Reaction engineering of the carbothermal production of beta'-Sialon

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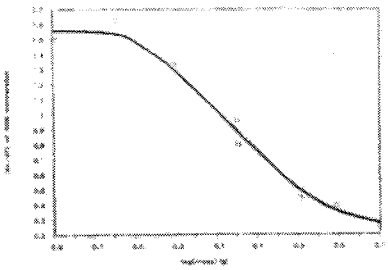
Introduction
The aim of the investigation is to develop a reaction engineering model for upscaling and reactor design applications.
Szekely's grain model, with spherical pellets and grains in a flat plate geometry, has been selected as the most appropriate.

Reaction

$$3Al_2O_3 \cdot 2SiO_2 + 4SiO_2 + 15C + 5N_2 \rightleftharpoons 2Si_3Al_3O_3N_5 + 15CO$$

Influence of bedlength

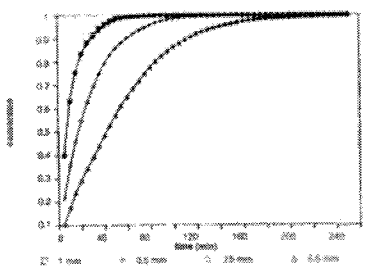


Conversion rate at 50% conversion vs reactor mass
T = 1673 K,
N_2-flow = 153 ml/min,
D_{tube} = 25 mm.

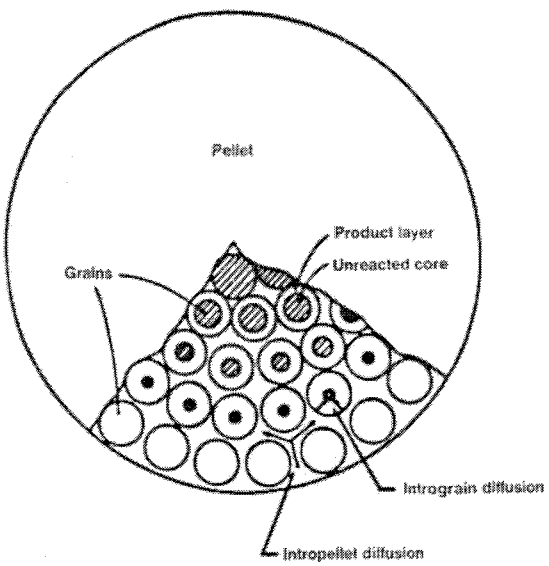
The grain model is a combination of:

- pore diffusion model for mass transfer in the pellets
- unreacted shrinking core model for the reaction in the grains, where reaction rate is supposed to be linear with the reacting surface area.

Influence of pelletsize

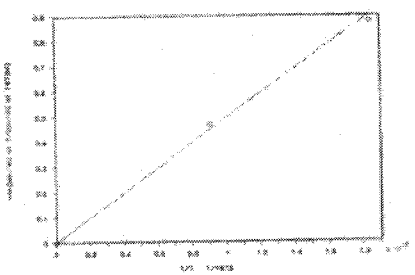


Conversion vs reaction time as a function of pellet size
T = 1673 K,
N_2-flow = 153 ml/min,
D_{tube} = 25 mm.



Sketch of the grain model

Activation energy



-ln (conversion rate at 50% conversion at temperature T/conversion rate at 50% conversion at 1673 K) vs
1/T-1/1673
N_2-flow = 153 ml/min,
D_{tube} = 25 mm.

Conclusions
- Reactor is differential when mass content is below 0.25 gram. Below this value CO-concentration does not influence chemical reaction rate.
- Pellet diameter below 1 mm: chemical reaction controls rate.
  Pellet diameter above 1 mm: chemical reaction + pore diffusion control rate
  Non-linear because of grain size distribution
- Chemical reaction activation energy = 405 kJ/mol.