MSE 445/545: Ceramic Processing

Lecture 16:
Chapter 22&23: Pressing & Extrusion

• Objectives:
  – List factors that affect flow rate
  – Describe 3 stages of compaction and microstructural change
  – Describe fill density, compact density, and compactability
  – List factors that affect sprinback
  – Derive load transfer eq
  – Describe 3 major compact defects and reasons
Dry pressing

• Variables
  – Thickness > 0.5 mm
  – Pressure: 20-200 MPa
  – Binder content: 0.02-0.12%
Powder flow and Die filling

• Particle size: >20 \( \mu m \) is best

• Factors that affect flow rate:
  • Funnel repose angle (Fig. 22.3)
  • Fines <20 \( \mu m \)
  • Extra large granules
  • Binder
  • Others?

• Fill density \( D_{fill} = 25-35\% \).
Compaction behavior

Compaction Ratio (eq. 22.1):
3 stages:
3 stages of compaction

Stage I: Granule flow

Stage II: Granule deformation

Stage III: Granule densification

Compact density (22.3)

Compactability (22.4)
Porosity

- Optimum granule density, fill density and compactability for highest density

- **Intergranular pores**
- **Intragranular pores**
- Persistent interfaces
Die wall effect

• Shear stress at wall

• Load transfer (eq. 22.7)
Three Compact defects

Lamination

End cap

Ring cap
Extrusion process and Equipment

http://video.google.com/videosearch?q=extrusion&hl=en&emb=0&aq=f#
Extrusion Mechanics
Flow Mechanisms

- Determined by the applied shear stress and shear stress
  1. Laminar flow + slippage at the wall
  2. Plug flow + slippage at the wall
  3. Plug flow near center + Laminar flow near the wall, + slippage at the wall
Defects

1. Insufficient strength and stiffness
2. Cracks and lamination
3. Surface craters and blisters
4. Periodic surface laminations
5. Curling of extrudate
6. Laminations from unjoined flow stream
7. Poor/rough skin
8. Gradients in stiffness
9. Tearing during cutting
10. Curling on drying

Reading Assignment: Ch. 22 and 23