THERMOPHYSICAL PROPERTIES AND MODELING OF HYDROGEN ISOTOPE PELLET PRODUCTION FOR THE FUELING OF FUSION PLASMA

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This thesis serves as a reference for thermophysical property data and modeling techniques used to design the pellet production systems for fueling of the ITER fusion plasma. Numerical models of hydrogen isotope liquefaction and solidification are presented. The purpose of the models is to aid in the operation and design of the pellet production systems used in the ITER device. The numerical models integrate a set of conservation equations in the flow direction and include variations in thermodynamic and transport properties of the hydrogen isotopes as well as the effect of viscous energy dissipation, latent heat of vaporization, and latent heat of solidification. The models are used to evaluate the most important variables that govern operation in order to guide experimental development efforts.

A review of the available thermophysical property data of the molecular hydrogen isotopes is presented. Property correlations are recommended where available. The need for further measurements of liquid thermal conductivity, convection coefficient during solid-liquid phase change, and viscous dissipation of the solid is established.

An experimental measurement cell was modified to simultaneously measure the viscous energy dissipation, liquid and two-phase convection coefficients, liquid and two-phase thermal conductivity, and the latent heat of solidification for the parahydrogen and normal hydrogen, as well as the orthodeuterium and normal deuterium systems. The measurements are compared to the existing literature. The Quantum Law of Corresponding States is used to predict the same flow properties for deuterium-tritide and tritium.

The models are compared to experimental measurements of a prototype pellet production facility in operation at Oak Ridge National Laboratory. The model is able to predict operation parameters of the prototype.