Early Stage Melt Ejection in Laser Percussion Drilling

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Abstract

Laser percussion drilling is widely used in the aerospace industry to produce cooling holes in jet engine components. This process is a thermal, contact-free process which involves firing a sequence of focused optical pulses onto a target material. During each optical pulse, the central portion of the target area heats to a liquid then vapor state where the expanding gas produces a recoil pressure that forces the liquid material to move outward and upward in a conical fashion. This paper presents a 2-D, time-dependent analysis of laser percussion drilling that focuses on the early stage of melt formation and ejection using a non-isothermal laminar flow model using COMSOL Multiphysics® 4.3.

Reference

1. M. Von Allmen, (1976), 'Laser Drilling Velocity in Metals,' 47, 5460-5463.
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3. G. Ng, P. Crouse, & L. Li, (2006), 'An Analytical Model for Laser Drilling Incorporating Effects of Exothermic Reaction, Pulse Width and Hole Geometry,' Intl. J. Heat & Mass Trans., 49, 1358-1374.
4. T. Eppes, I. Milanovic, & D. Shetty, (2009), 'Laser Percussion Drilling Modeling Utility,' J. Laser Appl., 21(2), 102-109.

Figures used in the abstract

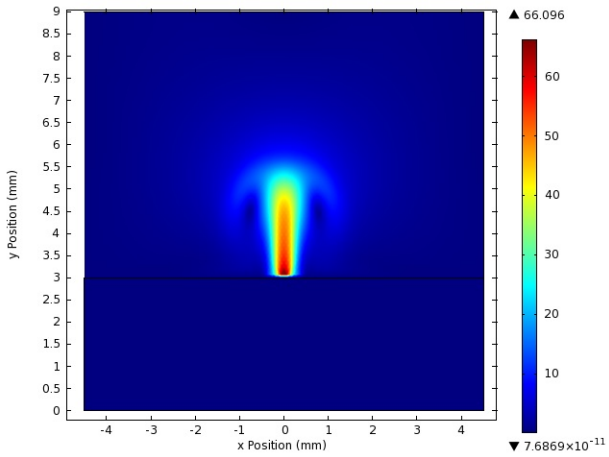

Figure 1: Velocity field (m/s) in the air region at t=2ms.

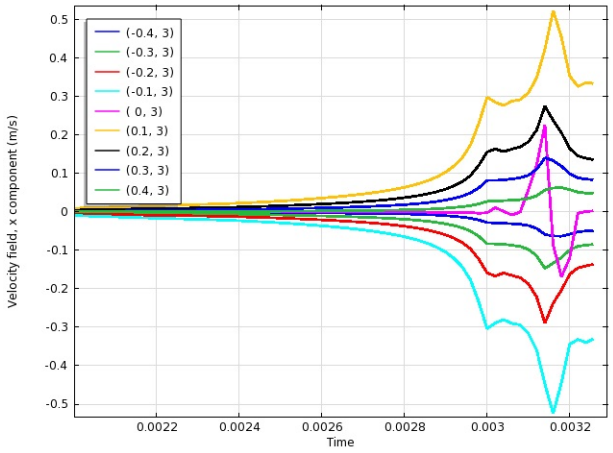

Figure 2: Velocity (m/s) versus time along x-axis 0.01mm below the target surface.

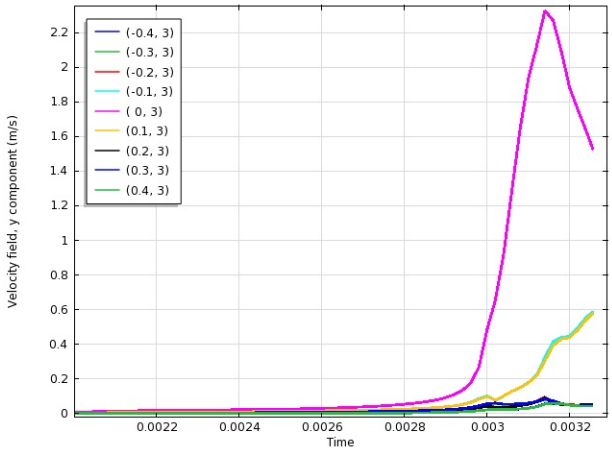

Figure 3: Velocity (m/s) versus time along y-axis 0.01mm below the target surface.

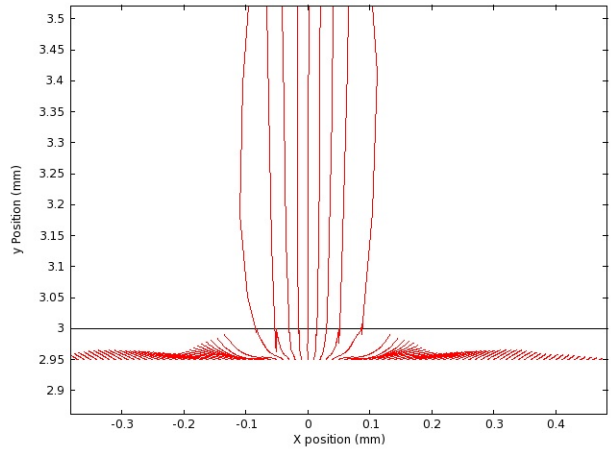

Figure 4: Particle flow history to 3.2ms at 0.5mm below the target surface.