Solid Oxide Fuel Cells are fuel cells that operate at high temperatures usually in the range of 600°C to 1000°C and employ solid ceramics as the electrolyte. In Solid Oxide Fuel Cells oxygen ions (O²⁻) are the ionic charge carriers. Solid Oxide Fuel Cells are known for their higher electrical efficiency of about 50-60% [1] compared to other types of fuel cells and are considered very suitable in stationary power generation applications.

It is very important to study the effects of different parameters on the performance of Solid Oxide Fuel Cells and for this purpose the experimental or numerical simulation method can be adopted as the research method of choice. Numerical simulation involves constructing a mathematical model of the Solid Oxide Fuel Cell and use of specifically designed software programs that allows the user to manipulate the model to evaluate the system performance under various configurations and in real time. A model is only usable when it is validated with experimental results. Once it is validated, numerical simulation can give accurate, consistent and efficient results. Modeling allows testing and development of new materials, fuels, geometries, operating conditions without disrupting the existing system configuration. In addition, it is possible to measure internal variables which are experimentally difficult or impossible to measure and study the effects of different operating parameters on power generated, efficiency, current density, maximum temperatures reached, stresses caused by temperature gradients and effects of thermal expansion for electrolytes, electrodes and interconnects.

Since Solid Oxide Fuel Cell simulation involves a large number of parameters and complicated equations, mostly Partial Differential Equations, the situation calls for a sophisticated simulation technique and hence Computational Fluid Dynamics will be employed. Computational Fluid Dynamics can provide three-dimensional localized information inside the fuel cell. For this thesis, COMSOL Multiphysics® version 4.2a will be used for simulation purposes because it has a Batteries & Fuel Cells module, the ability to incorporate custom Partial Differential Equations and the ability to integrate with and utilize the capabilities of other tools like MATLAB®, Pro/Engineer®, SolidWorks®.

Fuel Cells can be modeled at the system or stack or cell or the electrode level. This thesis will study Solid Oxide Fuel Cell modeling at the cell level. Once the model can be validated against experimental data for the cell level, then modeling at higher levels can be accomplished in the future. Here the research focus is on Solid Oxide Fuel Cells that use hydrogen as the fuel. The study focuses on solid oxide fuel cells that use 3-layered, 4-layered and 6-layered electrolytes using pure YSZ or pure SCSZ or a combination of layers of YSZ and SCSZ. A major part of this research will be to compare SOFC performance of the different configurations of these electrolytes. The cathode and anode material used are (La0.6Sr0.4)0.95-0.99Co0.2Fe0.8O3 and Ni-YSZ respectively.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2006, Visvesvaraya Technological University, India

Committee in Charge:
Dr. Nina Orlovskaya, Chair, MMAE
Dr. Yunjun Xu, Co-Chair, MMAE
Yunjun Xu, MMAE
Tuhin Das, MMAE

Approved for distribution by Dr. Nina Orlovskaya, Committee Chair, on January 1, 2012.
The public is welcome to attend.