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Absolute instability in Plasma jet

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The stability of the plasma jet generated in the VKI Inductively Coupled Plasma wind tunnel Plasmatron is investigated numerically using the Linear Stability Theory, as a novel approach to quantify the uncertainties in the studies of ablative materials for TPS and high enthalpy flows. This study aims at developing a numerical tool using LST, matching available experimental results from Cipullo [1] including the instabilities shapes and frequencies for a wide range of operative conditions (stagnation pressure and power combinations) in the facility.
Jet flows can sustain two types of instabilities: either absolute or convective (see [2] among others). Previous LST studies conducted at VKI [3] [4] matched partially the experimental observations for some of the operative conditions of the facility. Unfortunately, the combination of extreme temperatures and low Reynold number of the plasma flow differ greatly from typical conditions studied in literature. For this study, the plasma flow is considered as a mixture of perfect gases in Local Thermodynamic Equilibrium and Chemical Equilibrium, which makes this study the first to investigate absolute instabilities in such conditions with LST.
The base flow is computed by fitting CFD simulations taking into account high temperature effects, and a spatio-temporal analysis is performed to determine the time-asymptotic behavior of the flow, concluding on the absolute/convective nature of instabilities at several streamwise positions. Preliminary results show that absolute intabilities dominate the stability beahvior of the jet for some experimental conditions. Moreover, the range of frequencies as well as the shape of the instabilities found by the LTE-LST model are coherent with the experimental observations. However, the growth-rate associated with these instabilities implies a rapid growth of the instabilities to the turbulent state which is not observed in the facility. So it seems possible that non-linear effects would mitigate this growth.

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