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Impact of Cold Start on Vehicle Fuel Economy and Performance

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Abstract*—*The goal of this research is to understand and quantify the impact and effects of low temperature operation has on the performance and efficiency of vehicle fuel cell systems through modeling. More specifically, this work addresses issues of the initial thermal transient known to the automotive community as "cold-start" effects. Cold-start effects play a significant role in power limitations in a fuel cell vehicle, and may require hybridization (batteries) to supplement available power. A fuel cell system model developed as part of this work allows users to define the basic thermal fluid relationships in a fuel cell system. The model can be used as a stand-alone version or as part of a complex fuel cell vehicle model.

Fuel cells are being considered for transportation primarily because they have the ability to increase vehicle energy efficiency and significantly reduce or eliminate tailpipe emissions. A proton exchange membrane fuel cell is an electrochemical device for which the operational characteristics depend heavily upon temperature. Thus, it is important to know how the thermal design of the system affects the performance of a fuel cell, which governs the efficiency and performance of the system.

***Keywords*— Vehicle, fuel cell model, power limitations.**

I. INTRODUCTION

Fuel cells are being considered for transportation because they have the ability to increase vehicle energy efficiency and significantly reduce or eliminate tailpipe emissions. It is well known that passenger vehicle with spark ignition engines release most of their unburn hydrocarbon (HC),Carbon monoxide (CO) and Nitrogen oxide (NO) emissions during first minutes of driving, while the three-way catalyst (TWC) is below its so-called "Light off temperature". As such, the introduction of catalytic converters was quickly followed by intensive efforts aimed at optimizing their performance during this „Cold start „period users to simulate a variety of vehicles.

The objective of this work is to develop a net power request model of a vehicle fuel cell system. This model will also be able to quantify the impact that cold-start has on the performance and efficiency of a fuel cell vehicle. Specifically this model will pay particular attention to the thermal system and the role that it plays on the initial thermal transient known as cold-start. Current models for vehicle simulations in ADVISOR™ do not account for the impact of the thermal fluid systems on the overall efficiency and performance of a fuel cell system. Quantifying the impact on efficiency will show the increase in energy use over a vehicle drive cycle. Using drive cycles with higher speeds and aggressive acceleration will show the overall performance loss due to operation at low temperatures.

II. FIGURES

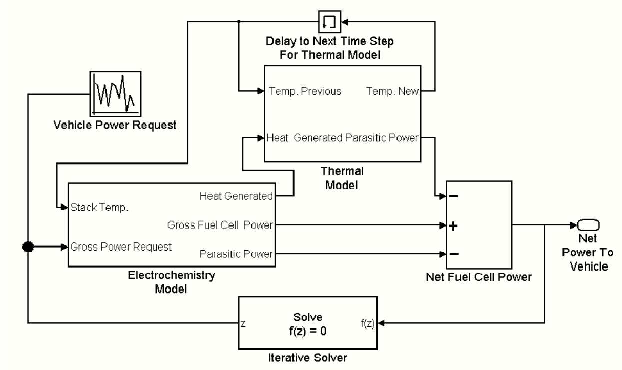
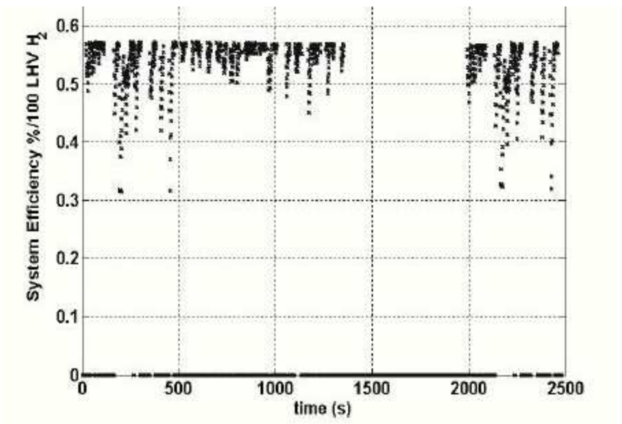


