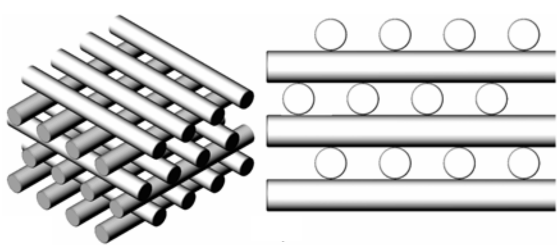
ROBOCASTING ENTERPRISES LLC

Research Brief - December 2007

Robocast Catalyst Monoliths Show Enhanced Conversion

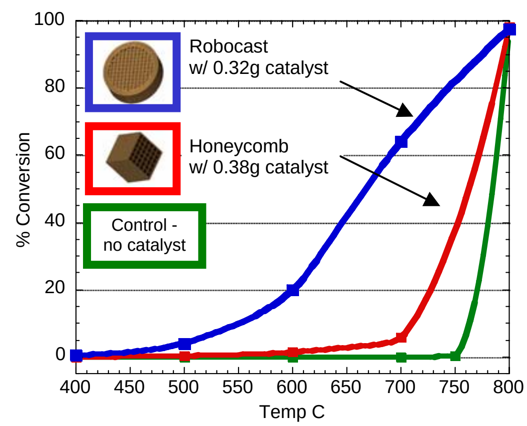
*Motivation:** Monolithic catalytic reactors have found use in applications such as emissions abatement, thermal combustion control, and production of hydrogen from various sources. Two monolithic support structures are commonly used to support the catalyst system in these applications; extruded honeycombs and reticulated ceramic foams. Standard extruded honeycomb monoliths offer high surface area/volume ratios and low pressure drop but have low gas-solid mass transfer. Reticulated ceramic foams also have high surface area/volume ratios with the benefit of good gas-solid mass transfer at the cost of highly-variable part-to-part pressure drop due to the random organic nature of the foam structure. Regardless, catalyst systems using these monoliths have been in existence for decades.

Robocast structures provide consistently-low pressure drops, high area/volume ratios, and excellent gas-solid mass transfer by utilizing a 3D arrangement of rods engineered to provide tailored porosity and tortuosity in all dimensions, increasing catalytic activity of the system. This allows for more efficient use of the catalyst so either less catalyst is needed to create the same amount of product or more product can be created with the same amount of catalyst. Furthermore, if it is economically feasible, Robocast structures can be fabricated entirely from the catalyst, creating catalyst monoliths which are yet more active than washcoated systems.



schematic of 3D Robocast structures

Accomplishments: The combustion of methane over a $BaMn_2Al_{10}O_{19-\alpha}$ catalyst was studied from low temperatures to that of homogeneous combustion (800ºC) where excessive NO_x formation, a common greenhouse gas, occurs. The catalyst is ceramic in nature and able to withstand high temperatures (>1000ºC) without significant surface area loss from sintering. Robocast monoliths were created to have identical surface area/volume ratio as a honeycomb monolith (27 cm^2/cm^3). Methane conversion at was consistently higher over the Robocast monolith at all temperatures up to homogeneous combustion with similar amounts of catalyst loading. Light-off temperature was also reduced from ~525ºC to ~400ºC by way of the Robocast monolith.



Analysis at 600ºC shows that conversion is 15X greater with Robocast monoliths. At this temperature, 4X the amount of catalyst is needed on the honeycomb monolith to perform the same amount of conversion. This can be attributed to a 3X increase in the Sherwood number of the Robocast system, a measure of the convective mass transfer.

* Original research was performed with J. Miller and R. Ferrizz at Sandia National Laboratories

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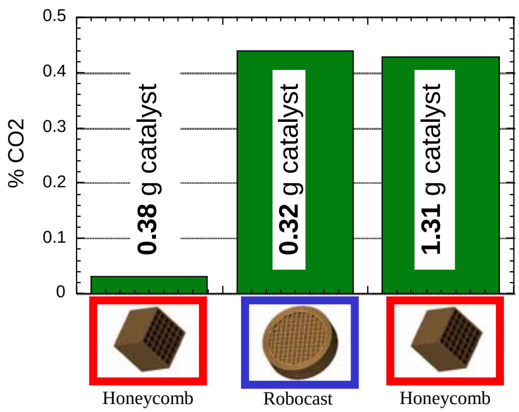
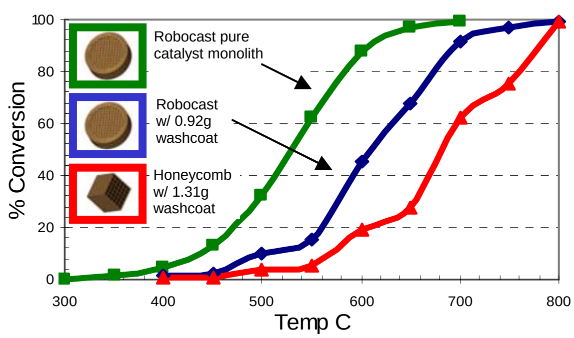


Creating monolithic structures from the catalyst itself proved to further increase the catalytic activity of the system. Pure catalyst monoliths were compared to Robocast and honeycomb monoliths loaded with the maximum amount of catalyst washcoat respectively. Light-off and 100% conversion temperatures were further reduced by the Robocast catalyst monolith.



Significance: Robocast monolithic structures can reduce the temperature of catalytic reactions through the increased mass transfer created by 3D structure. This decrease in temperature may allow for a decrease in greenhouse gas emissions. Additionally, less catalyst may be needed to perform the same amount of conversion as extruded 2D monoliths. Inexpensive catalyst systems may lead to more efficient structures, Robocast catalyst monoliths.

Related Research Briefs:

- Robocast monolith structures have been proven to have higher flow reproducibility than reticulated foam monoliths. *See Research Brief: Consistent Flow through FCT Structures.`*
- Robocast monoliths show superior performance when compared with honeycomb monoliths. *See Research Brief: Advanced Catalyst Support Structures.*
- Thermal runaways and thus a chance for catalyst sintering and performance loss may be reduced with Robocast monolithic supports. *See Research Brief: Novel Diesel Particulate Traps from Robocasting.*

Robocasting Enterprises is the sole licensee for manufacturing with this technology

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