Summary of Dissertation

Title: A study on the high precision measurement of thermo-mechanical properties in materials at ultra-high strain rate based on Taylor impact test

(Taylor 衝撃圧縮試験に基づく超高ひずみ速度における材料の熱・力学特性の高精度測定に関する研究)

高 崇

This dissertation proposed a method for measuring the thermo-mechanical behavior of materials used in aerospace industries by expanding the Taylor impact test which can achieve the deformation rate level same to the impact of space debris, meteorite, etc. on spacecraft.

Focusing on the nonuniform deformation, a measurement method for stress-strain curve was proposed by combining the distributions of strain as well as stress simultaneously. The distribution of strain was measured from the deformation profile of specimen. The distribution of stress was calculated from an assumption which the internal forces in elasticity and plasticity-dominant regions distribute linearly, and the impact force as a boundary condition. Then, the high-speed camera for taking the deformation profile of specimen and Hopkinson pressure bar for measuring the impact force were introduced into the experiment apparatus and the stress-strain curve was measured by only single test after the feasibility of the proposed method was checked by finite element simulation.

Furthermore, a calculation method for distribution of strain rate considering the spatial difference method was proposed. Besides, a calculate method for distribution of temperature was established based on heat conduction equation and the temperature rise at a local point on specimen. To capture the temperature at a local point, a temperature measurement system contained 5 PIR fibers, lens and infrared detector was designed. Then, the distribution of strain rate as well as temperature were attempted to measure from the proposed method by performing the experiment.

Finally, a specimen with a pulse-shaper was designed to suppress both the extra oscillations and excessive local deformation. Then, a stress-strain curve with a higher accuracy was measured by employing the designed specimen after the size of the specimen was determined by finite element simulation.