Constant Velocity 'Flying Spot' to Measure the In-Plane Thermal Diffusivity of Solids and the Thermal Resistance of Vertical Cracks

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Optical excited infrared thermography (IR) has been widely used to measure the thermal diffusivity of solids and to characterize vertical cracks. The “Flying spot” technique consists in exciting the sample surface with a focused laser beam moving at a constant velocity along the surface, whilst an infrared camera records the temperature field. We have developed a new scanning system based on a galvanometer mirror that allows an easy control of the spatial and temporal displacement of a laser spot over the sample surface. In the first part of this work, we have found an analytical solution for the surface temperature corresponding to a laser spot moving at a constant velocity at the surface of an anisotropic sample. It has been demonstrated that the natural logarithm of the temperature profiles perpendicular to the laser scan are parabolas. Moreover, the inverse of the second order coefficient of the parabola as a function of time is a straight line whose slope depends, through a simple formula, on the thermal diffusivity, laser radius and laser velocity. In this way, the thermal diffusivity of the sample can be retrieved. This method is especially useful for moving samples, as is the case of in-line manufacturing. We have validated the method by measuring samples of known thermal properties. In the second part, the same experimental setup is used to characterize the thermal resistance of vertical cracks. An analytical expression for the surface temperature has been found. The presence of the crack produces a discontinuity in the temperature field. By fitting the temperature profile along the laser movement direction, the thermal resistance can be obtained. We have prepared calibrated vertical interfaces by inserting very thin metallic tapes between two blocks of the same material. The agreement between nominal and retrieved thermal resistances confirms the validity of the model.