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Research of the process of formation of gas-powder stream at realization of «Rapid Prototyping» technology

The influence of the system forming a gas-powder jet in the zone of influence of focused laser radiation on the quality and productivity of laser fusion of powder material when implementing Rapid Prototyping technology has been noted by many experts in this field of scientific research. To calculate coaxial nozzles, simple engineering dependencies are mainly used, which cannot determine the distribution of the concentration of the powder composition in the laser processing zone. That is why, the use of numerical modeling of the behavior of a gas-powder jet in the zone of exposure to focused laser radiation as a tool for designing optimal nozzle designs is an urgent task. Based on the analysis of a priori information, [1-8], the following can be noted, the schemes for supplying the powder composition to the focused laser radiation exposure zone have a significant effect on the performance and quality of laser alloying, and are also conditionally divided into two groups, the first supply of powder material under a certain angle, 2nd coaxial to laser radiation.

A numerical simulation of the behavior of the gas-powder jet supplied to the zone of focused laser radiation through coaxial nozzles (having different designs) was carried out using the following algorithm:

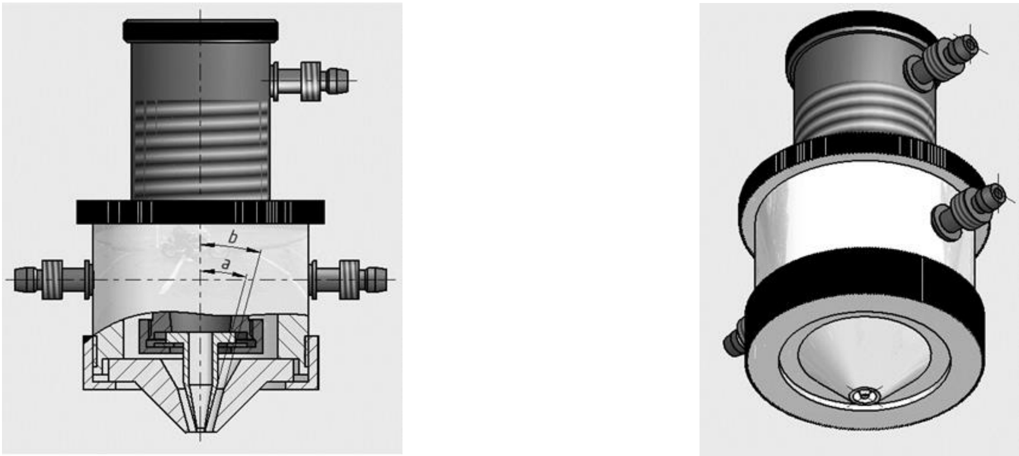
-creation of a three-dimensional (parametric) model of a coaxial nozzle;

-creation of a three-dimensional model of the internal cavity of coaxial nozzles and designations of regions that describe the boundary conditions of calculation;

-creation of a computational grid of finite elements of the internal cavity of coaxial nozzles with the designation of boundary conditions at given regions;

-direct calculation of the trajectory of the powder flow and analysis of the results.

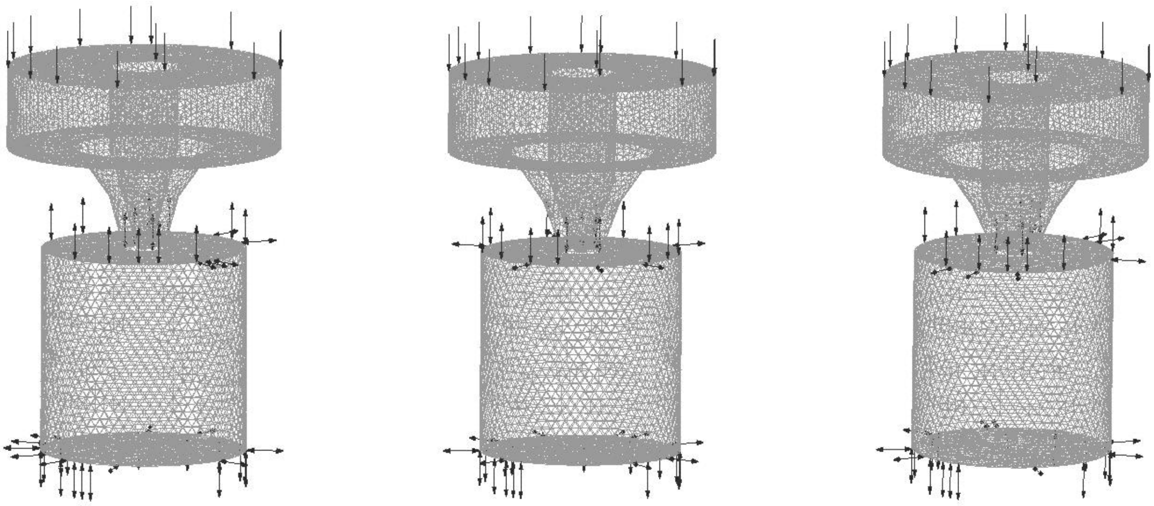
To create a three-dimensional parametric model of a coaxial nozzle (fig. 1), a CAD automatic design system was used.



