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The main objective of this research is to study the effects of high energy and ultrashort laser on materials. A dual-phase lag (DPL) model was used to investigate the heat conduction in a gas-saturated porous medium subjected to a short-pulsed laser heating. The energy equations for the powder and gas phase were combined together to obtain a DPL heat conduction equation with temperature of the powder layer as the sole unknown. A perfect correlation obtained from Laplace transformation was applied to analytically solve the DPL problem with internal heat source. The Riemann sum approximation is applied to find the inverse Laplace transform of the powder layer temperature distribution. Variations of powder temperature at heating and adiabatic surface and powder temperature distribution were studied. The results showed that the analytical solutions were in a good agreement with the numerical solutions. The effects of phase lags times, pulse width, laser fluence, porosity on the DPL behavior of the gas-saturated powder layer were also investigated.

Kirchhoff transformation was introduced in the solution of three dimensional inverse heat conduction problem of a thin sheet. Three dimensional heat transfer problem was solved by simplifying to one dimensional problem through modal expansions. Using Hadamard Factorization Theorem, transfer function which showed the relationship between the front and back surfaces heat quantities i.e., temperature and heat flux as infinite product of polynomials is established. The inverse Laplace transforms of the polynomials showed the relationships for every mode in the time domain. The front surface heat quantities were revealed through iterative time domain operations from the data on the back surface. Seven points for smoothing and third order polynomial in derivative calculation were used in Savitzky-Golay (S-G) method. The comparison between direct solution, Conjugate Gradient Method (CGM) and DCT/Laplace transform solutions were shown as well as Root Mean Square (RMS) of the errors at different time steps for DCT/Laplace solution and CGM method are presented.

A three-dimensional numerical simulation as conducted for a complex process in a gas-solid system, which involves heat and mass transfer in a compressible gaseous phase and chemical reaction during laser irradiation on a urethane paint coated on a stainless steel substrate. A finite volume method (FVM) with a co-located grid mesh that discretizes the entire computational domain was employed to simulate the heating process. The results showed that when the top surface of the paint reaches a threshold temperature of 560 K, the polyurethane starts to decompose through chemical reaction. As a result, combustion products CO2, H2O and NO2 were produced and chromium (III) oxide, which serves as pigment in the paint, was ejected as parcels from the paint into the gaseous domain. Variations of temperature, density and velocity at the center of the laser irradiation spot, and the concentrations of reaction reactant/products in the gaseous phase were presented and discussed, by comparing six scenarios for different laser powers ranging from 2.5 kW to 15 kW with an increment of 2.5 kW.

A two-dimensional axisymmetric transient laser drilling model was used to analyze the effects of laser beam diameter and laser pulse duration in the laser drilling process. The model includes conduction and convection heat transfer, melting, solidification and vaporization, as well as material removal results from the vaporization and melt ejection. The model was first validated with the available results from literature. The validated model then applied to study the effects of laser beam size and pulse duration on the geometry of the drilled hole.

A sample-based stochastic model was presented to investigate the effects of uncertainties of various input parameters, including laser fluence, laser pulse duration, thermal conductivity constants for electron, and

electron-lattice coupling factor, on solid-liquid phase change of gold film under nano- to femtosecond laser irradiation. Rapid melting and resolidification of a free standing gold film subject to nano- to femtosecond laser are simulated using a two-temperature model incorporated with the interfacial tracking method. The interfacial velocity and temperature were obtained by solving the energy equation in terms of volumetric enthalpy for control volume. The convergence of variance (COV) was used to characterize the variability of the input parameters, and the interquartile range (IQR) was used to calculate the uncertainty of the output parameters. The IQR analysis showed that the laser fluence and the electron-lattice coupling factor have the strongest influences on the interfacial location, velocity, and temperatures.