Computational Fluid Dynamics Modeling Supports Fuel Reformer Research

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Challenge

To make them practical for use in light-duty fuel-cell vehicles, the current generation of fuel reformers – which convert conventional fuels to hydrogen – must be improved and scaled up to produce more power. But it's not as simple as increasing the size of the components – any number of other factors can throw off the performance of the reformer, even in scaling up to 5 kW (Figure 1).

Technical Approach

Argonne is developing a three-dimensional CFD reformer model that can be used to evaluate the interacting local effects of fluid flow, heat transfer, mass transfer, and chemical reactions. The model helps researchers to

- Identify the most promising fuels and the best operating and design parameters
- Quantify the effects of these parameters on reformer performance
- Diagnose heat transfer and mixing problems
- Explore options to improve performance

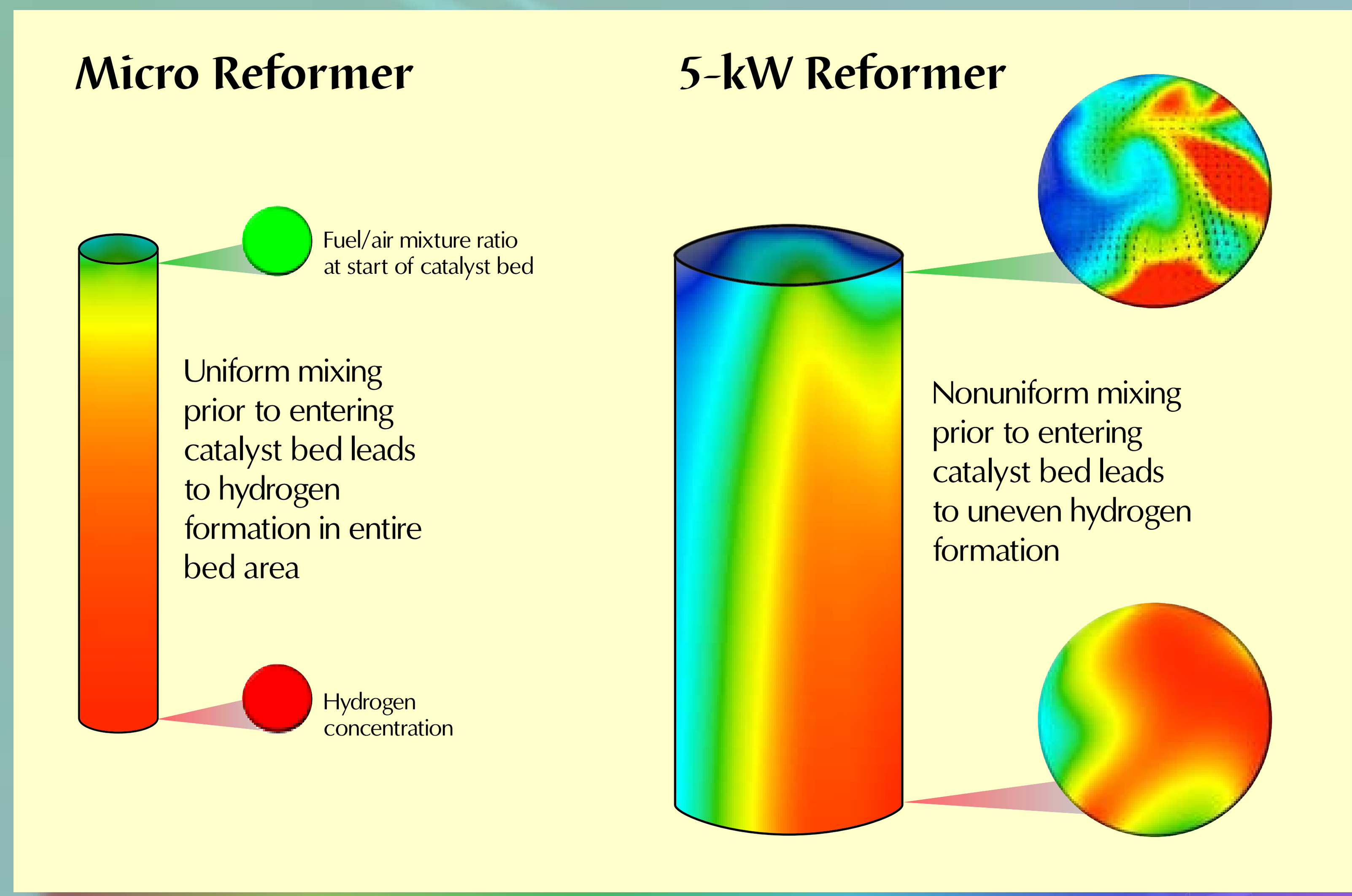

Figure 1: Factors such as incomplete mixing can degrade the performance of the reformer.

Results

Argonne ran CFD codes simultaneously on a cluster of PCs – providing far more computational cells (300,000 vs. 50,000) and a more accurate picture of conditions inside the reformers.

Mixing and Heat Transfer

Because reaction rates inside the reformer are extremely sensitive to temperature and mixing of O_2, fuel, and steam (Figures 2 and 3), Argonne modeled different mixer designs to see where increased temperatures and incomplete mixing reduced the reformer's efficiency and to help identify an optimal mixer design.

