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Analysis of a New Design of Metal Directed Energy Deposition Nozzle

Shu-San Hsiau[1*], Bing-Zhi Wang [1], Li-Tsung Sheng[2]
[1]Department of Mechanical Engineering, National Central university
Zhongli District, Taoyuan City 32001, Taiwan (R.O.C.)
[2]Department of Mechanical and Electro-Mechanical Engineering, National Ilan University
Yilan City, Yilan County 260007, Taiwan (R.O.C.)
[*]sshsiau@cc.ncu.edu.tw

Extended Abstract

Nowadays, the metal directed energy deposition with quick response to parts development and being capable to produce hollow, complicated structure parts that can't easily be fabricated to realize with conventional tooling skills has become an art can't be disregarded. In aviation, military and automotive industries, for the benefits over prior arts in weight reduction, it is remarkably irreplaceable.

The DED parts are constructed with metal powder, meanwhile powder materials applied in DED are of high cost with respect to traditional powder materials [1] and the utility of the powder is crucial to the cost of the parts. In 2019, Ju et al. [2] make optimization on the nozzle structure in powder utility efficiency. Kovalev et al. [3] analyse the operation parameters as different function gases flow rate in the supply-inlets to understand the effects of the gases on the powder. Gao et al. [4] and Kovalev et al. [3] devoted to research the flight motion of the powder and the interaction between powder and the laser beam before and after entering the molten pool to understand roles of powder and to improve powder utility-efficiency. Moreover, a specific method is developed to extract gas outside the nozzle to affect the powder flow direction to improve the powder utility efficiency (Whitfield et al. [5]). There are many methods in this field, however, to our knowledge, there are no attempts by the studies before to bypass partly some powder carrying gas to enrich the powder concentration and guide the outdrawn gas to the out ward shielding channel. This phenomenon (i.e., enrich the powder concentration) can constrain the ejected powder expanding in the cladding zone to improve powder utility.

In this study, we propose a nozzle structure including a bypass duct in the middle of powder conveying channel. Inside the bypass duct, due to the geometry of channel of bypass duct, it makes sharp turns of flow direction of gas and powder. On the other hand, the difference between powder and gas densities is large enough to cause the trend to separate these two materials at the inlet of bypass duct. The gas with smaller density is easier to change its flow direction, while the metal powder tends to flow in the original direction, then they tend to separate.

This research is carried out with CFD simulations executed on 3D CAD made models to predict powder flow motion. Firstly, it needs to verify that the gas is extracted out with trivial tiny volume fraction of the powder. And then make a comparison of the shape of powder flow in the cladding zone to show that the powder concentrates better than the nozzle without a bypass extraction in the conveying gas channel. Additionally, the distribution of the volume fraction of powder flow in the cladding zone is to be analysed, to find the highest volume fraction of powder in the cladding zone. The information above can be used to design a new nozzle structure to offered a higher utility efficiency.

Keywords: Directed energy deposition, Powder supply nozzle, bypass duct, carry gas flow, Metal powder flow

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