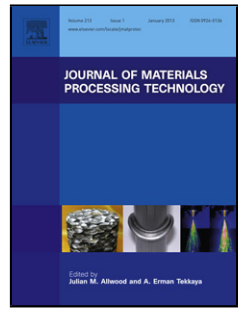

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Numerical investigation of gas-disperse jet flows created by coaxial nozzles during the laser direct material deposition

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Abstract

The paper presents the results of modelling of powder transport during the laser direct material deposition, involving standard coaxial nozzles made by Trumpf and Precitec and radiation of a CO_2-laser with the power up to 4 kW. The patterns of particle trajectories positions are shown in the space for various geometries of coaxial nozzles (the double and triple ones). It is shown that collisions of particles and walls of the transport channel impose the governing effect on the particle trajectories, geometry of the powder jet, and density of particles distribution in the flow and on the substrate. Inelastic collisions with walls cause velocity decrease after the reflection, which has a positive effect on the powder flow profile and focusing. Heating of particles depends on the position of their trajectories and residence time in the high-intensity radiation area. It is also shown that the triple coaxial nozzle has wider options to control the gas-disperse flows than the double coaxial nozzle. The preferable position of the substrate, 20 ± 5 mm, is found by calculations; here, the focusing of the powder jet into the laser spot and heating of the super-alloy Ti-6Al-4V particles in the radiation field are optimal. The results can be used to improve the laser cladding and direct material deposition process.

Keywords: laser cladding; coaxial nozzle; powder transport; particle collisions with wall; particles trajectory; velocity and temperature.

Introduction

The method of Direct Material Deposition (DMD) involving the laser cladding technology permits having different metal, ceramic, and gradient coatings. The laser build-up method enables not only to recover parts but also manufacture 3D articles of a complex spatial shape (Toyserkani et al., 2005). There are several methods to organize the supply of powder particles in the laser-action zone; they use specially designed nozzle headings (Lester et al., 2013). Improvement and creation of effective models of the powder transport with necessary localization and controllability of the powder jet requires the detailed analysis of the calculation methods and diagnostics of the processes occurring during the transportation of disperse materials and their build-up on the part surface.