Estimation of Material Parameters from Pulse Thermography Data in Time and Frequency Domain

Karl Heinz Gresslehner, Bernhard Stotter [C, S], Guenther Mayr and Guenther Hendorfer
School of Engineering and Environmental Sciences, University of Applied Sciences Upper Austria, Wels, Oberösterreich, Austria
bernhard.stotter@fh-wels.at

Jakov Sekelja
FACC AG, Ried im Innkreis, Oberösterreich, Austria

In this work we present a method to analyze pulse thermography data, obtained by measurements as well as simulations, to estimate the following three important thermophysical sample parameters: ω_0 (the characteristic frequency, which corresponds to the diffusion time t_d), B_1 (the Biot number at the front side) and H (the ratio of the Biot number at the rear side B_2 to B_1). The procedure is referred as Parameter Reconstruction in Frequency and Time Domain (PRFTD) and is a further development of the previous work Parameter Reconstruction in Frequency Domain (PRFD). The procedure was developed for a 1D solid of length L. The PRFTD procedure consists of three main steps in time domain with a subsequent fitting procedure in frequency domain. This procedure can be applied for measurements in reflection and transmission mode setup. The three main steps in time domain are:

1) Fit of the measured or simulated data based on physically piecewise continuous trial functions.

2) Estimation of the diffusion time t_d by using the Thermographic Signal Recognition (TSR) method when analyzing reflection mode data or by using the Linear Diffusivity Fit (LDF) method when analyzing transmission mode data.

3) Integral Fourier Transformation (IFT) of the trial functions. The advantages of the IFT are, on the one hand the avoidance of the well-known problems arising from discrete Fourier transformation and on the other hand the applicability of the existing analytical solution of the heat transfer equation in a closed form on the transformed data. Therefore, the remaining material parameters B_1 and H can be estimated by a subsequent fitting procedure in frequency domain.

To use the PRFTD procedure only the condition of a homogeneous material must be fulfilled. Due to this characteristic, the PRFTD procedure can be used as a reference method for the calibration of other methods (e.g. TSR and LDF).