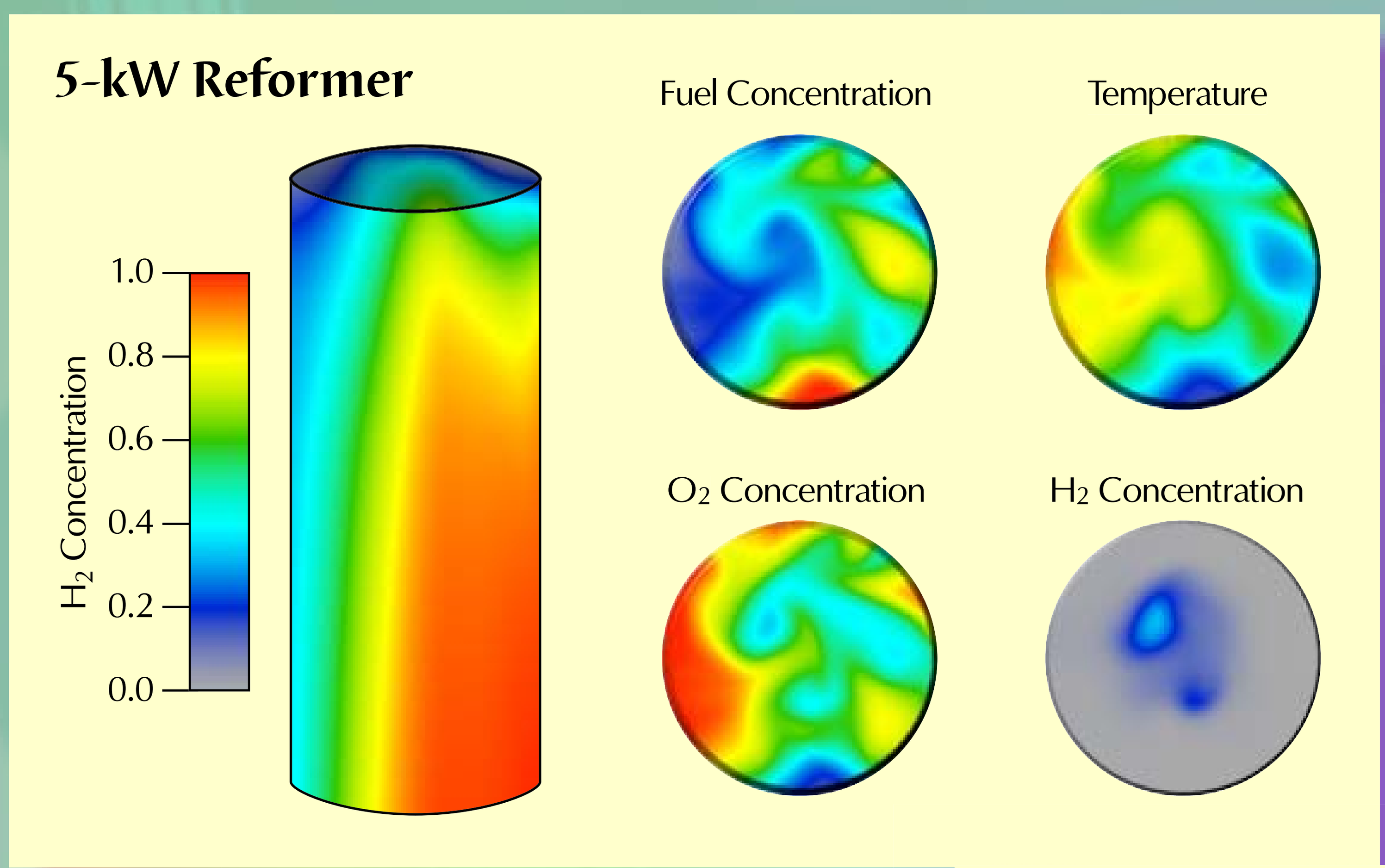

Figure 2: CFD models identified fuel-starved hot spots and O_2-starved cold spots in the reactor that