Optimization of the output and efficiency of a high power cascaded arc hydrogen plasma source

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The operation of a cascaded arc hydrogen plasma source was experimentally investigated to provide an empirical basis for the scaling of this source to higher plasma fluxes and efficiencies. The flux and efficiency were determined as a function of the input power, discharge channel diameter, and hydrogen gas flow rate. Measurements of the pressure in the arc channel show that the flow is well described by Poiseuille flow and that the effective heavy particle temperature is approximately 0.8 eV. Interpretation of the measured I-V data in terms of a one-parameter model shows that the plasma production is proportional to the input power, to the square root of the hydrogen flow rate, and is independent of the channel diameter. The observed scaling shows that the dominant power loss mechanism inside the arc channel is one that scales with the effective volume of the plasma in the discharge channel. Measurements on the plasma output with Thomson scattering confirm the linear dependence of the plasma production on the input power. Extrapolation of these results shows that - without a magnetic field - an improvement in the plasma production by a factor of 10 over where it was in [van Rooij et al., Appl. Phys. Lett. 90, 121501 (2007)] should be possible.