Designing a 3D Printed Catalyst Carrier That Maximized Reaction Yield

Dominque Beck, Moosa Obaidullah, Justin Santiago \ Dr. Niechen Chen

Department of Industrial and Systems Engineering, College of Engineering and Engineering Technology, Northern Illinois University

Problem Description
- A catalyst is a substance that increases the rate of a chemical reaction without itself undergoing permanent chemical change.
- Test of basic household Amberlyst catalyst against specially made catalyst carrier.
- Certain parameters of catalyst carrier affect the reaction yield.
- How will differentiating parameters effect reaction yield?

Catalyst Conversion Process
- After catalyst carriers are printed, chemistry department pours an acid solution through carriers.
- Acrylonitrile butadiene styrene material reacts with solution to create acid groups, allowing catalytic reaction.

Objective
- Design and develop a catalyst carrier that maximizes reaction yield.
  - Increase fluid resistance so reaction will take place over a longer timespan.
  - Maximize interior surface area by using a lattice design so reaction will happen quicker.

Design Method
- Team will use CAD software to design interior mesh of catalyst carrier.
- Catalyst carrier has set parameters that must be followed.
- Each catalyst carrier will have a unique interior mesh following a lattice structure design.
- CAD file is imported into CAM software to generate 3D printer toolpath.
- Catalyst carriers are 3D printed using method of Fused Deposition Modeling.
- Printed using Acrylonitrile Butadiene Styrene (ABS) material.

Iteration 1
Issues
- Geometries were too small to print.
- Solution could not easily flow through.
- Acid solution causes thermal expansion.
- Acid solution leaks and disfigures part.
- Over emphasis on increased surface area.

Expansion Ratio Testing
- Our solution to the issues faced in iteration 1 was to develop small coupons. Coupons are measured before and after being treated with chemical solutions. Expansion ratio testing was conducted to account for the swelling of future parts.

Iteration 2
Issues
- Second iteration of parts are updated to account for swelling during catalyst conversion and catalytic reaction processes using the expansion ratio from the coupon testing.
- A lip was added onto new parts to account for solution leakage and easier handling by chemistry department.

Expansion Ratio Testing Results
- Coupon diameter and side lengths expanded 1.66% while wall thickness shrank 6.1% after being printed and treated with acid.
- Coupons expanded 2.22% after being treated with second solution, chloroform, while wall thickness shrank 10.1%.

Conclusions
- Only maximizing surface area is not an effective approach.
- Sacrificing some surface area to account for printability and proper liquid flow is essential.
- None of our original assumptions held true.
- When treated with acid and chloroform solution, the walls of the catalyst carrier tend to decrease while the outer edges tend to expand.
  - Possibly due to thermal expansion and/or printer error.

Future Work
- Experimentation is ongoing.
- Chemistry department does not expect to be done with experimentation until the end of May.
- Multiple iterations are needed to finalize a design.

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