3D IMAGING OF THE TEXTURE EVOLUTION DURING CONVECTIVE DRYING OF SOFT SHRINKABLE MATERIALS

A.Léonard, S. Blacher, P. Marchot, J-P. Pirard, M. Crine

Laboratory of Chemical Engineering, Department of Applied Chemistry, University of Liège, Building B6C, Sart-Tilman, 4000 Liège, Belgium – **A.Leonard@ulg.ac.be**

Material

SOFT MATERIAL = wastewater sludge

- Collected after secondary settling and thickening
- Mechanically dewatered in a laboratory filtration-expression-cell
- Extruded into small extrudate
  - Diameter = 12 mm
  - Height = 15 mm

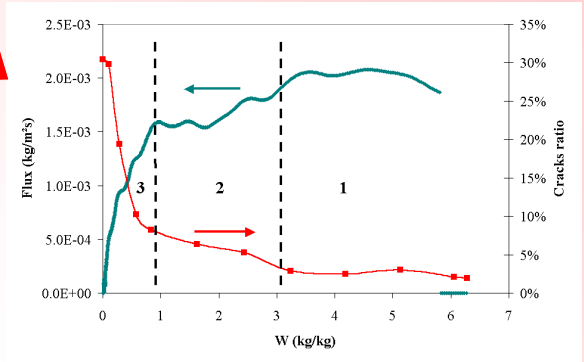
DRYING of SOFT MATERIALS

SHRINKAGE | **CRACKS**

PRODUCT QUALITY ?

FINAL TEXTURE ?

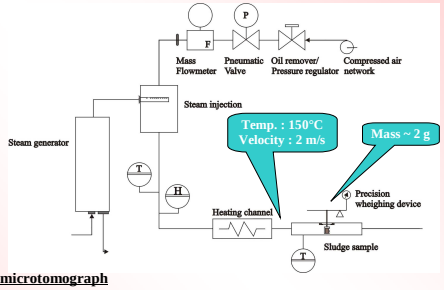
Relation between cracks formation and drying kinetics



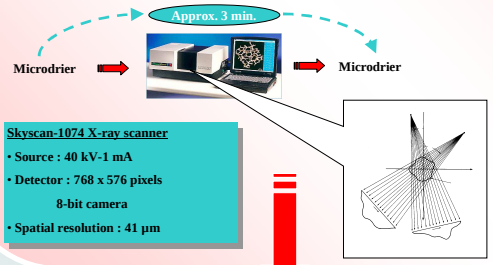
1. External transfer limitations
Constant mass flux
No crack
2. Mixed external and internal transfer limitations
Mass flux decrease
Beginning of cracs development
3. Internal transfer limitation
Sharp mass flux decrease
Strong increase of cracks ratio

Experimental set-up

Convective microdryer



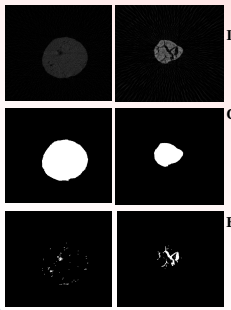
X-Ray microtomograph



Skyscan-1074 X-ray scanner
- Source : 40 kV-1 mA
- Detector : 768 x 576 pixels
  8-bit camera
- Spatial resolution : 41 µm

2D Cross-sections

IMAGE ANALYSIS ⇒ Binary cross-sections



Initial gray level images of wet (6.05 kg/kg) and dry samples (0 kg/kg)

Corresponding filled binarised image ⇒ equivalent diameter

Equivalent diameter + height

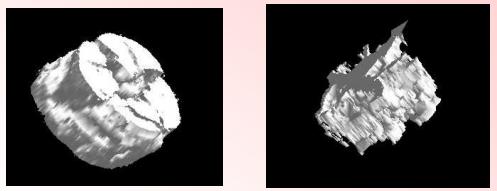
⇓

Shrinkage curve

Binarised image ⇒ cracks quantification and characterisation
- number of cracks
- cracks ratio = area of cracks/ total area
- cracks eccentricity
- cracks orientation

3D reconstruction

2D images ⇒ 3D images



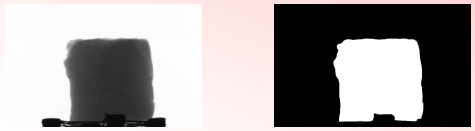
Example of 3D images of completely dried sample

Left : Structure of the solid with internal craks

Right : Reconstruction of cracks structure

Projections under 4 angles

IMAGE ANALYSIS ⇒ Binary images



Original gray level image **Binarised image ⇒** height from the sample

Conclusions

X-ray microtomography is a very efficient non intrusive experimental technique to follow changes of size, shape and texture that soft material undergo during a drying treatment. The analysis of the internal texture of the dried samples reveals crack formation at the end of the drying process. The onset of crack formation is clearly related to the appearance of internal transfer limitations. A possible explanation could be that internal diffusional limitations induce moisture gradients which bring about mechanical stresses, causing the development of cracks. Further works are under development to characterize the internal moisture gradients by X-ray microtomography.

Aknowledgement

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