Experimental Investigation on Velocity and Temperature Distributions of Turbulent Cross Flows over Transpiration Cooled C/C Wall Segments

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One of the key technologies of today's high performance rocket combustion chambers is the effective protection of thermally heavy loaded components like the inner walls of thrust chamber and nozzle. This issue will become even more important for perspective engines were considerably increased energy densities are expected within the combustion chamber system. In this respect, ceramic combustion chamber concepts, which can be actively cooled by transpiration cooling, might serve the arising demand for more efficient cooling techniques of future rocket propulsion systems.

At the Institute of Aerospace Thermodynamics (ITLR) of the University of Stuttgart, experimental studies on transpiration cooling using CMC materials are conducted. Designed and manufactured at DLR's Institute of Structure and Design (IBK), porous C/C samples are investigated as reference material for this certain material class.

The projected paper is going to report of these studies and their findings with respect to the influence of gaseous coolant injection into a subsonic turbulent hot gas boundary layer over a transpiration cooled C/C wall segment. Beside the characterization of the used material and test bench, details according the instrumentation as well as the applied data processing will be given. On this background, velocity and temperature profiles of the hot gas flow with and without transpiration cooling will be presented. Diagrams like those of Fig. 1 and Fig. 2 illustrate the effect of coolant injection into a turbulent hot gas boundary layer and will serve as origin for continuative studies of the local boundary layer characteristics. In this means, methods according to Clauser and Preston are going to be introduced and applied to quantify the local values of friction coefficient and Stanton number. The flow profiles as well as the boundary layer characteristics will be compared and discussed for different hot gas and coolant flow conditions.

In doing so, the contribution attempts to support the general understanding of the physical effects of transpiration cooling applied to CMC materials.

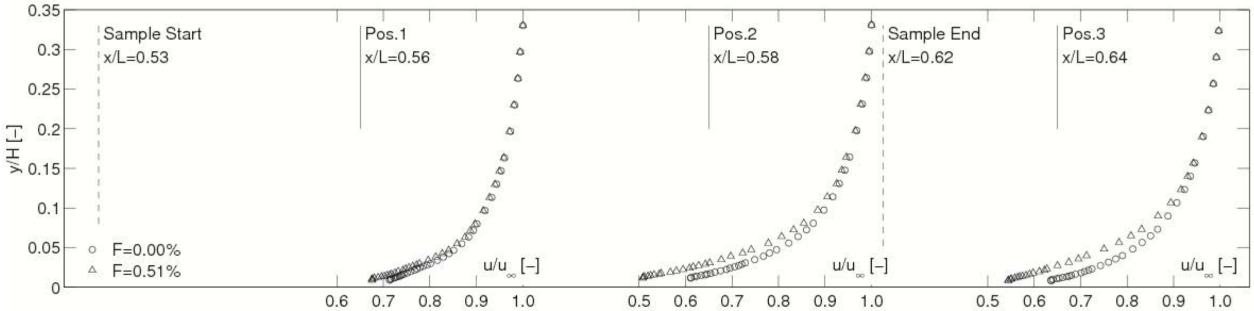

Figure 1: *Velocity profiles with and without coolant flow over transpiration cooled C/C wall segment*

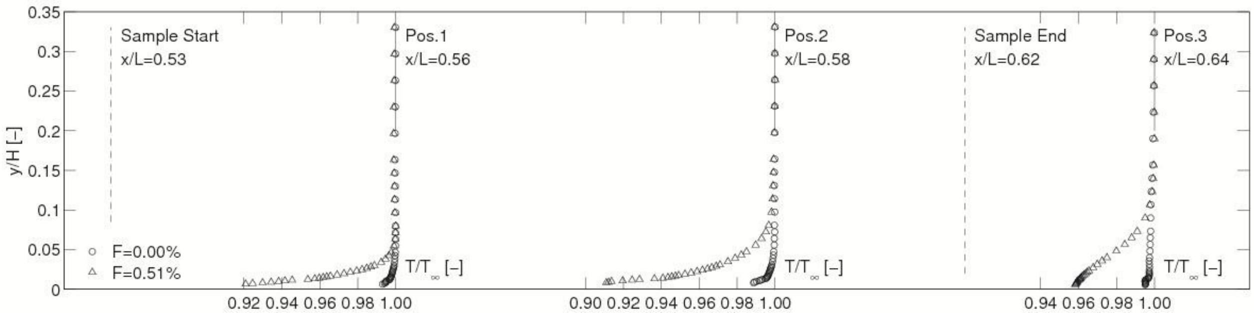

Figure 2: *Temperature profiles with and without coolant flow over transpiration cooled C/C wall segment*

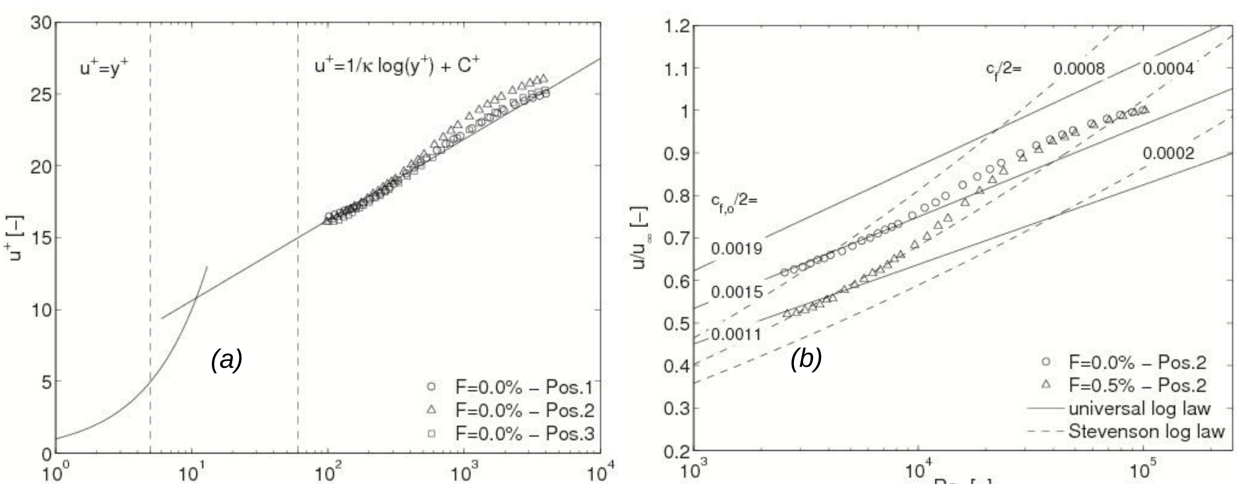

Figure 3: *(a) Measured and processed data in comparison with the logarithmic law of the wall and (b) Clauser plots to determine the wall friction coefficient with and without transpiration flow ($F = 0.0\%: \frac{c_{f,0}}{2} = 1.5 \cdot 10^{-3}$ and $F = 0.5\%: \frac{c_f}{2} = 0.4 \cdot 10^{-3}$).*