# Thermal Analysis of Additive Manufacturing

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## Abstract

Additive Manufacturing (AM) deposits successive, discrete layers of material of finite thickness in a transient manner to make an object of almost any shape from a digital model and thus contrasts with the traditional subtractive approaches commonly used to fabricate components. Additive manufacturing technology can be used throughout the product life cycle, from pre-production to full-scale production in addition to tooling applications and post-production customization. AM has the potential to make complex components from traditional aerospace alloys of high strength aluminum, titanium and nickel, and by the nature of the deposition process transient high temperatures are obtained in localized regions associated with the deposition process.

AM technology inherently involves a range of phenomena including:

• Molten metal flow
• Transient heat transfer in the manufactured component
• Liquid to solid phase change during material deposition
• Microstructural and phase evolution
• Residual stresses development during manufacture
• Distortion of the manufactured component

This study used COMSOL Multiphysics® software to analyze the laser powder bed additive manufacturing process. The laser is modeled as a moving heat source with time dependent heat transfer causing local, transient melting of the metal powder. Heat transfer is considered to take place due to convection in the molten metal pool, solidification of molten metal and conduction, convection and radiation to the surrounding environment (Figure 1). Addition of consecutive layers has been automatically integrated into the model to allow prediction of the thermal history of the component geometry during deposition. The results show that the inclusion of Maragoni convection is required to provide an accurate description of the thermal history near the liquid metal pool, with increasing distance the effect of convection in the liquid metal pool is less significant.

## Figures used in the abstract

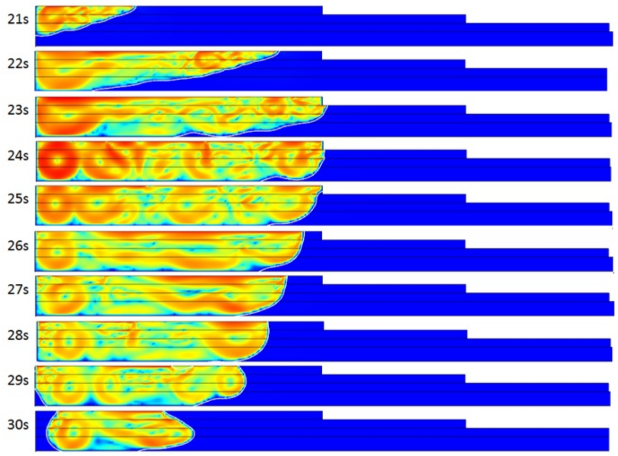


**Figure 1**: Transient temperature distribution due to moving laser during AM layer deposition.