Inverse Process Analysis for the Acquisition of Thermophysical Property Data

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Objective: Increase the accuracy of thermophysical property data for solidification processing.

Background: The evolution of fraction solid and density during solidification is required for the analysis and design of materials processing and industrial application. Applications include the elimination of shrinkage voids, microporosity, and macrosegregation in the aluminum, steel, and metalcasting industries.

Differential Scanning Calorimetry (DSC)
A heat transfer model has been developed to account for thermal lags in the DSC system. The model parameters are time constants associated with appropriate heat transfer mechanism among the key system components.

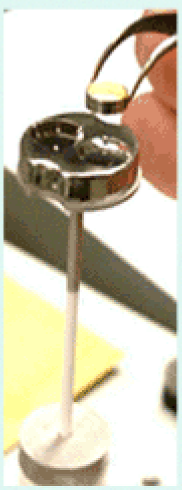

Figure 1. Cell mounting for heat-flux type DSC system used for high-temperature applications.

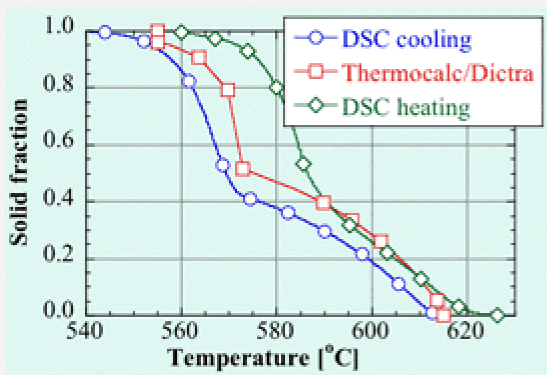

Figure 2. Fraction solid obtained from DSC data and analytical model for the DSC system.

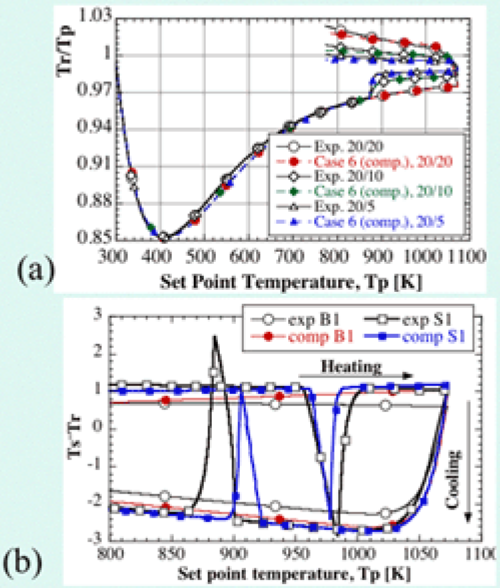

Figure 3. Numerical simulation results agree well with experimental results for different cooling rates: (a) temperature ratio reference side to set point, (b) differential temperature between the sample and reference sides.

Dilatometer

The new sample holder was designed such that a uniform heat flux distribution is attained with minimal modifications made to the rest of the dilatometer. *The new design will decrease the experiment time by a factor of ten.*

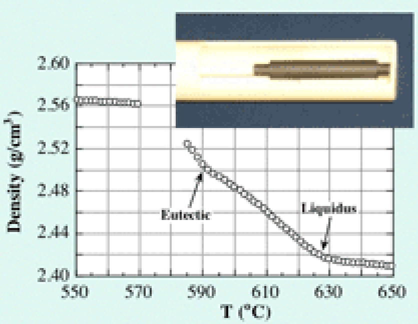

Figure 3. Solidus, Eutectic and Liquidus temperatures are erroneously seen at 570, 590, and 627°C while they are estimated to be 559, 572 and 613 °C from DSC data.

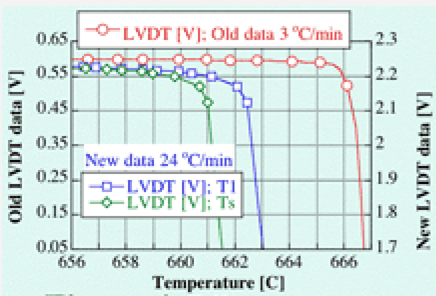

Figure 4. Dilatometry (LVDT) data as function of temperature for pure aluminum. The melting point is observed at 666, 662.3, and 661 °C for the old set-up, and the new setup (measured and estimated temperatures), respectively.

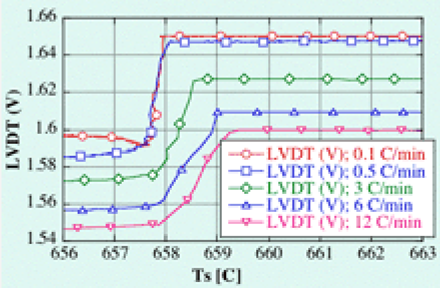

Figure 5. **Dilatometry (LVDT) data as function of temperature for pure aluminum at different heating rates. Higher melting point temperatures are observed at higher heating rates. Robust.**

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