ENERGY- AND WATER-BALANCE CONSIDERATIONS IN THE DESIGN AND OPERATION OF PEMFC STACKS

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Performance comparisons of fuel-cell stacks tend to emphasize power-density parameters, *e.g.*, kW/l, kW/kg, and/or kW/m^2. These are undoubtedly important since they are key to the size, weight, and cost of the cell stack. However, these parameters alone are not sufficient when comparing stack performance since other stack characteristics have significant impact on the cost, efficiency, and complexity of the complete fuel-cell system. One should also consider other critical factors, such as: catalyst loadings, reactant stoichiometries, reactant pressure drops, and demonstrated decay rate and lifetime operating under conditions similar to the desired application. In addition, for some applications, other factors can be critical (*e.g.*, transient responses and ability to start rapidly in sub-freezing conditions).

In transportation applications, maintaining the fuel-cell system in energy and water balance can be particularly challenging under some conditions [1, 2]. This is because the requirement for vehicle power plants includes operating for extended periods at high current densities (*i.e.*, low efficiency), and the space available for heat exchangers (*i.e.*, radiators) or water-recovery devices is necessarily limited. The operating characteristics of the fuel-cell stack can significantly effect how difficult it is to achieve the system's energy- and water-balance requirements. Additionally, the optimum operating characteristics are not always obvious. For example, operating a fuel-cell stack with an elevated exhaust pressure is advantageous from a cell performance and water-vapor equilibrium perspective; however, more parasitic power is required to operate the compressor(s) and, therefore, more heat must be rejected for a given net power output.

In this paper a simple system model will be used to show the effect that selected stack characteristics have on the energy- and water-balance of the system. In particular, the impact of varying operating pressure, air stoichiometry, and delta *T* of the air and coolant exhaust from the stack will be examined. Although exit pressure is key, these other factors are also very important (*e.g.*, see Figs. 1 and 2). In addition, typical values of these key parameters obtained employing UTC Fuel Cells' proprietary PEM stack technology [3] will be compared with the typical values reported for PEM stacks from other stack developers.

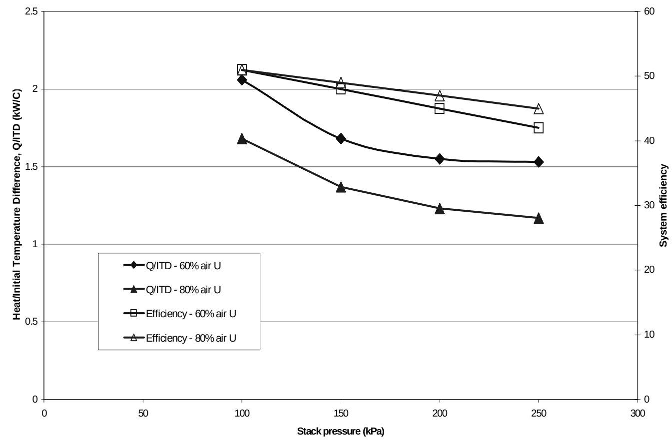

Figure 1. Effect of air utilization and stack pressure on the heat rejection required to maintain water balance at rated power, and the overall system efficiency, as predicted by simple system model. Model inputs: ambient T = 38 C, air RH = 0%, H_2 RH = 100%, air utilization = 60 or 80%, H_2 utilization = 99%, compressor efficiencies = 60%, rated power = 60 kW_{NET}.

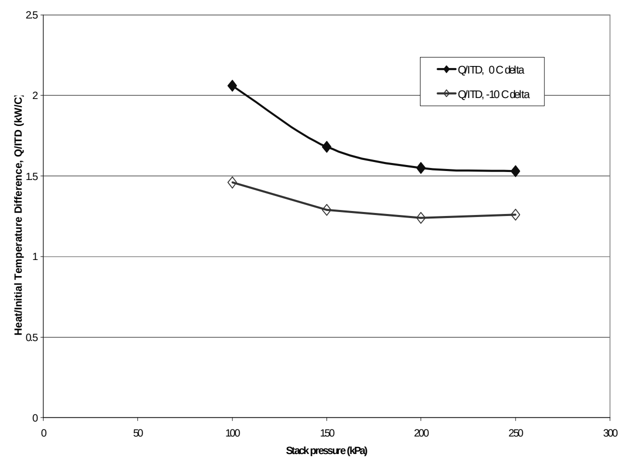

Figure 2. Effect of stack ΔT (= air-exhaust T – coolant-exit T) on heat rejection requirement of system in water balance. Model inputs: same as Fig.1 (where stack ΔT was set to 0) and air utilization = 60%.

References

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3. C. Reiser, "Ion Exchange Membrane Fuel Cell Power Plant with Water Management Pressure Differentials, *U.S. Patent 5,700,595* (1997).