IN -PLANE TEMPERATURE AND POWER DISTRIBUTION OF VACUUM PLASMA SPRAYED (VPS) SOFC FOR MOBILE APPLICATIONS

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The main point in manufacturing and operating metallic substrate supported SOFCs for automotive applications like Auxiliary Power Units (APU; Fig. 1) - developed by Delphi Automotive in cooperation with BMW Group - is to be in control of thermal expansion coefficient mismatches between the metallic substrates, the ceramic reaction layers of the cells, deposited by vacuum plasma spraying and the metallic stack components. The proper choice of materials, spraying-, stacking- and operation-parameters has to be made to keep thermomechanical stresses as low as possible.
Quality assurance for an industrially utilizable VPS-SOFC-product requires the use of defined operation conditions (for example: minimum start-up time, minimum air temperature at inlet e.g. "temperature shock stability").

If reactant air is used as a coolant (Tab. 1) and as heat-up medium (Tab. 2) temperature incline during operation can initiate thermo-mechanical stresses leading to the destruction of the cell-compound on long-term operation and especially under thermal cycling. The influence of temperature on ionic conductance of the electrolyte and in consequence on cell performance can strengthen this effect. To minimize stresses the temperature gradient over the cell area has to be kept as low as possible (by for example: sophisticated air distribution). The conversion of electric energy into thermal energy at points of high ohmic resistance (between cathode and metallic bipolar plate) and therefore the formation of hot-spots is another point that has to be taken into consideration.

To gain information on temperature, current-density and voltage a specialized measuring device for in-plane measurement was designed. It provides distribution measurements of temperature, power-density and impedance on active cell areas of up to 150 mm*150 mm utilizing resolutions from 2*2 up to 5*6 measuring points. It is a powerful tool in optimizing air and fuel distribution, reducing contact resistances, localizing hot-spots, detecting leakage currents when additionally applied to sealing areas and acquiring basic data for simulation.

The examination of cells in steady and non-steady state with preheated or non-preheated air and different heat-up rates and procedures allows to outline operation conditions of VPS-cells. Conditions such as different ways of electric contacting of the cathode to the metallic bipolar plate, maximum and minimum gas-flow-rates, the design of gas-ducts on both air and fuel side, long-term and thermal-cycling behaviour of different sealing technologies. Consequently to tune the whole system to the designated heat up procedure required for an automotive auxiliary power unit.

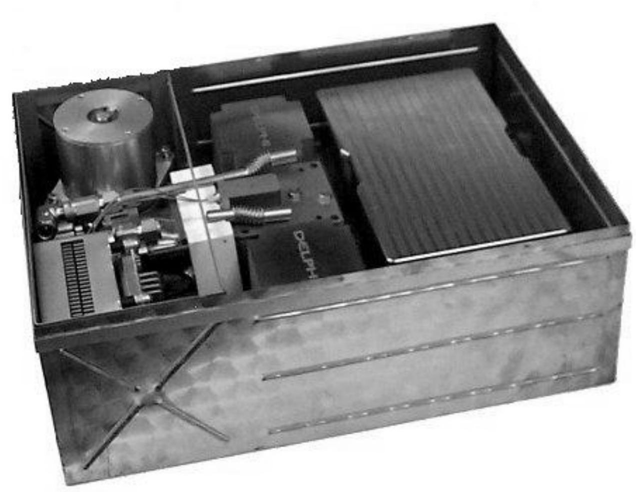
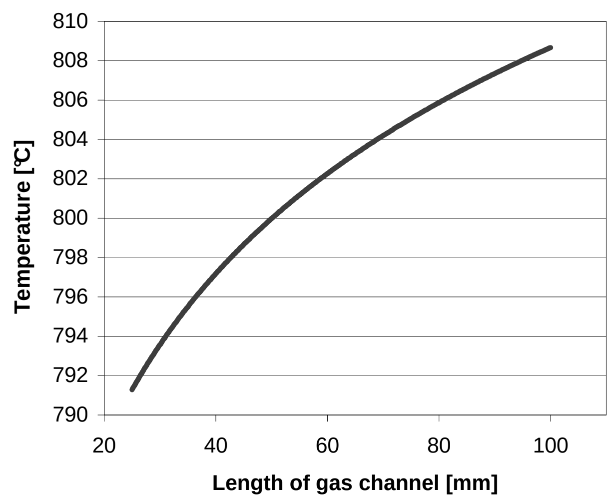
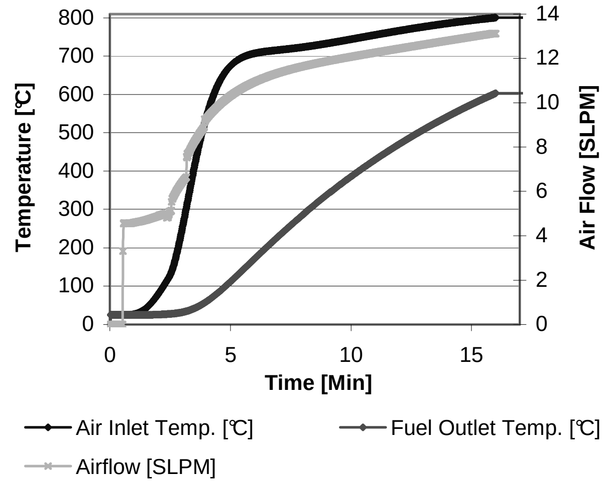


***Fig.1**: Second generation automotive APU (by Delphi Automotive)*



***Tab.1**: Temperature gradient on cathode surface from air-inlet to outlet (as measured in co-flow)*



***Tab.2**: Heat-up process of a single cell(as calculated)*