STUDY OF THE UNCERTAINTY BEHAVIOUR FOR THE SPECIFIC TOTAL ENTHALPY OF THE HYPERSONIC PLASMA WIND TUNNEL SCIROCCO AT CIRA

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1. INTRODUCTION

In the mid eighties the European Space Agency (ESA) realizes the need of a particular facility to carry out experimental ground tests. The intention was to realize a large Plasma Wind Tunnel, very powerful, in order to test full scale component of spacecrafts in earth atmosphere re-entry conditions. Indeed, in hypersonic, differently from other aerodynamic regimes, the heat fluxes distribution is affected by the absolute sizes of the bodies inside the flow field. This means that it is not possible to apply scaling factors, and so the possibility to have large size models in these plasma wind tunnels is a huge advantage.
This facility, named SCIROCCO as the warm wind coming from the Sahara Desert and acting on the Mediterranean costs, was so designed and built in Capua, in southern Italy. It is composed of some particular subsystems, each of them being among the largest in the world (Fig.1).

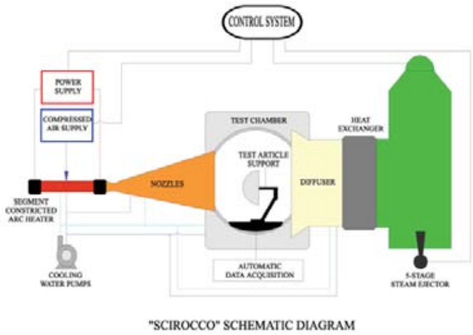

Fig. 1: Scheme of SCIROCCO Plasma Wind Tunnel

The aerothermodynamic process in SCIROCCO is based on a gas (air) supplied to the arc heater at a very high pressure of 87 bar ([1], [3], [4]), coming from a complex Compressed Air System at CIRA. The pressure of the air in the arc heater is of 1-17 bar ([1], [2], [4]), the temperature 2000-10000 K ([1], [3], [4]) and the air mass flow rate 0.1-3.5 kg/s ([1], [3]).
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 up to 30 minutes.
Downstream the Test Chamber, the Diffuser has the function to reduce 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, that follows the Vacuum System, reduces the nitrogen oxides concentrations created inside the plasma flow behind the limits imposed by the Italian law.
This very large, powerful and complex facility allows researchers and engineers to reproduce entire reentry trajectories of space vehicles into the atmosphere.

2. SCOPE OF THE WORK

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.

In Fig. 2 and Fig. 3 the operating envelope of the facility and the hypersonic flow at the exit of SCIROCCO Conical Nozzle are shown ([1], [5]). It is possible to notice the possibility to reach very high values of enthalpy, that together with the large allowable size of the models represent huge possibilities to make on ground experiments regarding the atmospheric re-entry field. The maximum nozzle exit section diameter is 1950 mm ([1], [2], [3]), where values of Mach number very much higher than 1 can be reached.

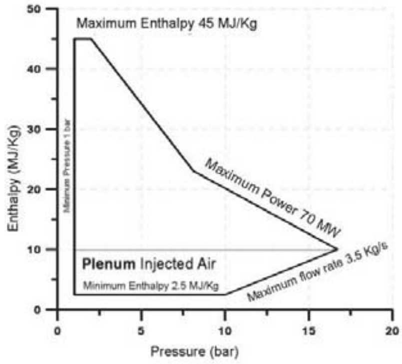

Fig. 2: The operating envelope of SCIROCCO

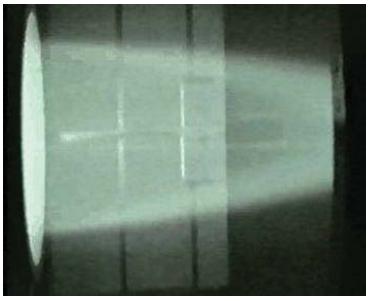

Fig. 3: SCIROCCO Hypersonic Flow

The specific total enthalpy is evaluated by means of a number of measurements, each of them concurring to its value and its uncertainty. 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 METAS library and by means of Monte Carlo simulations are presented together with the obtained results and discussions about them.

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