Understanding the flow of hard metal powders and pastes

M. Just[1,2,a], A. Medina Peschiutta[1,2,b], J. Baller[1], R. Useldinger[2]
[1]Department of Physics & Materials Science, University of Luxembourg, 1511 Luxembourg, Luxembourg.
[2]CERATIZIT Luxembourg S.à r.l., Route de Holzem, 101, L-8232, Luxembourg

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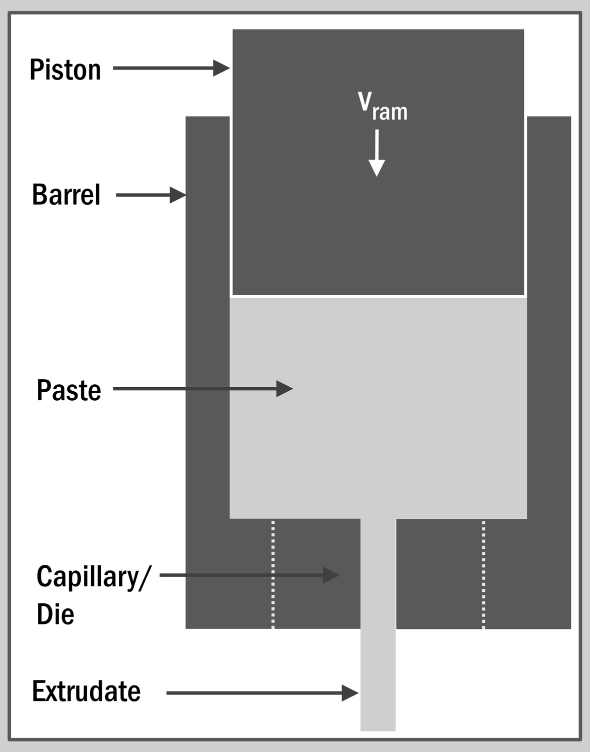
HM - Paste

Capillary rheometer

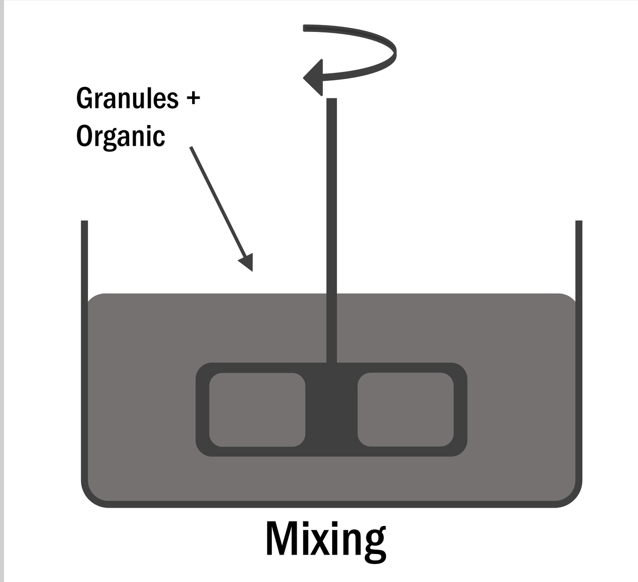


Objective

Develop constitutive physical models which describe the flow of hard metal pastes and to find the relevant boundary conditions (e.g. slippage at extruder walls)

Experimental approach

- Differential scanning calorimetry (DSC)
- Capillary rheometry
- Dynamic mechanical analysis (DMA)



Paste rheology

- Chemical composition
- External factors (temperature, shear stress)

Corrections for the paste flow in a capillary rheometer

- Bagley correction (pressure drop at the entry of the capillary)
- Mooney correction (effect of slipping at the capillary wall)
- Weissenberg-Rabinowitsch correction (velocity profile of the paste inside the capillary)

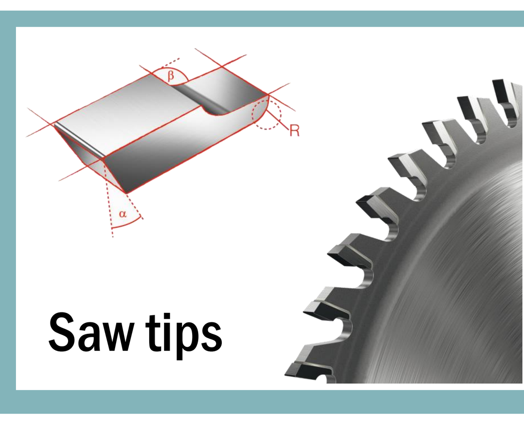
RHAMEP[b]

