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Study of the Uncertainty Behaviour for the Specific Total Enthalpy of the Hypersonic Plasma Wind Tunnel Scirocco at Italian Aerospace Research Center

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Abstract : By means of the expansion through a Conical Nozzle and the low pressure inside the Test Chamber, a large hypersonic stable flow takes place for a duration of up to 30 minutes. Downstream the Test Chamber, the diffuser has the function of reducing the flow velocity to subsonic values, and as a consequence, the temperature increases again. In order to cool down the flow, a heat exchanger is present at the end of the diffuser. The Vacuum System generates the necessary vacuum conditions for the correct hypersonic flow generation, and the DeNOx system, which follows the Vacuum System, reduces the nitrogen oxide concentrations created inside the plasma flow behind the limits imposed by Italian law. This very large, powerful, and complex facility allows researchers and engineers to reproduce entire re-entry trajectories of space vehicles into the atmosphere. One of the most important parameters for a hypersonic flowfield representative of re-entry conditions is the specific total enthalpy. This is the whole energy content of the fluid, and it represents how severe could be the conditions around a spacecraft re-entering from a space mission or, in our case, inside a hypersonic wind tunnel. It is possible to reach very high values of enthalpy (up to 45 MJ/kg) that, together with the large allowable size of the models, represent huge possibilities for making on-ground experiments regarding the atmospheric re-entry field. The maximum nozzle exit section diameter is 1950 mm, where values of Mach number very much higher than 1 can be reached. The specific total enthalpy is evaluated by means of a number of measurements, each of them concurring with its value and its uncertainty. The scope of the present paper is the evaluation of the sensibility of the uncertainty of the specific total enthalpy versus all the parameters and measurements involved. The sensors that, if improved, could give the highest advantages have so been individuated. Several simulations in Python with the METAS library and by means of Monte Carlo simulations are presented together with the obtained results and discussions about them.

Keywords : hypersonic, uncertainty, enthalpy, simulations
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