led to reduced hydrogen production.

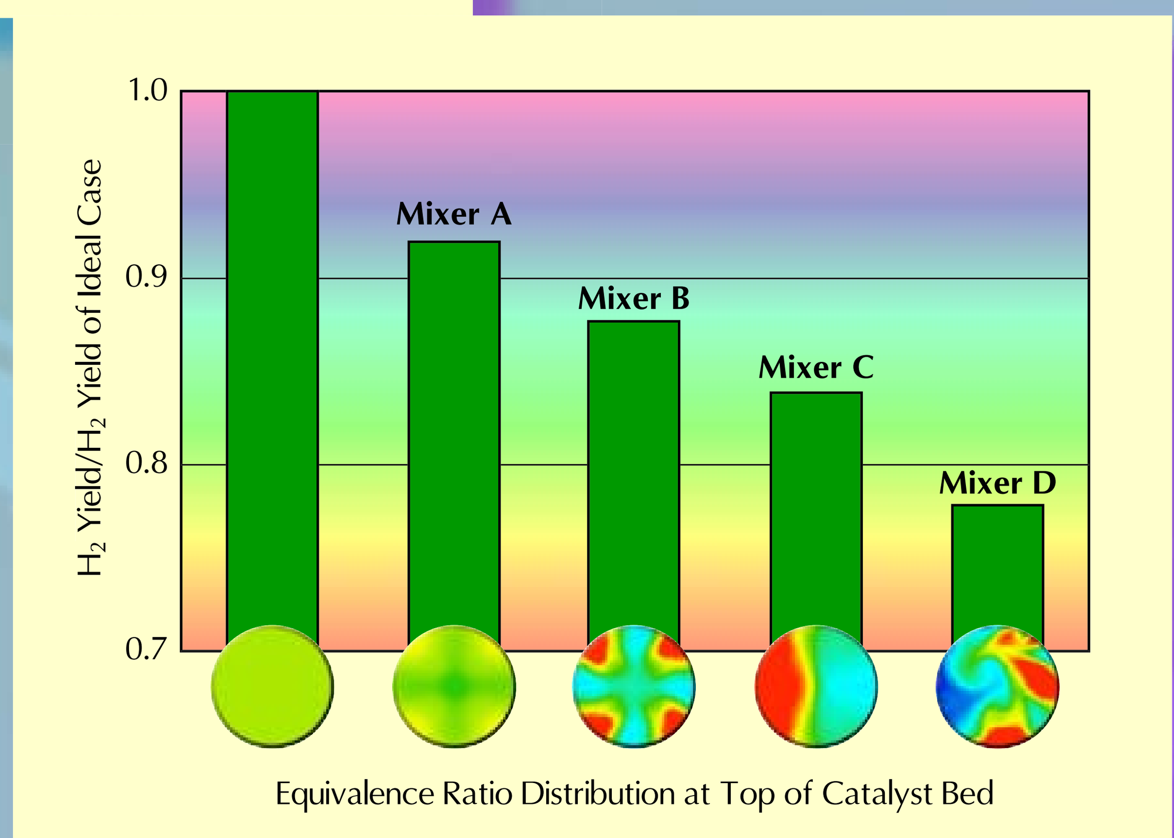

Figure 3: Hydrogen yield is highly sensitive to mixer design.

