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FEA Simulation of Thermal Processes during the Direct Metal Laser Sintering of Ti64 Titanium Powder

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Abstract: With regard to the fact that laser sintering belongs to the high-temperature processes in which metal particles are sintered by a high-power laser, forming a homogenous structure, it is necessary and important to know the characteristics and the mechanism of these thermal processes. A high-power laser system produces three forms of heat that include convection, conduction, and radiation. These thermal processes affect the formation of internal stresses and tension that lead to deformations and rapidly influence the resulting quality, dimensions, density, micro-structure, and mechanical properties of fabricated parts. In response to this fact, it was important to analyse these heat transfer methods instantly during the direct metal laser sintering (DMLS) process simulation and subsequently monitor the parameters and settings of the sintering equipment in order to obtain acceptable manufacture outputs intended for further use. This work is focused on the creation of a FEA simulation model and the simulation of thermal processes across an object during and after the sintering process in the cooling stage, when it is important to consider a laser beam trajectory, temperatures of individual elements affected by the laser beam, and current laser energy in time. A 3D FEA simulation model was created in order to represent actual behaviour of a part during the sintering process. The simulation model consisted of two sub-models, particularly the building platform model with the dimensions of 250 mm x 250 mm x 22 mm, with stainless steel as the selected material, and the model of individual layers of sintered titanium powder with the dimensions of 10 mm x 10 mm x 0.03 mm. The total number of used layers was 12, which represents the total thickness of 0.36 mm. Applied power was P = 170 W. The simulation as such was carried out using the FEA software, Simulia Abaqus supported on the Windows x86-64 platform, which uses an integrated solver to make thermal and mechanic calculations. The calculations included also the impact of the protective argon atmosphere located in the process chamber. Mutual impact between individual layers was also considered. The simulation results were confronted with the results of already performed experimental studies of other scientific works, with the compliance and confirmation of assumptions being on a very good level.

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