MPS simulation for a melt pool involving melting and resolidification

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The melting and resolidification of powder beds play an important role in additive manufacturing and nuclear engineering. Defects such as gas pores may appear inside the finished part, probably due to the initial gaps among the powders. In this study, the melt pool due to a laser beam is simulated by a multiphase moving particle semi-implicit (MPS) method.

Keywords: MPS Method, Heat-transfer, Phase-change, Melt Pool, Gas Pore, Additive Manufacturing

1. Introduction

In order to manufacture the geometrically complex parts that are common in the nuclear and other engineering fields, selective laser melting (SLM) is one of the potential solutions. Defects generated during SLM, such as gas pores, can adversely affect the performance of the manufactured components. The gaps generated by powder compaction may be one of the reasons for the generation of gas pores. [1,2] It is expensive and time-consuming to investigate the formation of gas pore through experiments. Computational modeling and simulation can overcome this difficulty.

2. Experimental Procedures

2-1. MPS Method

In this study, the melt pool due to a laser beam was simulated by a multiphase moving particle semi-implicit (MPS) method, where the heat-transfer and phase-change models are coupled. The influence of thickness of powder layers on the generation of gas pores was discussed.

2-2. Simulation Procedures

In the simulation, a laser beam scanned a powder bed with regularly stacked spherical powder. The melt pool formed and resolidified. As shown in **Fig**. 1, the cases with different thickness of powder layers were simulated. The simulation results showed that the gas was discharged through the continuous gaps and did not remain in the component.

Fig. 1 Melt pool simulation by MPS

3. Conclusion

The simulation showed that the gas was easily discharged through the continuous gaps in the metal melt pool. Thus, the entrapped gas among powder particles may not be a reason for the pores inside the finished parts. In future work, the behavior of the entrapped gas inside a powder particle will be investigated, because such entrapped gas is not connected with continuous gaps.

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References

[1] Antonella Sola, and Alireza Nouri. "Microstructural porosity in additive manufacturing: The formation and detection of pores in metal parts fabricated by powder bed fusion." Journal of Advanced Manufacturing and Processing 1.3 (2019): e10021.

[2] Jing C., et al. "Microstructure, porosity and mechanical properties of selective laser melted AlSi10Mg." Chinese Journal of Aeronautics 33.7 (2020): 2043-2054.