ANALYSIS OF TRANSITION TO TURBULENCE OF A HIGH-SPEED FLOW OVER A RIGID SURFACE

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Turbulence onset within an initially laminar flow is one of the thorniest (if not *the* thorniest) problems of Fluid Mechanics. Its physics is not yet fully understood, while the models so far proposed have often limits or heavy, clouding assumptions. Furthermore, experimental evidences require often special facilities (quiet wind tunnels) whose design process can be long and difficult, and operations tricky. CFD, then, in its most advanced and reliable declination —DNS, is still limited by otherwise huge computing requirements to the treatment of low-Re_∞ flows and in some cases with restrictive assumptions.

During this thesis both the analytical/numerical and experimental aspects of the problem have had attention. In the first case this was by a novel approach based on the work of P. Glansdorff and I. Prigogine on irreversible Thermodynamics. And in the second case by the work done about a "quiet" supersonic wind tunnel that was designed at the von Karman Institute to host experiments on roughness-induced transition and turbulent spots detection on a flat plate at different Mach numbers.

Much of the work done in the previous academic year has been devoted to the supersonic wind tunnel qualification. This has comprised the exploration of the facility Mach (and corresponding Reynolds) number range and the measurements of the mass-flow fluctuations in the freestream (*Figure 1*). The latter measurements campaign was specifically aimed at assessing the degree of quietness of the facility. Once qualified, the same facility has hosted Pressure-Sensitive-Paint experiments, to measure the pressure field around a single tetrahedral roughness element, and oil skin-friction measurements, to assess the status of the boundary layer along the facility walls. The results of these test campaigns have suggested some modifications to the facility itself, which have been implemented, and the opportunity of artificially generating the turbulent spots. For this latter purpose an electric circuit and the relative hosting for the wind tunnel has been designed *(Figure 2).* Its purpose is to release an electric spark within the boundary layer as strong as to destabilize it and directly produce the turbulent spots. This assembly and its effectiveness in producing the spots are currently under test in a low-speed wind tunnel by the use of oil- and smoke-visualization techniques. This test campaign aims also at the assessment of the electric spark (and its high-voltage circuit) effects on the instrumentation that will share the plate in the wind tunnel with the spark generator.

The work done on the analytical/numerical model has amounted to the check of its results with the use of fluctuation trends output by a Linear-Stability code for compressible flows, which has been integrated in the main code of the model. Whilst the neutral points are correctly detected by the model, the stable and unstable ones are not, and work is to be done on this latter aspect.

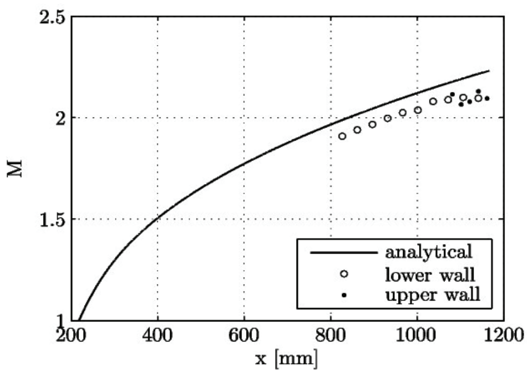

Figure 1 : Mach number along the WT divergent

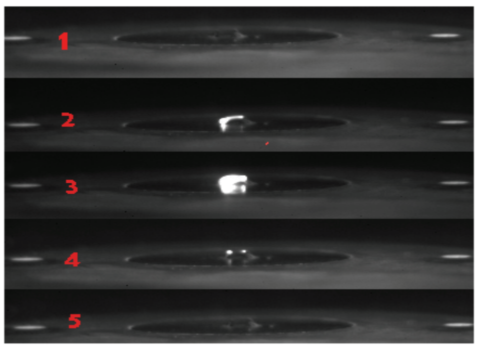

Figure 2 : Electric spark (high-speed camera visualization)