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Modelling and high-pressure simulation of helium plasma discharges

A plasma discharge in a Helium gas reactor at different pressures and at low currents (0.25 to 0.45 A) has been investigated by Computational Fluid Dynamics (CFD) modelling coupled with the Maxwell's equations. This topic is of interest because plasma is known to contain chemically active species and charged particles, which can be used in a wastewater treatment application. There is a need to improve the design of the plasma reactors used in wastewater treatment applications to increase its effectiveness and efficiency. An understanding of the physical phenomena describing the plasma dynamics and the calculation of the discharge temperature are vital to optimize the design of reactors and consequently the plasma treatment.

The pressure in the simulation was varied between 2 to 8 MPa to determine the influence of pressure on discharge parameters. The results showed that a large density gradient in the reactor, combined with the gravitational force, becomes the driving force of the natural convection in the reactor at higher pressures and has a strong influence on the velocity magnitude. The natural convection effect caused a slight bending of the discharge in the 8 MPa case. A decrease in pressure caused the bending effect to diminish, and a low current arc type of discharge was observed at lower pressures.

The simulated discharge was further investigated at atmospheric pressure. The natural convection effect is not dominant at atmospheric pressure. This was observed in the symmetry of the temperature, density, and velocity magnitude plots, obtained at an electric current of 0.35 A. At atmospheric pressure, a larger temperature value is calculated as the electric current increases. An increase in electric current resulted in the calculation of larger electric current density values. This was expected as more energy is being added to the reactor system.

The CHPC resources allowed for simulations to be completed within a realistic timeframe, and useful trends and results were obtained. These results can be used to influence the design of a reactor. All calculations were performed on the Lengau cluster by requesting ten virtual nodes, each with 24 cores running 24 message passing interfaces (mpi) processes.

Student?

Yes

Supervisor name

Dr Samuel A. Iwarere

Supervisor email

samuel.iwarere@up.ac.za

Primary author: Mr MAHARAJ, Avinash (University of KwaZulu-Natal)

Co-author: Dr IWARERE, Samuel (University of Pretoria & University of KwaZulu-Natal)

Presenter: Mr MAHARAJ, Avinash (University of KwaZulu-Natal)

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