ROUGHNESS INDUCED TRANSITION FOR FLIGHT EXPERIMENTS

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Aerodynamic heating is one of the most critical design parameters when atmospheric reentry is considered. This heating is drastically increased when the boundary layer transitions from laminar to turbulent. This transition on the boundary layer nature can result from many factors, among which one of the most important is the presence of discontinuities on the surface along which the boundary layer has developed. This and other phenomena will be investigated by the ESA EXPERT flight experiment program. From the work done on the EXPERT-KHEOPS configuration in the Mach-6 VKI-H3 wind tunnel, the characteristic points where transition is likely to occur were evaluated based on both SHUTTLE and PANT criteria.

Three groups of perturbations were investigated: **distributed roughness**, which simulates nose cap erosion at high temperatures; **gaps** that may appear as a result of the differences between the thermal dilation between zones of different materials; and **isolated roughness** elements, intended to be used at a specific location of the model to study the effects of boundary layer transition and its nature during the flight tests.

Infrared thermography is used during the tests phase to track the temperature evolution on the surface (Figure 1), which can indicate transition to turbulence through the increase of heat transfer. A CFD study was conducted with the COSMIC code to find the boundary layer characteristic parameters necessary to apply the transition criteria.

The results are compared with different correlations proposed to assess transition, including those used for vehicles such as the space shuttle or the X-33, and ballistics range tests. A transition parameter usually represented by a Reynolds number based on the boundary layer edge conditions at the location of the roughness and the momentum thickness is determined. On the abscissa axis a disturbance parameter involving the roughness height in association with other parameters is set. The shuttle criterion proved to be a non-universal correlation, highly dependant on the geometry analyzed. Results form the H3 tests of the Kheops geometry are found to be in good agreement with ballistics range results plotted with PANT criterion parameters (Figure 2).

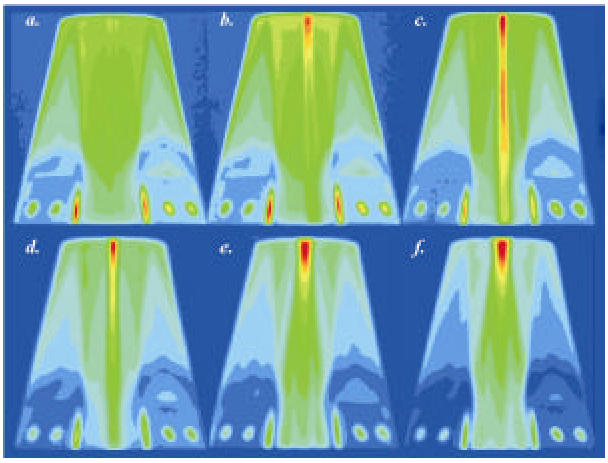

Figure 1: Infrared thermography for isolated roughness a. 0.1mm b. 0.2mm c. 0.31mm d. 0.4mm e. 0.72mm f. 0.98mm

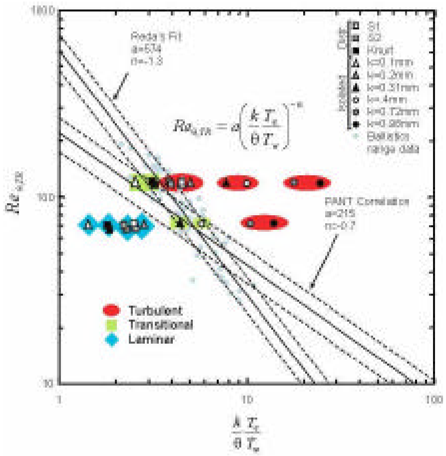

Figure 1 : PANT Correlation. Results for distributed and isolated roughness with ballistics range results