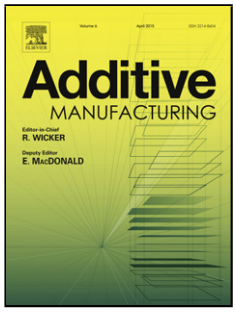


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# Effective Liquid Conductivity for Improved Simulation of Thermal Transport in Laser Beam Melting Powder Bed Technology

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## Abstract:

An effective liquid conductivity approach has been developed to describe the convective transport modes existing within the melt pool in powder bed additive manufacturing processes. A first principles approach is introduced to derive an effective conductive transport mode that encompasses conduction and advection within the melt pool. A modified Bond number was calculated by comparing surface tension forces with viscous forces within the melt pool region. It was determined, due to the small size scale of melt pools in powder bed processes, that the surface tension gradient driven flow, or the Marangoni effect, is the dominant mass transport phenomenon within the melt pool. Validation was conducted by comparing simulation melt pool widths and depths against experimental measurements for Inconel 718 built at beam powers of 150W, 200W and 300W and a scan speed of 200 mm/s. By introducing the effective liquid conductivity, simulated melt pool widths were up to 50% closer to experimental widths and simulated melt pool depths were up to 80% closer to experimental measurements. Analytic temperature profiles and melt pool dimensions are compared between Ti6Al4V, Stainless Steel 316L, Aluminum 7075 and Inconel 718 built with similar process parameters, while including effective liquid conductivity. The reasons for differences in temperature and melt pool geometry are discussed.

## 1. Introduction

The field of additive manufacturing is of great interest due to its ability to create net-shape or near net-shape parts with very little waste material. AM processes are layer-upon-layer fabrication of parts governed and controlled by digital designs and facilitated by computer aided design (CAD) software [1]. While AM theories have existed since the late 19$^{th}$ century [2], the first modern example is the stereolithography process developed by 3D systems in 1986 [3], [4]. In recent years, however, most reported research efforts have been focused on powder bed