Spectral Analysis Of Thermal Emission From Melt Pool During Laser Material Processing

M. Ćwikła[1], P. Koruba[1], A. Zakrzewski[1], P. Jurewicz[1], J. Reiner[1]

[1]Wroclaw University of Science and Technology, Wrocław, Poland

Abstract

Laser technologies such as welding, cutting and metal deposition are widely used in the industry. High quality requirements regarding process products cause that there is often a need to monitor the process. For this purpose, optical sensors integrated with a laser head are often used. In many cases the light coming from an external light source is analyzed after being reflected from the sample. This allow measuring distance from the laser head to sample or measure keyhole during laser welding.
However, laser material processing is strongly related to high emission of visible and infrared radiation. Therefore, the signal acquired by the sensor during the laser process can be disturbed. Hence, it is crucial to determine the radiosity of the melt pool in the wavelength spectrum which sensor operates in.
In this paper, we present a 2D axisymmetric numerical model of melt pool formation as a result of heating a material with high power laser beam. For this approach Heat Transfer in Solids and Fluids and Laminar Flow interfaces coupled by Non-isothermal Flow and Marangoni effect multiphysics from COMSOL Multiphysics® Heat Transfer Module and CFD Module were used. Moreover, we used Surface to Surface interface to perform multiband analysis of radiosity of the surface. Analyzed bands were defined for visible range which sensor being under our investigation operates in.
Firstly, the model was simplified to describe blackbody emissive characteristics and constant temperature on the surface was assumed. The numerically obtained results of radiosity were compared to theoretical calculations and results of experimental measurements of blackbody calibrator. Subsequently, material properties such as conductivity, viscosity and phase change parameters of 316L steel were implemented to the model. Diode laser beam characterized by top-hat intensity distribution was defined as superficial heat source. Moreover, ALE approach allowed melt pool formation (External Fluid Interface). In this case surface tension is considered as the main factor that defines geometry of the melt pool. For this reason its influence on melt pool shape was described in detail. The radiation properties of 316L steel such as absorption and emissivity coefficients were set based on literature data as well as values determined by measuring the temperature of the process with two color pyrometer and assuming grey body behavior of the melt pool.
In order to validate described model an experiment was carried out for the same process parameters. It included a coaxial spectral radiosity measurements using high resolution spectrometer mounted to optical monitoring port of the laser head. Moreover, metallurgic cross-sections were investigated to compare melt pool geometry with the results obtained within the model.

Figures used in the abstract

Figure 1 : The simulation results of laser melting process including temperature distribution, liquid phase indicator and surface radiosity.

Figure 2 : The resultative radiosity of the melt pool as a function of wavelength in visual spectrum

Figure 3 : The comparison between black body theory, simulation and measurement results. In case of simulation a simplified model with constant temperature equal to the one set on black body calibrator.