ASSESSMENT AND VALIDATION OF INTERMITTENCY TRANSPORT EQUATIONS FOR MODELING HYPERSONIC TRANSITION WITH COOLFluiD AND CFD++

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Transition from laminar to turbulent remains an unsolved, very challenging and extremely important subject for the whole community of fluid mechanics. In particular, the study of high speed transition is very important for the efficient design of the thermal protection system of hypersonic vehicles. Through, laminar, turbulent and finally transitional RANS simulations, using COOLFluiD and CFD++, the present work attempted to give insights into hypersonic transition.

The project was started with laminar simulations to analyze and compare the codes capabilities. The numerical results were compared to the well known laminar Reference Temperature Method of Eckert and to experimental data. Overall, good agreement was found.

Turbulent simulations were then carried out. The results were compared to Eckert's turbulent Reference Temperature Method and to experimental data from the VKI Mach 6 facility (H3). Overall, the agreement was satisfactory. Transition from simulation having no dedicated model was also studied.

Two-dimensional transitional flat plate simulations were then performed. The influence of the viscosity ratio (VR) on transition location was shown. The model was then used to simulate a hypersonic transitional test case from the Imperial College. After adjusting the inlet turbulence level, the agreement between numerical and experimental data was good.

Finally, 3D laminar and transitional simulations on a flat plate model presenting a small roughness element at its surface were carried out with CFD++. Regarding the laminar simulations, the topology of the flow was described and the influence of roughness induced vortices on the heating rates was shown. The limitations of the laminar approach were then illustrated, and, finally, some transitional results were presented and gave some improved characteristics with respect to experimental data from H3.

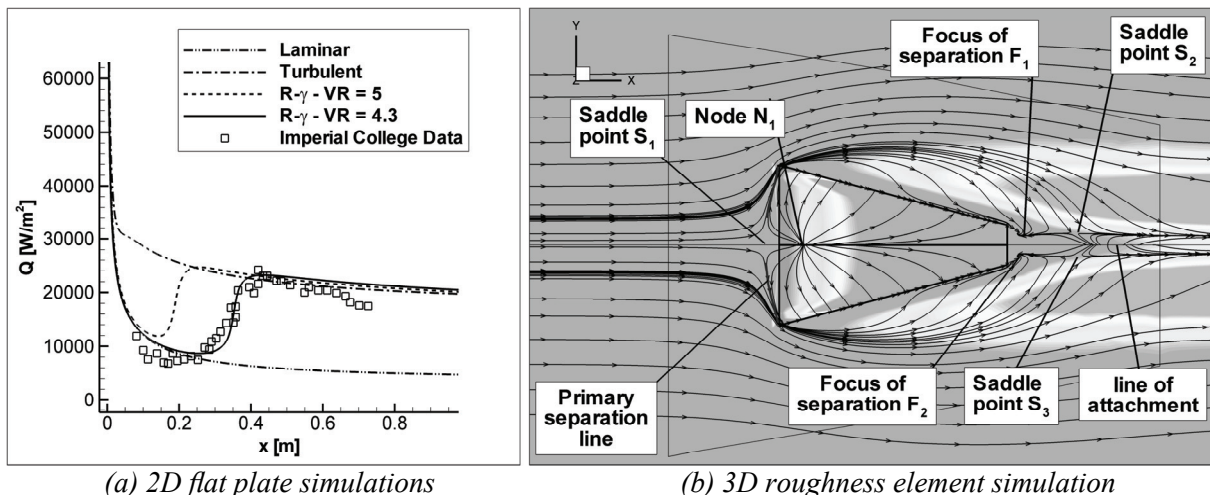(a) 2D flat plate simulations   (b) 3D roughness element simulation

Figure 1: Laminar, turbulent and transitional hypersonic simulation