Investigation of Influence of Pulse-periodical Laser Radiation Power on Stability of Liquid-metal Contacts between Powder Particles during Selective Laser Sintering

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Abstract

A connection between pulse–periodical laser radiation power and stability of liquid-metal contacts between powder particles during selective laser sintering (SLS) is determined based on analysis solving the problem of stability of liquid column in the gravity and capillary forces field. On the grounds of obtained relationships the optimization of pulse–periodical laser radiation power and SLS-process duration is realized, that allows to produce voluminous powder porous materials with pre-determined physical and mechanical properties and surface geometry. Results of metallographic investigations of powder porous materials of titanium powder produced with technological regimes calculated by means of obtained relationships are given in the work

Keywords : titanium powder, Selective Laser Sintering (SLS), machine of powder laser stereolithography, contact neck

1. Introduction

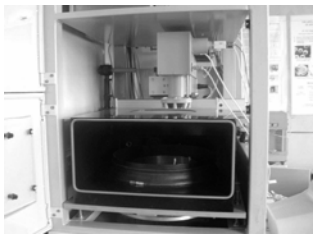
The selective laser sintering (SLS) [1–3] is used to obtain products with complicated surface geometry which strength is dependent on dimension and stability of liquid-metal contacts between powder particles being formed under effect of laser radiation pulse.

The aim of the work is the investigation of influence of laser radiation pulse power on stability of liquid-metal contacts of spherical titanium powder during SLS.

2. Experimental and Results

When carrying out investigations spherical titanium powder of fraction (–0,315 + 0,2) mm is used, which has been placed into hermetical chamber of the technological unit of experimental machine of laser powder stereolithography (Fig. 1).

a) appearance



b) technological unit

Fig. 1. Machine of powder laser stereolithography.

The height of investigated powder layer corresponded to the size of its particles. SLS is realized with technological regimes calculated using elaborated mathematical model determining stability of liquid-metal contacts of spherical powder during laser radiation. Calculated results are shown in the table below.

Table 1. Calculated values of SLS technological regime for spherical titanium powder of (–0,315+0,2) mm fraction

No.	Parameter of laser radiation	Dimensions of quantities	Value
1	Radiation wave length	μm	1,06
2	Pulse duration	ms	2
3	Average pulse power	W	75 – 150
4	Radiation diameter	μm	1

Microstructure of obtained specimen is studied with the metallographic MSM-2 microscope of "Akashi" company, which magnification changed within the limits of 50 to 200 during carrying out investigation.

A contact neck between powder particles which relative diameter in relation to D0 corresponds to ρ 1~ 0,2 is shown in Fig. 2. Specimen are obtained at laser radiation power value of 75 W.

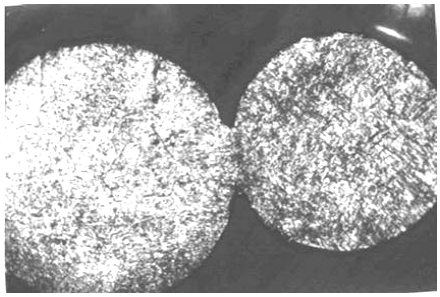


Fig. 2. Contact neck between particles at laser radiation power of 75 W, X200.

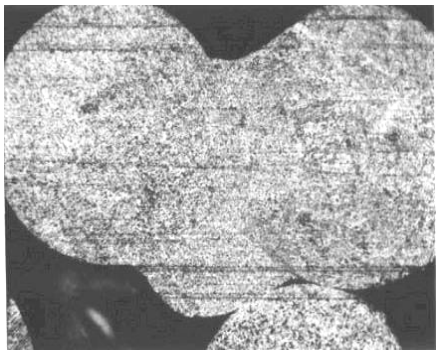


Fig. 3. Contact neck at laser radiation power of 150 W, X200.

Fig. 3 shows contact neck which diameter corresponds to diameter of powder particles. The specimen is obtained after exposing of laser radiation pulse with power of 150 W what is two times more than power used for obtaining of previous specimen shown in Fig. 2.

3. Summary

1. The mathematical model determining condition of stability of liquid-metal contacts between spherical powder particles depending on laser radiation power allowing to evaluate regimes of SLS is elaborated.
2. The carried out theoretical and experimental investigations showed:
   - stability of liquid-metal contacts during SLS is influenced by material and size of powder particles as well as diameter, power and duration of laser radiation pulse;
   - so, for example, for spherical titanium powders with particles diameter of 1 – 1000 μm the critical power value of laser radiation pulse exceeds in two times the value when the liquid-metal phase is formed on the surface of powder particles;
   - when increasing the critical value of laser radiation pulse power stability of liquid-metal contacts is disturbed;
   - for spherical titanium powders with particles diameter of 1 – 1000 μm the critical power value can rise in 4 times by increasing of laser radiation diameter from 500 nm to 1 mm, and vice versa can lower in 5-6 times by increasing of laser radiation pulse duration.

4. References

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