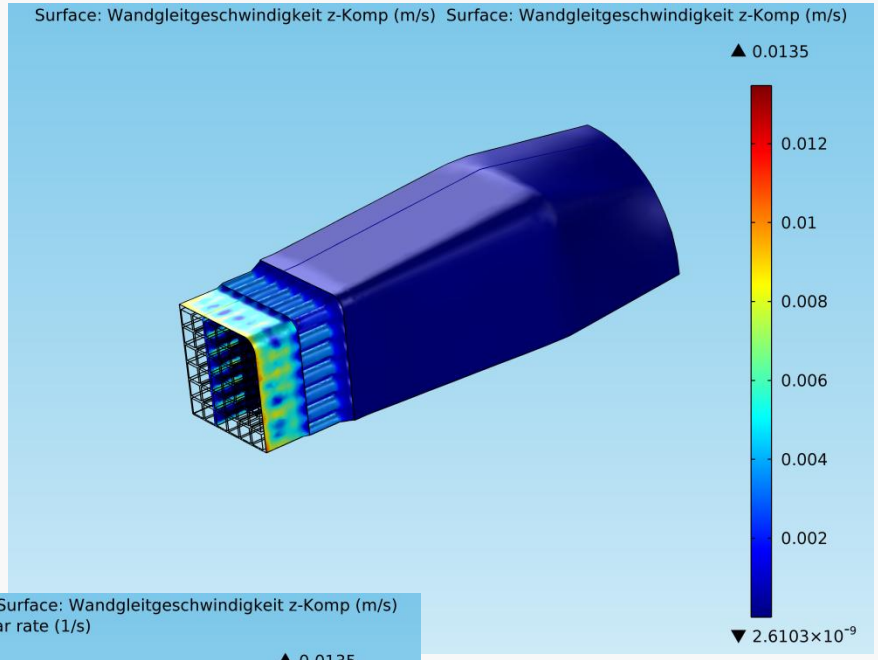


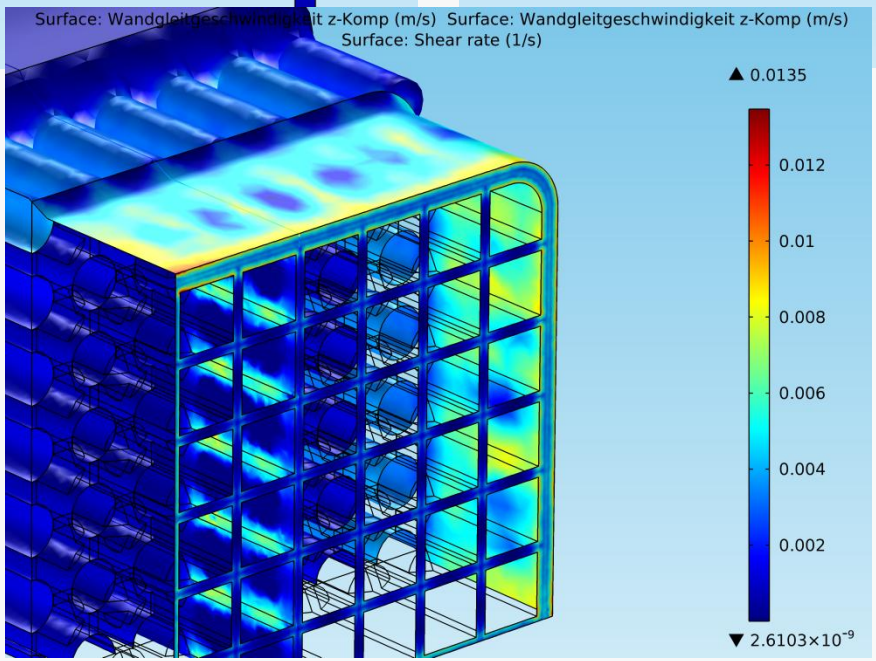
Shear rate distribution



wall slip velocity







Wall slip velocity

Simulation of viscoplastic fluids needs wall slip computation for correct simulation

Simulation and procedure technology is based on a Bingham modell with 4 parameters

Determination of the characteristic material parameters including wall slip is possible with expansion flow rheometer

COMSOL with extension PSM is an efficient tool for the analysis of the wide range of viscoplastic fluids