Tailor-made Components for Process Engineering Made by Selective Electron Beam Melting

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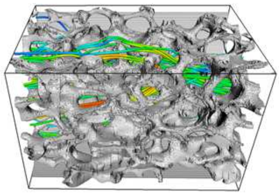
Why Additive Manufacturing in Process Engineering?

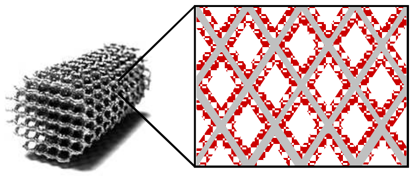
- Process equipment – e.g. reactors, heat exchangers and mixers – plays a key role in chemical process technology
- Manufacturing of components featuring an optimized geometry is highly desirable
- Additive Manufacturing – e.g. by Selective Electron Beam Melting (SEBM) – enables a three-dimensionally free design

General workflow

1. **Computer-aided modelling and design of optimized components[1]**
   Optimization with regard to
   - Fluid dynamics
   - Heat and mass transport
   - Reaction kinetics
2. **Additive Manufacturing of components via the SEBM process[2]**
3. **Surface modification by application of an appropriate coating**
   - Dense or porous coatings
   - Carbonaceous[3] or oxidic materials, e.g. Al_2O_3 or SiO_2
   - Catalytically active components, e.g. Pt, Pd
4. **Experimental validation of the novel equipment**
   - Performance test in selected demonstrator reactions
   - Hydrodynamic characterization of open cellular structures[4]



Simulation of the flow field in a random foam structure.



Schematic representation: structured reactor with catalytically active coating.

Application: energy storage in chemical compounds

Chemical compounds – e.g. methanol, ammonia or liquid organic hydrogen carriers[5] – are discussed as safe and convenient transport and storage medium for hydrogen.

The liberation of hydrogen (dehydrogenation) from its carrier molecule is challenging:

- Strong volume expansion due to formation of gaseous hydrogen
- Large heat of reaction: all dehydrogenation reactions are endothermal
- Gas liquid separation: liquid and gaseous products have to be separated efficiently

Technical approach: structured reactors for continuous dehydrogenation reactors

- Modelling of thermofluiddynamics to derive the open cellular structure
- Additive Manufacturing of structured tubular reactors via SEBM
- Internal structure and tube shell is manufactured as one part (excellent heat transport)
- Void space inside the reactor enables efficient hydrogen removal
- Coating of the cellular structure by heterogeneous catalyst via dip coating

Technical implementation: hydrogen release unit (HRU) [6]

- Apparatus for the dehydrogenation of liquid organic hydrogen carriers
- 10 tubular reactors are mounted in parallel in the HRU
- Heat of reaction is supplied by hot air in cross flow
- Hydrogen productivity reaches 10 L_{norm}/min
- Power density corresponds to 4 $kW_{el}/L_{reactor}$ in combination with a PEM fuel cell

Cone-shaped reactor e.g. for strongly volume expanding reactions.

Prototype of hydrogen release unit for dehydrogenation of LOHC.

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