Politechnika Śląska

Wydział Mechaniczny Technologiczny

ROZPRAWA DOKTORSKA

„Wpływ wybranych technologii wytwarzania stopów Co-Cr-Mo z proszków na ich strukturę i własności”

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Abstract

This doctoral dissertation, entitled "The Influence of Selected Manufacturing Technologies of Co-Cr-Mo Alloys from Powders on Their Structure and Properties," presents the manufacturing methods and research results of biomaterials produced using three technologies: injection molding, selective laser melting, and uniaxial pressing in a closed die, with particular emphasis on the influence of the atmosphere used during sintering or melting on their structure and properties. The choice of technology was determined by market demand, i.e., the need for producing biomaterial components with complex shapes, either produced individually and tailored to the patient's needs or mass-produced. Each of the selected technologies has a different set of advantages and disadvantages, as well as specific applications. Uniaxial pressing in a closed matrix is used for large-scale production of elements with a simple shape. Injection molded elements are also produced on a large scale, which additionally have a complex shape, while product personalization is the domain of selective laser melting technology.The choice of material was dictated by its high mechanical properties and corrosion resistance. The Co-Cr-Mo alloy is the most suitable of all metal alloys for the production of orthopedic implants, connectors, anchoring elements in dentistry and prosthetic substructures, i.e. wherever high loads occur.

Based on a series of conducted studies, it was demonstrated that the SLM (Selective Laser Melting) technology for producing biomaterial from Co-Cr-Mo powder is the most optimal choice, considering both the elimination of intermediate production steps and the best mechanical properties of the material. This technology requires the optimization of the production process in order to obtain a material with the desired structure and without the distortion effect that occurred during the melting and cooling of the alloy. Pressed and injection-molded, sintered materials also exhibited good strength parameters but did not fully meet or were at the lower limit of the ISO 5832-4 standard. The analysis of the produced materials showed that, regardless of the applied technology, the predominant phase in the sintered structures was the γ phase. The use of a nitrogen atmosphere during sintering promotes the formation of nitrides that strengthen the matrix and significantly improve wear resistance and mechanical strength. It was also observed that nitrogen stabilizes the γ phase, increasing the alloy’s corrosion resistance and plasticity. Properly chosen conditions at every stage of the production process of pressed or injection-molded materials allow for the creation of components with acceptable or even superior properties of the obtained alloy, and it is anticipated that heat treatment will further improve their mechanical properties.