Granules preparation → Two production routes

paste → Paste preparation →
- Extrusion
- Metal injection moulding
- 3D printing

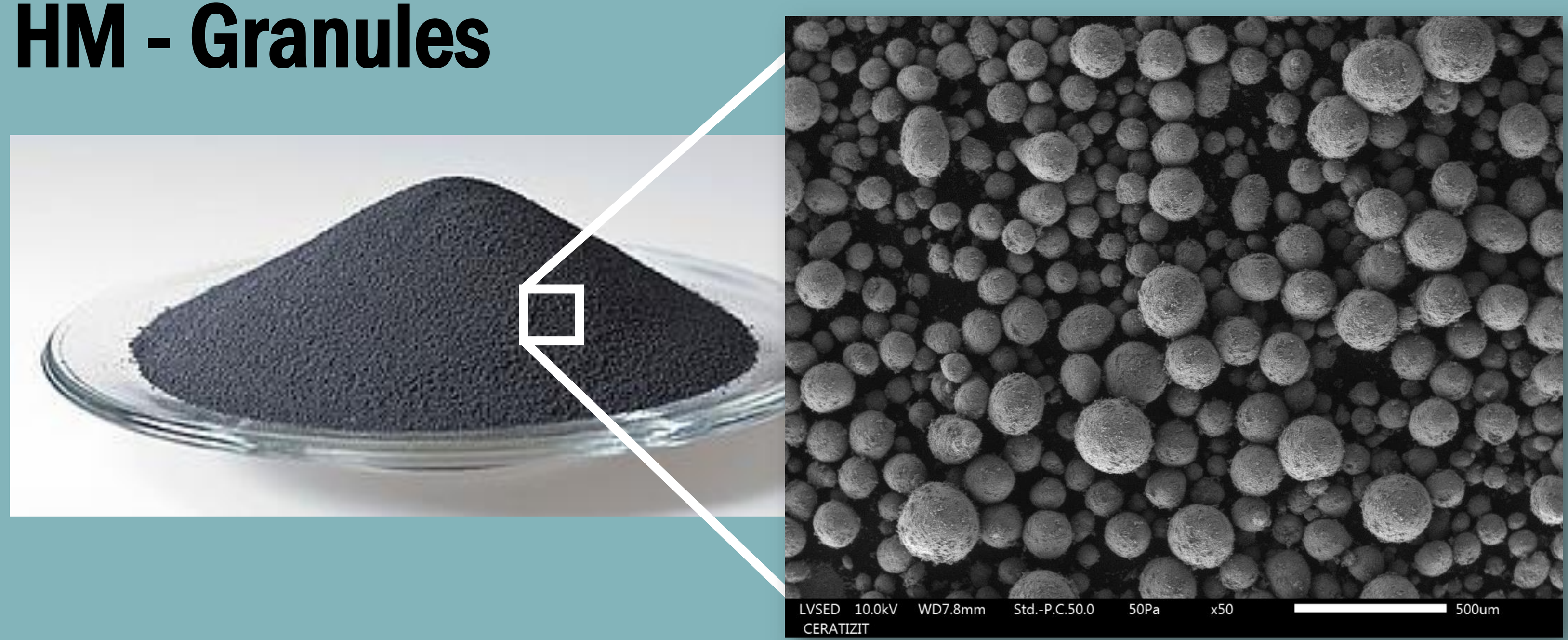
granules →
- Uniaxial die pressing
- Isostatic die pressing

