論文 / 著書情報
Article / Book Information

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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Residual stress is inevitably generated during thermal spraying and plays a critical role in the performance of thermal barrier coatings. It is of great significance to understand the mechanisms of stress evolution and fracture behaviors in thermal sprayed coatings. In this dissertation, a model experiment was carried out to evaluate the mechanics of paraffin droplets during the impact, solidification, and cooling process, which partly simulated the deposition of thermal spray particles. In the experiment, molten paraffin droplet was dropped onto a pre-cooled 430 stainless steel substrate. Evolutions of strain and temperature at the substrate back surface were measured by a bi-axial strain gauge and several thermocouples, respectively. During the solidification and cooling process of the paraffin droplet, tensile residual strain was developed at the substrate back surface. Effects of substrate pre-set temperature, drop height (impact velocity), droplet temperature, and paraffin wax materials on the residual strains were fully investigated. Experimental results suggested that the residual strains increase with the reduction of substrate pre-set temperature, drop height, and droplet temperature. Cracking and debonding were observed in solidified splats depending on the experimental conditions.

An elastic finite element (FE) analysis was conducted to calculate the distribution of splat stress and interfacial stresses as driving forces for cracking and debonding, respectively. Comparison between calculated splat stress and paraffin's tensile strength provided a reasonable explanation for the cracking behaviors observed in the splats. Interfacial debonding criteria were estimated by comparing the calculated interfacial stresses and observed debonding behaviors. Coupled thermo-mechanical FE analysis was then performed to calculate the evolutions of residual strain and substrate temperature during the solidification and cooling process of paraffin droplets. The effect of creep of solidified splat was considered by using a strain hardening form of creep law, in which the creep properties were measured by a four-point bending method. Calculation results revealed that creep deformation is a critical factor influencing the stress-strain evolution. Based on the calculation results, the effect of interfacial adhesion on residual strains was investigated considering several drop impact conditions. It verified that a poor adhesion at the splat/substrate interface induced a higher degree of stress relaxation.

Debonding of solidified splat with a substrate is a crucial issue dominating the reliability of thermal sprayed coatings and was therefore specifically investigated. It was found that the debonding is prone to take place at lower substrate pre-set temperature, lower drop height, and lower droplet temperature. A scraping method was employed to measure the adhesion strength of splats formed under various impact conditions. The results showed good accordance with debonding behaviors in drop impact experiments. The scraping tests also indicated that the residual tensile stress in splats reduces the scraping forces, and prevents the complete removal of splats during the scraping process. Numerical results of stress distributions along splat/substrate interface coupled with scraping tests provided reasonable explanations for observed debonding behaviors of single splats.

Based on the model experiments and numerical simulations, the evolution of residual strain, cracking and debonding behaviors, and splat/substrate adhesion strength was fully discussed considering the effects of several experimental conditions. Findings from a series of experiments and analyses showed some similarities to actual phenomena during thermal spraying. These can help to understand the fundamental mechanisms of the deposition of single particles and provide important guidance for optimizing thermal spraying processes.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).