INVESTIGATION ON ROUGHNESS INDUCED TRANSITION IN THE VKI LONGSHOT FACILITY

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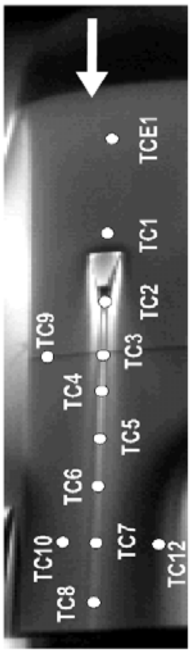
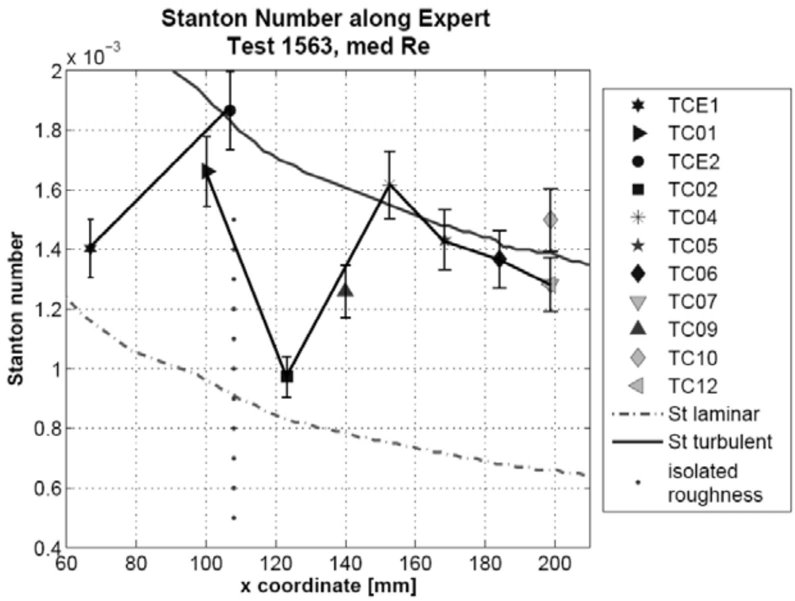
Laminar-turbulent transition in hypersonic flows is crucial for vehicle design and optimization. The strong impact of the boundary layer state on the heat flux distribution affects the sizing and the mass distribution of the thermal protection system (TPS) and thus the payload and costs. Therefore, the transition process in hypersonic flows has to be studied in order to correctly predict thermal loads and to minimize the application and dimension of the TPS. In this project roughness induced boundary layer transition is experimentally investigated in the hypersonic flow regime at M = 14. Quantitative and qualitative measurements are conducted on the Expert and on the IXV model. The primary interest is the characterization of the boundary layer state in terms of laminar-turbulent transition. Measurement techniques, such as oil visualization, schlieren technique, thermography and heat flux measurements using thermocouples, are evaluated in terms of their capabilities to detect transition. The investigation shows that the combination of qualitative and quantitative measurement techniques, such as thermocouples and thermography, allows the characterization of the state of the boundary layer. Capabilities and limitations of the measurement techniques used are discussed and potential improvements pointed out. An error analysis estimating the uncertainties of the heat flux measurements, the pressure measurements and the wind tunnel test conditions is performed. Beyond, the repeatability of the wind tunnel test conditions is discussed.

Recent literature reveals that surface temperature effects on high speed vehicles influence aerothermodynamic properties such as heat loads, strong interaction phenomena and viscous drag. Especially flight performance and structural layout are influenced but also the laminar-turbulent transition process since the surface temperature effects influence the boundary layer properties. Therefore, similarity parameters to be respected in ground testing to allow extrapolation to flight are discussed. It is shown that to fulfill the similarity parameter the Expert model has to be heated in the nose region and cooled at the rear part which is difficult to accomplish. Simulations of model parts should be conducted instead. Furthermore, it would be necessary to increase the static temperature at the nozzle exit of the Longshot which is not feasible. The discussion finally reveals that a duplication of the flight conditions in the Longshot facility respecting all thermal similarity parameters is subject to limitation.





Test 1563, medium Re, 2.5mm isolated roughness, distributed roughness at the nose (height: 0.6mm)