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3D unsteady model of arc heater plasma flow using the ARC Heater Simulator (ARCHeS) JEREMIE MEURISSE, STC at NASA Ames Research Center, ALEJANDRO ALVAREZ LAGUNA, von Karman Institute for Fluid Dynamics, NAGI MANSOUR, NASA Ames Research Center — Arc jets are unique facilities used to evaluate the performance of Thermal Protection Systems (TPS) for hypersonic vehicles. They produce a high pressure and high enthalpy plasma flow to simulate the extreme heat encountered during atmospheric entry. The constricted arc heater part of an arc jet increases the test gas temperature by Joule heating. This study details the development of the three-dimensional unsteady plasma flow analysis tool, ARCHeS (ARC Heater Simulator). Coupled Navier-Stokes, radiative transfer and Maxwell equations yield current density, magnetism, radiation and flow field solutions. Results from plasma flow simulations performed using 1200 processors will be presented. The present work constitutes the first demonstration of an unsteady three-dimensional plasma flow simulation of a high pressure and high enthalpy arc heater that captures kink instabilities of the electric arc. It is found that the arc attachment is mainly driven by upstream arc instabilities. Analysis of the electric arc dynamics will provide better intuitive understanding of the complex behavior of plasma flow observed in arc jets. Massive parallel simulation capability is inherited in ARCHeS from its OpenFOAM framework, making such studies possible.

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