Fast Start

To be acceptable to light-duty vehicle drivers, reformers must be able to start quickly. Argonne is modeling the reformer and running experiments to identify the best strategies for rapid startup (Figure 4).

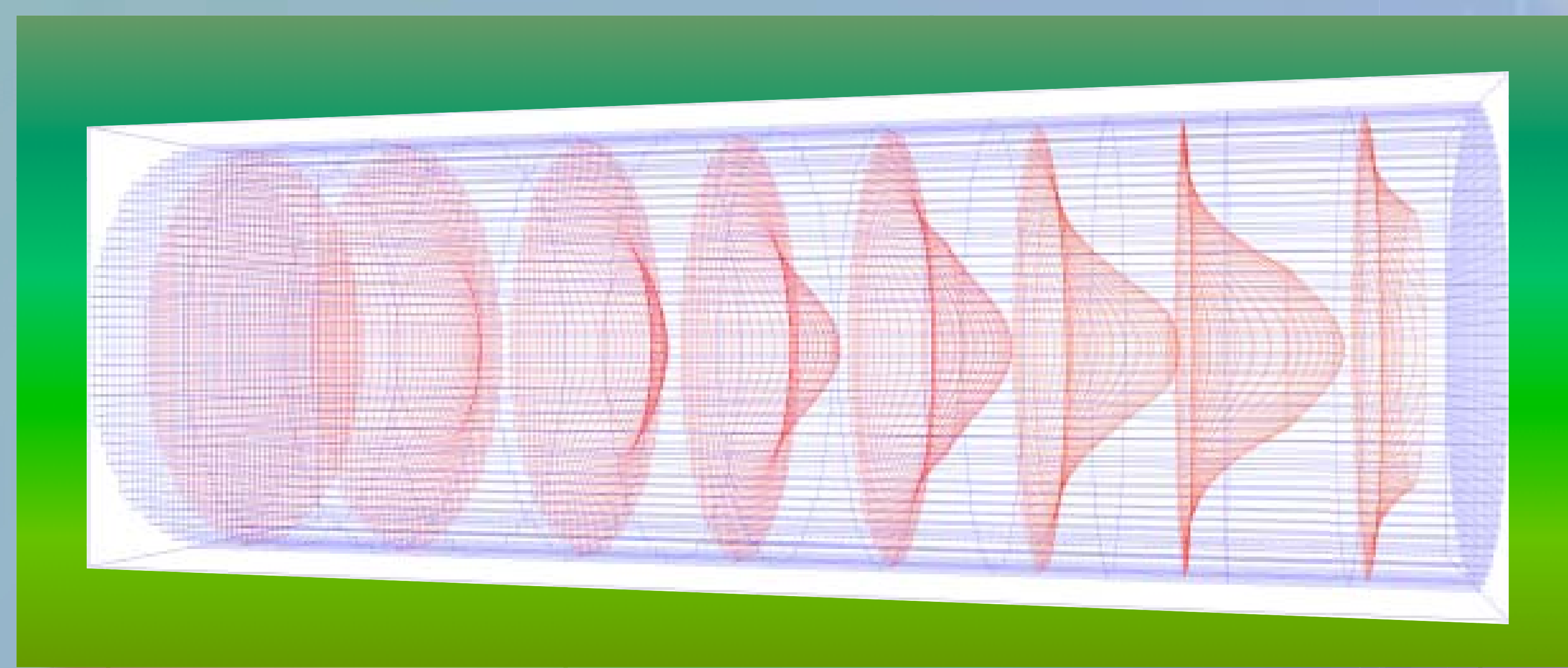

Figure 4: Transient CFD computation reveals that a 950-K isosurface reaches the reformer catalyst exit within 30 seconds.

Benefits

- Quickly and inexpensively "alter" components and configurations in the reformer model
- Run many virtual CFD tests in the time it takes to modify equipment design for lab experiments
- Respond more rapidly to the research needs of DOE and our industrial partners

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