Fig.1: Block Diagram of the Fuel Cell Model

III. FUEL CELL EFFICIENCY DURING HOT-START FTP-75.



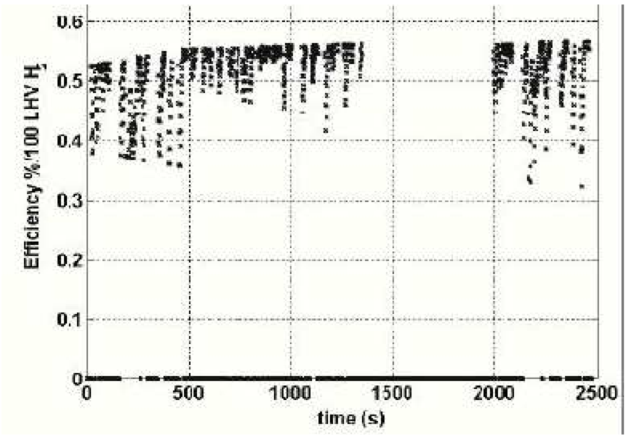


Fig.2: Fuel Cell Efficiency during Cold Start FTP-75

IV. CONCLUSION

The work presented has developed a net power request model for a vehicle fuel cell system. The model has the capability of quantifying the impact of low temperature operation on the efficiency and performance of a fuel cell system. A finite difference Blumped capacitance model was developed that has the ability to model the initial cold- start transient. Analysis of the system involved characterizing the system during steady state operation and in a dynamic vehicle system.

The model has two main parts, the electrochemistry model, and the thermal model. The electrochemistry model is responsible for determining the operating point of the fuel cell and the parasitic power required to run the system. Addressing the issue of the cold-start transient is the responsibility of the thermal model. This model uses a finite difference lumped capacity approach to model the fuel cell stack as well as the reservoir and plumbing. The thermal model also includes a humidifier, condenser, and radiator that affect the overall performance and efficiency of the fuel cell system. Implemented into the model is an operating control strategy that places limits on the operation of the fuel cell system that would be enforced in a practical application.

REFERENCES

[1] Adams, James A., Woong-chul Yang, Keith A. Oglesby and Kurt D. Osborne, “The Development of Ford‟s P2000 Fuel Cell Vehicle,” SAE Paper 2000-01-1061, March 6-9, 2000

[2] ADVISOR, Wipke, Keith, “CTTS Vehicle System Analysis Homepage,” http://www.ctts.nrel.gov/analysis Atwood, Paul. Gurski, Stephen D. Nelson, Douglas J. Wipke, Keith B. and Markel

[3] Tony (2002), "Degree of Hybridization Modeling of a Hydrogen Fuel Cell PNGV-Class.Vehicle," Proceedings of the 2002 Future Car Congress, June 3-5, Arlington, VA, SAE paper 2002-01-1945, 10 pgs. Barbir, Frano. Balasubramanian, Bhaskar. Neutzler, Jay. “Trade-off Design Analysis of Operating Pressure and Temperature in PEM Fuel Cell Systems,” ASME AES-Vol. 39, 1999

[4] Boettner Daisie D., Gino Paganelli, Yann G. Guezennec, Giorgio Rizzoni, Michael J. Moran, “Proton Exchange Membrane Fuel Cell System Model for Automotive Vehicle Simulation and Control,” IMEC2001 / AES-23666 Proceedings of 2001 ASME Congress and Expositions Nov 11-16 2001

[5] Candusso, Denis, Elisabeth Rulliere, Seddik Bacha, “Modeling of a Fuel Cell Hybrid Power Source for a Small Electric Vehicle,” 18th Electric Vehicle Symposium 2001 Ceraolo, R. Giglioli, C. Miulli, A. Pozio, “A Dynamic Model of Proton Exchange Membrane Fuel Cell” 18th Electric Vehicle Symposium 2001

[6] Doss, Ezzat Danial., Rajesh Ahluwalia, Romesh Kumar, “Hydrogen-Fueled Polymer Electrolyte Fuel Cell Systems for Transportation,” Chemical Technology Divison, Argonne National Lab, ANL-98/16 August 1998

[7] Fronk, Matthew H., David L. Wetter, David A. Masten, Andrew Bosco, "PEM Fuel Cell System Solutions for Transportation," SAE Paper 2000-01-0373, in SAE SP-1505, Fuel Cell Power for Transportation 2000, pp. 103-108