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THERMO-VISCO-ELASTIC MODEL OF POWDER LAYER MODIFICATION BY MOVING HEAT SOURCE *

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There are fundamentally different methods of synthesizing 3D material in powder technology. In one of them, the powder is preliminary sprayed on the surface to be treated and then the surface is scanned by laser radiation or an electron beam. In the other, the powder is fed directly into a melt bath, which is pre-formed in the area of a moving energy source. In either case, the powder undergoes a change from a solid state to a liquid state and back; the entire process is accompanied by a variety of physical and chemical phenomena. Before the planetary scale boom in additive technologies, similar methods were actively developed for coating and surface treatment of materials. In mathematical modeling of the accompanying phenomena, the problem arises of selecting or constructing a suitable model that adequately describes the behavior of the material in both the solid and liquid phases, as well as in the two-phase region. Related to this is the variety of modeling approaches. Numerous publications analyze purely thermophysical models for calculating temperature fields at different variants of the heat source setting; study the behavior of fine particles in the melt bath; describe powder melting and melt flow in the unmelted powder, including using filtration theory; analyze variants for calculating residual stresses, etc.

In spite of the fact that each of the approaches allows obtaining interesting results and studying a number of phenomena, the process of creating a new material in dynamics proves to be insufficiently studied.

The present work aims to compare two variants of the coupled model the treatment by moving heat source of powder layer placed on a substrate. The models are based on the Maxwell thermo-viscous-elastic medium model and considering melting: (A) under the condition of a single melting temperature, in the neighborhood of which the effective heat capacity and viscosity change and (B) under the condition of melting in a certain temperature interval, in which the effective heat capacity and viscosity depend on the fraction of the liquid phase. In any case, the rheological properties change from those of the liquid phase to those of the solid phase. The applicability of the Maxwell model and its generalizations to the description of the synthesis of new materials is shown, for example, in [1-4].

Different variants of the coupled model (with and without taking into account the heat release from possible chemical reactions) are of independent interest. The possibility of transition to a two-level coupled model, when melting and/ or chemical reactions are described within the framework of the mesolevel model (at the level of powder particles), is discussed.

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