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An Inverse Formulation for Solution of Free-Boundary Problems

In this presentation we are concerned with the two-phase solidification (Stefan) problem as a common example of a free-boundary problem. We reformulate this problem as an inverse problem in which a cost functional is minimized with respect to the position of the interface and subject to suitable PDE constraints. An advantage of this formulation is that it allows for a thermodynamically consistent treatment of the interface conditions in the presence of a contact point involving a third phase. Furthermore, such a formulation also makes it possible to solve optimal control problems in essentially the same way as the “direct” problem. We describe an efficient iterative solution method for the inverse formulation of the Stefan problem which uses shape differentiation and adjoint equations to determine the gradient of the cost functional. Performance of the proposed approach is illustrated with sample computations concerning 2D steady solidification phenomena. This investigation is a part of a broader research effort related to optimization of advanced welding techniques used in automotive manufacturing.

Joint work with Oleg Volkov.