DESIGN METHODOLOGY, SCIENCE, AND TECHNOLOGY TO MANUFACTURE HIGH TEMPERATURE POLYMER ELECTROLYTE MEMBRANES FOR FUEL CELLS

By

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ABSTRACT

According to the Department of Energy (DOE), there exist many challenges in the commercialization of all fuel cells related to among other things the cost of manufacturing components, of particular interest, polymer electrolyte membranes (PEM). Unfortunately, due to variations in material properties, stringent quality requirements (e.g. dimensional accuracy, no holes), and non-standardized geometry, conventional manufacturing approaches may not be suitable for newer membrane solutions. Implementation of new, innovative, and/or customized conventional manufacturing processes to fuel cell membrane production can offer significant cost reductions, flexibility and repeatability to the fuel cell industry. This research presents a design methodology, the science, and technology to develop a PEM membrane casting system.

The unique design methodology to develop a manufacturing casting system entails: 1) receiving input from material developer and end users; 2) gathering chemical, mechanical, and physical fluid properties 3) understanding the material's characteristics and behavior; 4) developing and evaluating system concepts; 5) prototyping and modeling (analytically and numerically) individual components and the system; 6) developing a detailed system design; 7) building and testing the system to compare analytical models to experimental data and; 8) optimizing the hardware and system based on comparison results.

Using the aforementioned methodology, a case study involving development of a closed membrane casting system to cast high temperature PEM membrane solutions for an industrial proprietor has been performed. It was found that novel membrane solutions can be made into film uniformly and continuously using slot die casting. The hardware design, which plays a significant role in overall system performance and membrane quality, evolved over the course of conducting this case study. It was found that the internal geometry can be modeled based on flow between infinite parallel plates. In addition, novel features were incorporated to allow for scalability, ease of assembly and disassembly, a unique heating capability, gap retention without localized adjustment, and lip sealing. Prior to manufacturing the slot die, CFD modeling was used to predict the flow behavior where it was shown that the flow would be fully developed and uniform.