Variation of optimal gas-supply condition along with deposition height in directed energy deposition

Shiho Takemura*[1], Ryo Koike[1] Yasuhiro Kakinuma[1] and Yohei Oda[2]

[1] Department of System Design Engineering,
Keio University, 3-14-1, Hiyoshi, Kohoku-ku, Yokohama, Kanagawa, 223-8522, Japan
e-mail: takemura@ams.sd.keio.ac.jp

[2] DMG MORI CO., LTD,
2-35-16 Meieki, Nakamura-ku, Nagoya, Aichi 450-0002, Japan
e-mail: yo-oda@dmgmori.co.jp

ABSTRACT

Directed energy deposition (DED), which is one of additive manufacturing applicable to metals, laminates the material on a baseplate by melting and solidifying with a high-power heat source. DED attracts various kinds of industries such as aerospace, automotive, and medical products [1]. However, powder-based DED wastes the material because powder is difficult to converge on the melt pool precisely. Therefore, many researchers have been investigating the powder supply process with various powder supply conditions. For example, Pan et al. analyzed on gravity-driven metal powder flow in a coaxial nozzle with various gas-flow rates and nozzle geometries [2]. Furthermore, in order to enhance the powder supply efficiency, a fluid-dynamics simulation would be helpful to estimate the powder behavior under the powder nozzle. Although Zhu et al. dealt with the influence of deposition height on the powder distribution with a 2D-axisymmetric model of coaxial nozzle [3], other researchers generally conduct the simulations assuming that the powder flow is free jet or injected on the baseplate. However, from the practical viewpoint, a detail investigation needs to be conducted considering the variation in the powder flow according to the difference in geometry around the deposition point.

In this study, the powder distribution is evaluated in the various deposition heights to predict the optimal gas-flow rate and powder-nozzle shape by a computational fluid dynamics (CFD) simulation based on Euler-Lagrange approach. A gas-solid multiphase-flow simulation is conducted by applying the discrete phase model. The 3D models for CFD simulation including the deposit with various heights are designed as shown in Fig. 1. By performing the CFD simulations, the distribution and velocity of particle and gas flow around the deposit are estimated. Comparison of these results indicates that the powder-flow diverges with the increase of the deposition height. Thus, it is necessary to increase the carrier gas-flow rates gradually when the deposition height gets high during the deposition in order to supply the powder to the melt pool stably. Furthermore, the modification in powder nozzle shape by shortening the convergence distance of powder flow also would be a useful approach to improve the powder supply efficiency regardless of the deposition height.

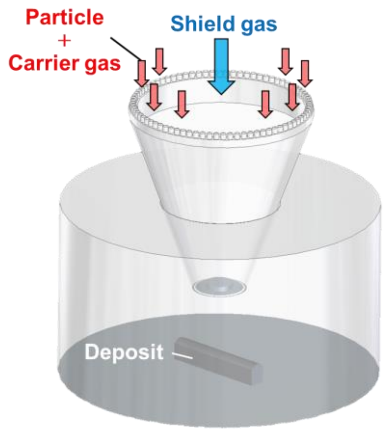

Fig. 1 3D-simulation model

REFERENCES

[1] M. Schmidt, M. Merklein and D. Bourell et al, “Laser based additive manufacturing in industry and academia”, *CIRP Annals - Manufacturing Technology*, Vol. 66, pp. 561–583, (2017).

[2] H. Pan, T. Sparks and Y.D. Thakar et al, ” The Investigation of Gravity-Driven Metal Powder Flow in Coaxial Nozzle for Laser-Aided Direct Metal Deposition Process”, *Journal of Manufacturing Science and Engineering*, Vol. 128, pp. 541–553, (2006).

[3] G. Zhu, D. Li and A. Zhang et al, ” Numerical simulation of metallic powder flow in a coaxial nozzle in laser direct metal deposition”, *Optics & Laser Technology*, Vol. 43, pp. 106–113, (2011).