Ultrasonic Thermometry for Real-Time Temperature Profiling of Industrial Materials and Processing

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There are growing demands for realizing noninvasive and real time measurements of internal temperature profiles for industrial materials at high temperature environments. It is also required to monitor transient temperature changes of various heated materials, mechanical parts and structures associated with high temperature processes. To meet such requirements, so-called “ultrasonic thermometry” which is a method for measuring internal temperatures by ultrasound has been studied extensively. The authors had proposed the effective ultrasonic thermometry for estimating internal and surface temperature profiles of heated materials. This method is basically a hybridized method consisting of ultrasonic pulse-echo measurements and finite difference calculations for solving one-dimensional unsteady heat conduction problem. One-dimensional temperature distributions along the direction of ultrasound propagation either inside or on the surface of a single side heating material are successfully determined by the method. The advantage of the method is that it is possible to determine the temperature distribution with no information on thermal boundary condition at the heating surface. In addition, distinctive features of the method are fast time response and high spatial resolution in measuring such temperature distributions. In this work, to demonstrate the practical feasibility of the method, several experiments with heated materials have been made. First, internal temperature profiles of single-side heating steels are successfully being measured during heating and cooling processes. Next, temperature profiling near friction surface of a steel specimen is also successfully performed. Heat-flux monitoring at an interface between two materials are also demonstrated. In addition, non-contact temperature monitoring of a rotating steel cylinder is made using a laser-ultrasonic technique. Although there still remain some issues to be examined and solved for the practical uses of the ultrasonic thermometry, the method is highly expected to be a unique and effective means that realizes online temperature monitoring for advanced process control of industrial materials processes at high temperature.