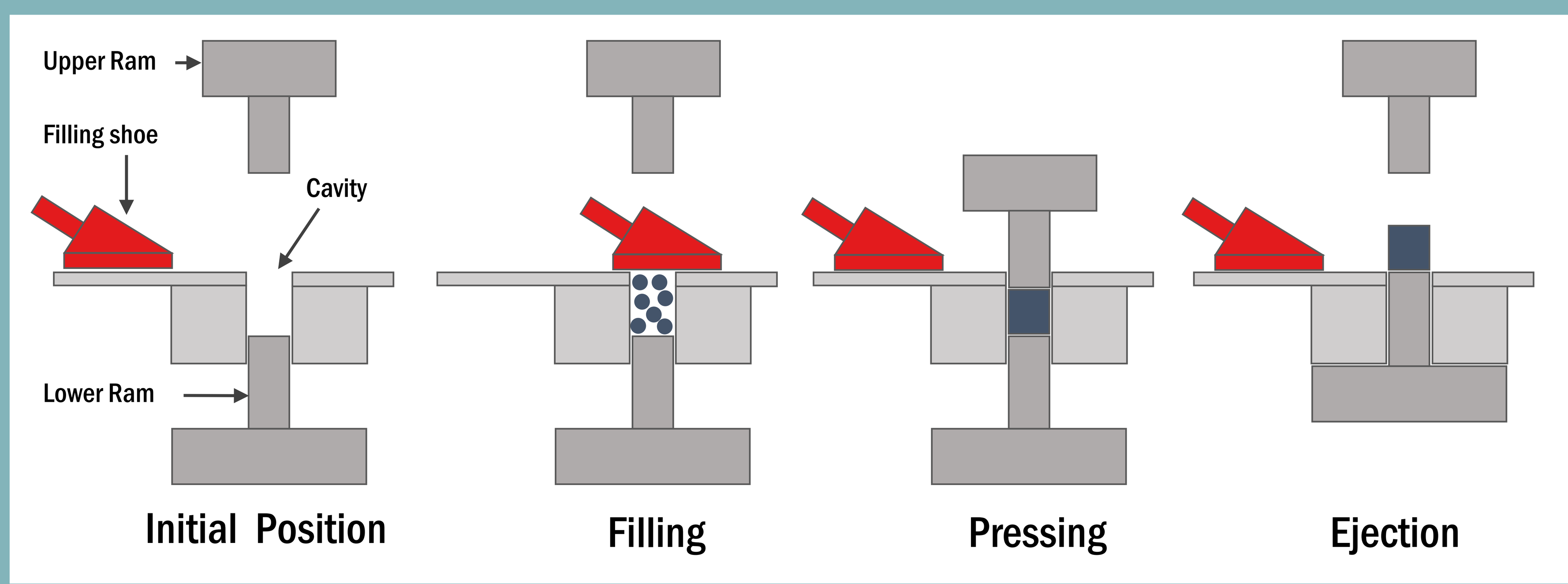
Forming → Finishing



MEPFLOW[a]

HM - Granules





Parameter influencing the filling process

- Technical setup of press (e.g. filling shoe speed, geometry)
- **Granules properties (e.g. roughness, granules distribution)**
- Environment (ambient temperature, humidity)

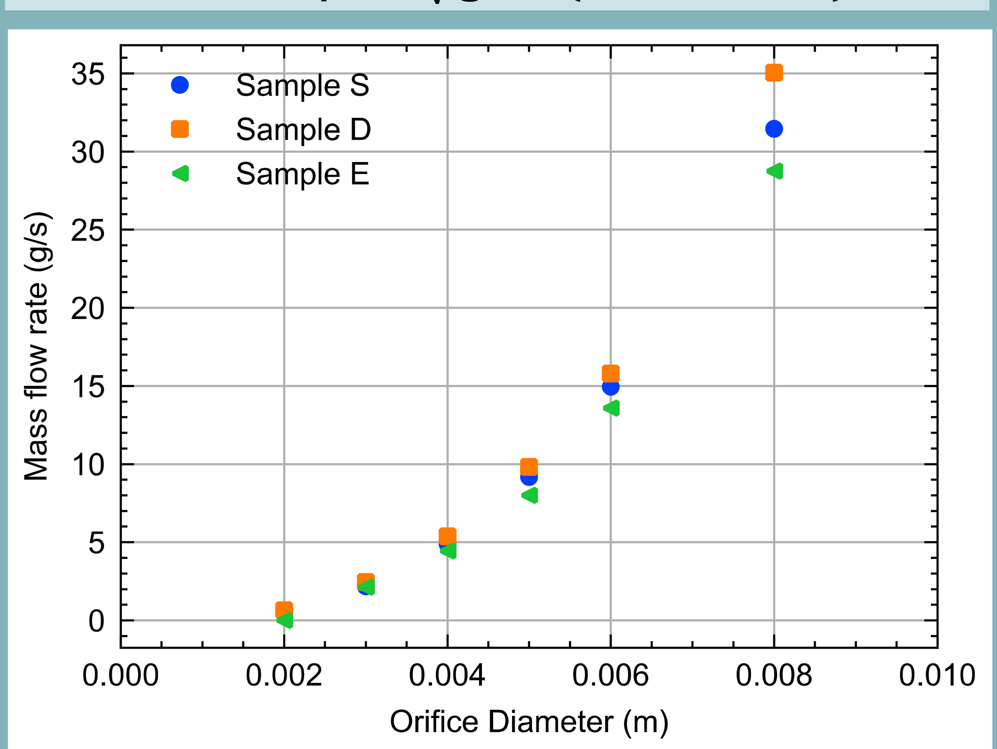
Requirements for the filling process

- Repetitive filling of the cavity
- Homogeneous granular density in the cavity
- High flowability leading to short filling times

Objective

Empirical model used to predict the flowability of HM-granules (based on the Beverloo law)

$$\dot{m} = C * \rho * \sqrt{g} * (A - k * d)^{2.5}$$



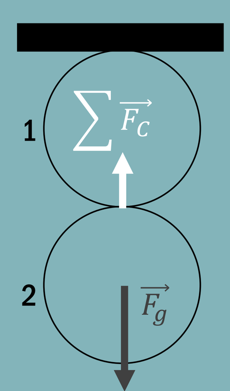
Critical points for initial Beverloo law

- Restricted to flat bottomed orifices and cylindrical containers
- Low precision for small orifices
- Polydisperse system represented by calculated diameter d
- Uncertain physical meanings of fitting parameters C and k

Experimental approach

Sieving of granular materials
- Angle of repose (friction coefficient)
- **Mass flow rate**
- Rheological measurements

Granular size matters!



$$Bo = \frac{\sum \vec{F_C}}{\vec{F_g}} \approx \frac{F_{vdW}}{F_g}$$ Simplified

For granules with identical chemical composition $Bo \sim \frac{1}{d^2}$