a) b)

Fig. 1. Three-dimensional model of a coaxial nozzle: a) -internal part of the cavity; b) general view; a-parameter of the angle forming the inner nozzle; b-parameter of the angle of generators external nozzle

Parameters a, b were changed (fig. 1, a) under the condition a=b in the range 20°-80°. The finite element mesh with the designations of the regions of three-dimensional objects of the coaxial nozzle cavities was created using the Meshing module of the Ansys Workbench software package (fig. 2).



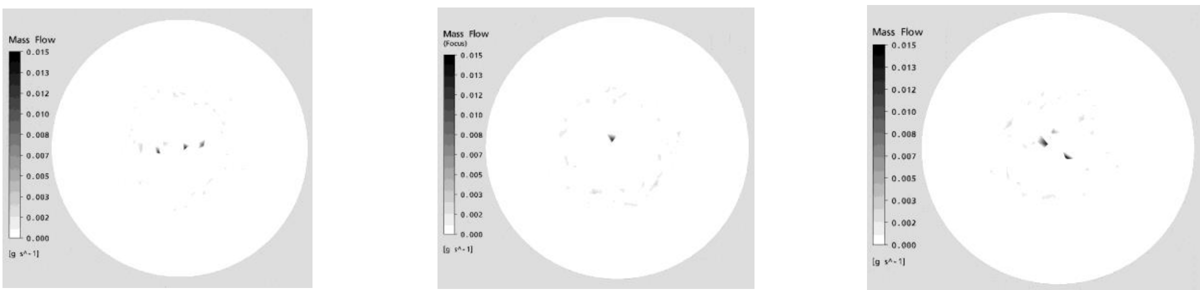
a) b) c)

Fig. 2. Grids of finite elements of the inner coaxial nozzle cavity: a)-geometry forming the external and internal nozzles 30° b)-the geometry of the forming external and internal nozzles 40°, c)-geometry of the external and internal nozzles 50°

The constructed finite element meshes were exported to the Ansys CFX software package; the capabilities of this module allow us to solve many different problems of hydrodynamics in modern engineering. To calculate the motion of the continuous and dispersed phases, the following boundary conditions of the regions and the properties of the medium were set. Based on the numerical simulation of the behavior of the gas-powder jet in space carried out using the Ansys CFX software package, it should be noted that the distribution of the concentration of the powder flow in the plane perpendicular to the axis of the trajectory of the gas-powder jet depends on the angles of the outer and inner nozzles, namely:

-with an increase in the geometry angle of the forming nozzles, an increase in the transverse concentration of the powder material is observed in the general case;

-with an increase in the geometry angle of the generators, an increase in the area of the transverse concentration of the powder composition in the zone of focused laser radiation is observed (fig. 3c), this is explained by the very small distance of the focus of the gas-powder jet from the cut of the coaxial nozzle, due to the large angles of the generators of the external and internal nozzles 50°.



a) b) c)

Fig. 3. The concentration of the dispersed phase of the gas powder jet in the plane perpendicular to the axis of the laser radiation:
a)-geometry of the angles of the forming nozzles 30°;
b)-geometry of the angles of the forming nozzles 40°;
c)-geometry of the angles of the forming nozzles 50°

Moreover, in all calculated cases (angles of the external and internal nozzles 20°-80°) when the geometry of the generators of the external and internal nozzles changes, the distribution of the concentration of the gas-powder jet changes from an annular to a circle completely filled with powder (fig. 3). In addition, it should be noted that a decrease in the angle of the forming nozzles leads to a distance of the minimum cross section of the powder jet (powder concentration) to the nozzle exit and, conversely, an increase in the angle of the forming nozzles leads to a decrease in the distance of the transverse concentration of the powder from the exit.

Conclusions

Based on numerical simulation in the Ansys CFX software package, the following was established:

1. It has been established that numerical modeling of the process of transporting powder particles in a gas stream allows us to design coaxial nozzles and to determine processing patterns in advance for any law of movement of the focused beam.

2. Changing the geometry of the angles of the forming nozzles is an effective factor in influencing the spatial distribution of the powder flow, namely, changing the focal plane of the powder concentration and also the shape of the gas-powder jet.

3. A change in the geometry of the angles of the forming nozzles leads to a displacement of the minimum cross section of the powder jet relative to the nozzle exit, and to a change in the gradients of the envelopes of the surfaces of the gas powder jet.

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