Development and Characterization of Zeolitic Honeycombs for Heat Storage

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Concerning energy policy, renewable energies are in focus of politics, society and economy. These energies – a typical example is solar energy – do require usable storage systems, because of seasonal and daily fluctuations while energy production. Within the joint project MAKSORE, the objective of the work at the Institut für Kunststofftechnik (IKT) and the Institute of Thermodynamics and Thermal Engineering (ITW) is the development and characterization of zeolitic honeycombs suitable for application in future sorptive heat storage systems.

Extrusion of Zeolitic Honeycombs

Zeolitic honeycombs are made from a so called molding compound, consisting of different components. In the present case, zeolite 4A or 13X supplied by Grace GmbH, Worms, are chosen as adsorption materials. Methylhydroxylethylcellulose (MHEC) from Ashland Inc., Covington, USA, is used as plasticizer, while a curable liquid silicone resin from Wacker Chemie AG, Munich, is used as a binder. Additionally, demineralized water is added to produce a processible mold. All components are added into an extruder using gravimetric dosing systems resp. dosing pumps.

Above mentioned extruder is a twin screw extruder ZSK 40 from Coperion, Stuttgart. Using such a twin screw extruder avoids an additional process step, as molding and shaping are done within one step. While processing, the mold can heat up because of shear input from the screws. Therefore, the extruder is cooled actively to avoid such heating.

Mass throughput was set to 10 kg per hour, while there are significant performance reserves to increase throughput later on. Zeolitic content of the molding compound was chosen as high as technically possible. This allows optimizing the porosity of the honeycombs since future molds will have lower filling grades to increase contents of pore-forming agents. Therefore, such molds will remain technically controllable and processible.

Different honeycomb dies are used to produce zeolitic honeycombs having wall thicknesses of 0.8 to 1.3 mm and varying cell densities. After extrusion, the produced honeycombs are cut and dried in a microwave oven. Finally, the honeycombs are tempered at 200 °C.

Characterization

Measurements of the compressive strengths, done at the IKT, are showing good results: If loaded cross-sectionally (in direction of extrusion), the honeycombs can reach compressive strengths of about 5 to 18 MPa, depending on the used die. When loaded laterally (cross to direction of extrusion), still 2.5 to 11 MPa can be measured. Such values are in the range of concrete. It also has been shown that honeycombs having thicker walls are mechanically stronger than those having thinner walls.

The adsorption properties of the honeycomb material have been analyzed in experimental investigation at the ITW. In a small scale laboratory fixed bed reactor (volume of 250 ml) adsorption and desorption cycles have been carried out under defined conditions. These experiments show that the processed zeolite still can adsorb a high amount of water. However, compared to a reference material (commercial beads supplied by Grace) the honeycomb material is characterized by a smaller adsorption capacity and slower adsorption kinetics. This indicates that the adsorption material is currently not fully available for adsorption. The limited adsorption kinetics might be due to the used mold, containing a maximum amount of zeolite and therefore only a marginal amount of material which can be removed for pore production.

Future Works

After having investigated the correlation between geometry, porosity and kinetics thoroughly, wall thickness and cell density of the honeycombs will be optimized. Therefore, the distribution of porosity will be improved according to the results of the honeycombs produced so far. Additionally, fluid dynamic simulations will be carried out to optimize the macroscopic geometry of the honeycombs. Thereafter, it will be possible to adapt molding compound and die to produce zeolitic honeycombs having optimized fluid dynamic properties and kinetics.

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