MICROSTRUCTURE AND GRANULOMETRIC CHARACTERISTICS OF HEAT-RESISTANT ALLOY POWDERS

IHOR LEMISHKA[1], TARAS KOVBASIUK[1], ANDRII ANDREILIV[1], OLHA HALIENKOVA[2], OKSANA MELASHCHENKO[3]

1. Lviv Polytechnic National University, Ukraine
2. Department of the Chief Metallurgist, JSC «Ivchenko-Progress», Ukraine
3. A. Pidgorny Institute of Power Machines and Systems of NAS of Ukraine

The paper studies the microstructure and granulometric characteristics of the powder of the heat-resistant chromium-nickel alloy VZh98, obtained by the method of centrifugal plasma spraying of the electrode. According to the results of scanning electron microscopy, the spherical morphology of the particles with a dendritic surface structure was established. The particle size distribution in the fractions of 63–200 μm and ≤63 μm was analysed, the polydispersity indices and average particle diameters for each fraction were determined.

Keywords: heat-resistant alloy, microstructure, granulometric characteristics, powder metallurgy, dendritic structure, polydispersity

Introduction. A major challenge in additive manufacturing of metal components is pore formation within the structure, which significantly reduces the mechanical performance and durability of printed parts [1]. The morphology, size distribution, and polydispersity of the initial powder are among the key parameters affecting the final product quality.

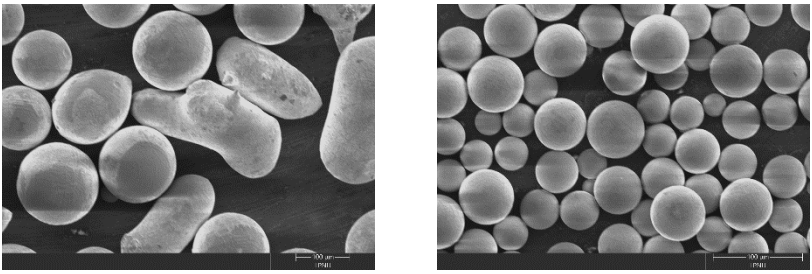
VZh98-based heat-resistant powders are widely applied in aerospace, energy, and transport industries due to their high thermal stability and gas corrosion resistance [2]. The quality of these powders depends on their microstructure, particle shape, surface condition, and granulometric composition [3].

Efficient layer-wise structure formation in 3D printing is driven by the powder's ability to pack densely and uniformly, which is governed by particle size and distribution [4]. This study focuses on the microstructural and granulometric characterization of VZh98 powders produced via the plasma rotating electrode process (PREP).

Research methods. Metallographic research was performed on the Thermo Scientific Apreo 2C microscope. Determination of the granulometric characteristics of the powders was carried out using ImageJ image analysis software.

Results and discussion. According to the results of scanning electron microscopy, it was found that the powder particles of the VZh98 alloy have a predominantly spherical shape with a slight dispersion in size (Fig. 1). The surface of the particles is characterized by a typical dendritic structure, which was formed during the rapid cooling process during spraying. Defects in the form of satellites

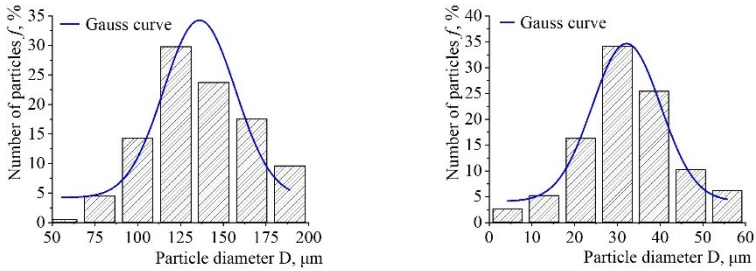
were observed on individual particles, however, their content was insignificant and, according to available data, does not significantly affect the quality of the powder for additive applications.



a b

Fig. 1. Morphology of spherical particles of powders of heat-resistant alloys VZh98 of different fractional composition: a – 63...200 μm; b – ≤63 μm.

Granulometric analysis showed that for the 63...200 μm fraction the average particle diameter was approximately 124 μm, while for the ≤63 μm fraction it was 29.7 μm (Fig. 2).



a b

Fig. 2. Histograms of the distribution of spherical particles of powders of heat-resistant alloys VZh98 of different fractional composition: a – 63...200 μm; b – ≤63 μm.

At the same time, an increase in polydispersity was observed with the transition to a smaller fraction: from 4.9% for the 63...200 μm fraction to 8.3% for the ≤63 μm fraction. This difference indicates a greater homogeneity of particles in the coarse powder, which can be an advantage during its dosing and application in the 3D printing process.

Conclusions. The conducted studies confirmed that the VZh98 alloy powder obtained by centrifugal plasma spraying is characterized by a spherical particle shape with a dendritic surface structure and a small number of satellites. Granulometric analysis showed that a decrease in the fractional composition is accompanied by an increase in polydispersity, which can affect the uniformity of

powder application in the additive manufacturing process. The results obtained can be used to optimize the choice of powder fractions in order to improve the quality of products manufactured by 3D printing.

1. *Duriagina Z., Pankratov A., Romanova T., Litvinchev I., Bennell J., Lemishka I., Maximov S. Optimized packing titanium alloy powder particles // Computation (Basel). – 2023. – 11. – P. 1–13. https://doi.org/10.3390/computation11020022*
2. *Sola A., Nouri A. Microstructural porosity in additive manufacturing: The formation and detection of pores in metal parts fabricated by powder bed fusion // Journal of Advanced Manufacturing and Processing. – J. Adv. Manuf. Process. – 2019. – № e10021. https://doi.org/0.1002/amp2.10021*
3. *Haines M.P., Rielli V.V., Primig S., Haghdadi N. Powder bed fusion additive manufacturing of Ni-based superalloys: a review of the main microstructural constituents and characterization techniques // J. Mater. Sci. – 2022. – 57. – P. 14687–14722. https://doi.org/10.1007/s10853-022-07631-4*
4. *Gibson, I., Rosen, D., & Stucker, B. (2015). Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing //Springer. Johnson Matthey Technology Review. – 2015. – 59(3). – P.193–198 https://doi.org/10.1595/205651315X688406*