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POSITION AND ACCELERATION CONTROL OF SAMPLE MATERIAL UNDER MICROGRAVITY CONDITION PROVIDED BY ELECTROSTATIC LEVITATION FURNACE

Abstract

The Electrostatic Levitation Furnace (ELF) which is planned to be used in the International Space Station (the ISS) is one of the experiment facilities for materials science currently under development in Japan Aerospace Exploration Agency. A unique feature of ELF is to levitate a sample material inside the electric furnace by means of the Coulomb's force during the fusion/solidification experiments. Though most of the experiments using ELF aim to measure physical properties of sample materials in their liquid state under the microgravity condition, the residual gravity in the ISS may deteriorate the accuracy working as a disturbance. Therefore, a position control system of ELF plays a important role to provide a good experiment environment by suppressing such disturbance. As we start designing the position control system, we set a limit to the strength of control inputs, i.e. electric fields generated by controller, not to impose excessive acceleration on the sample. The position control gains were designed to keep the sample at the designated position under the condition to satisfy this limit as well. Instability of sample's electric charge is another issue to be solved so that the fusion/solidification experiments are really made possible. Most of the materials suitable for ELF experiment have a tendency to lose their electric charge significantly when they are fused by laser heaters. Hence, we adopted an adaptive control method based on Recursive Least-Squares Algorithm (RLSA) which can identify the sample's electric charge in real time. Using the residual gravity in the ISS and the fluctuation of electric charge measured during the sounding rocket experiment, many numerical simulations have been conducted to verify the functionality of the position control system. As a result, it has been proved that both the sample position and acceleration imposed are well under control even when the electric charge changed widely. This paper first introduces a design of position control system of ELF with the method to determine the control gains, and secondly explains the theoretical aspect of the adaptive control with RLSA. Then, the results of computer based simulations will be presented to show the validity of the system according to the experimental request for microgravity.

Key Words: Electrostatic Levitation Furnace, Recursive Least-Squares Algorithm