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Topic #1

Design of Fluidic Chevrons for Jet Noise Reduction

Subject Areas: Aircraft Engines; Flow Instabilities, Aero-Acoustics

Chevron mixing devices are used to reduce noise from commercial separate-flow turbofan engines. Mechanical chevron serrations (see for example https://ntrs.nasa.gov/citations/20040139205) at the nozzle trailing edge generate axial vorticity that enhances jet plume mixing and consequently reduces far-field noise. Fluidic chevrons generated with air injected near the nozzle trailing edge create a vorticity field similar to that of the mechanical chevrons and allow more flexibility in controlling acoustic and thrust performance than a passive mechanical design. In addition, the design of such a system has the future potential for actively controlling jet noise by pulsing or otherwise optimally distributing the injected air.

For this project, the design group will first develop a prediction and simulation tool for investigating high-speed air flow through nozzles with special emphasis on noise generation. Chevron attachments will then be considered to quantitatively evaluate their performance in noise reduction. Various designs of chevron-style geometries will be considered.

Deliverable: A CFD model/prototype

Team composition: 3 MEM students

Sponsor: TBD Aircraft manufacturers like Boeing and GE will be contacted for guidance and support.

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Topic #2
Nicotine Extraction from Tobacco Using Supercritical Fluid Technology

Subject Areas: *Supercritical fluid systems*, *optimization theory*

Since the Drug Abuse Advisory Committee has classified nicotine as an addictive substance this enables the U.S. Food and Drug Administration to control and monitor the levels of nicotine in cigarettes and tobacco. There are several reports on the extraction of nicotine from tobacco using liquid extraction techniques; however, since some of these suggest the use of aqueous buffers (Saunders et al., 1981; Sudan et al., 1984), subsequent liquid extractions are necessary to allow screening for pesticides using gas chromatography-mass spectrometry (GC-MS).

The use of supercritical fluids (CO_2 in particular) for the extraction of organic compounds from a wide variety of matrices is increasing due to the favorable properties of these fluids. Supercritical fluids have lower viscosities and higher solute diffusivities, hence improving the mass transfer and reducing the time needed for the extraction. The influence of particle size, cell geometry, and packing of the extraction cell was investigated for the extraction of nicotine from tobacco using supercritical CO_2.

The design group will investigate possible approaches to deliver a steady flow of supercritical CO2 to a reactor containing nicotine samples. Design activities will be focused towards optimizing extraction time. The presence of water during the extraction step, which was introduced either by the packing material or by addition to the mobile phase, is important in order to desorp the nicotine from the cellulose matrix in the shortest possible time.

Deliverable: A working supercritical flow reactor
Team composition: 3 MEM students
Sponsor: TBD

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Topic #3

Dry Textile Dyeing using Supercritical CO_2

Subject Areas: *Supercritical fluid systems*, *optimization theory*

Supercritical carbon dioxide is well known for its ability to extract chemicals such as caffeine from coffee beans or solvent from aerogels. However, recent studies **(https://www.sciencedirect.com/science/article/abs/pii/S0896844623001900)** are being performed that do the opposite: as a more eco-friendly means of dyeing a textile, researchers have begun investigating the application of dyes to a given fabric using supercritical CO_2 rather than with the more-conventional water. Reports show that the dry-application with supercritical CO_2, under optimal conditions, applies a much deeper color to the fabric in comparison to the conventional method. For this project, develop a supercritical CO_2 reactor that can house fabric and dye, and investigate the mechanisms of supercritical CO_2 dyeing to identify the optimal pressure and temperature values for deep dye coloration.

Deliverable: A working model/prototype

Team composition: 3 MEM students

Sponsor: TBD

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Topic #4
Efficient Modelling of Acoustic Metamaterials for the Performance Enhancement of an Automotive Silencer

Significant potential for acoustic metamaterials to provide a breakthrough in sound attenuation has been unlocked in recent times due to advancements in additive manufacturing techniques. These materials allow the targeting of specific frequencies for sound attenuation. To date, acoustic metamaterials have not been demonstrated in a commercial automotive silencer for performance enhancement. A significant obstacle to the practical use of acoustic metamaterials is the need for low cost and efficient modelling strategies in the design phase.

This design team will investigate the effect of acoustic metamaterials within a representative automotive silencer. The acoustic metamaterial design is achieved using a combination of analytical and finite element models. The acoustic metamaterial will then be compared with commonly used techniques in the silencer industry to gauge the effectiveness of the acoustic metamaterials. FLUENT simulations will be used for the preliminary design. The design team will attempt to show that acoustic metamaterials can be used in practical settings, such as an automotive silencer, to improve the overall sound attenuating performance.

Deliverable: A working model/prototype

Team composition: 3 MEM students

Sponsor: TBD