Simulation of Dynamic Thermal Fields Assisting DMLS Additive Manufacturing of Biocompatible Ti-Alloy

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Abstract

For the complex 3D biocompatible metallic parts, with high level of customization, used in medical prosthesis and implants Direct Metal Laser Sintering (DMLS) and Selective Laser Melting (SLM) are the most common Additive Manufacturing technologies used nowadays. However, both technologies require costly post-processing operations of the 3D printed parts and are faced with quality and precision limitations.
A dynamic thermal field assisting a wider area of the powder bed fused with laser during DMLS metal powder printing could modify the heat flow distribution within the 3D printing process and during successive printed layers consolidation, with effects upon post-processing paths.

COMSOL Multiphysics® was used to analyze and describe in depth the thermal field distribution into the Ti-6Al-4V ELI spheroids powder bed during the laser sintering, and the successive layer addition and heating for a usual DMLS process were modeled and simulated with COMSOL Multiphysics®.
A new path of heat transfer within the powder bed was designed, modeled using the results of material data analysis and the DMLS process characteristics. SolidWorks® models were exported through the LiveLink™ for SolidWorks® add-on in COMSOL Multiphysics® where heat transfer and phase transformation analyses were performed. Each phase of the process was properly described and designed with the use of 3D/2D plot groups and line graph tools in COMSOL Multiphysics®.
In order to simulate accurate processing conditions, COMSOL Multiphysics® material data base was used and customized with new material (Ti-6Al-4V ELI, Grade 23).

Biocompatible 3D printed parts made from metal powders have to answer very strict requirements related to the medical end-using area particularities. Meanwhile, they have to face design challenges to overcome the pitfalls related to shape sharpness and residual thermal stress resulting from 3D Additive Manufacturing itself.
The Dynamic thermal fields assisting DMLS process of biocompatible titanium parts would reduce or eliminate post-processing cost of the printed parts.

Figures used in the abstract

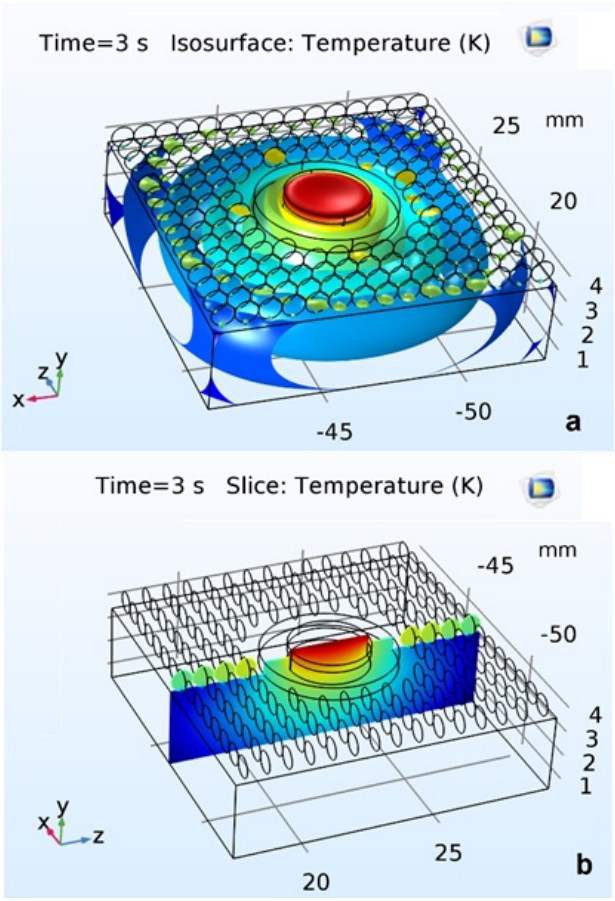

Figure 1: Isothermal of the newly assisted DMLS process (t=3.0s).