For presentation at the 12th International Coating Science and Technology Symposium, Rochester, NY. 20-22 September 2004.

An Overset Grid Method for Modeling the Dynamics of Coating Applicators

P. R. Schunk, E. D. Wilkes, and D. R. Noble

Multiphase Transport Processes Department

Sandia National Laboratories

Albuquerque, NM 87185-0834

Fully implicit, moving mesh finite element approaches based on the Arbitrary Lagrangian/Eulerian (ALE) formulation have been the workhorse in computer-aided coating flow analysis for decades. These methods are superior to all other alternatives when applied to coating flow configurations characterized by a steady flow state, as is usually the case during successful operation of a slide-, slot-, or roll-coating flow on rigid, smooth substrate. Unfortunately, several technologically important coating-applicator configurations exist in which the flow during operation cannot be classified as steady in any chosen reference frame. For example, gravure-roll coating operations are unsteady due to the translation of solid-surface features through the coating nip; in fact, any self- or pre-metered coating process on a non-smooth substrate will be unsteady. Classical ALE methods often fail in these applications due to excessive mesh distortion.

We propose a new modeling approach that circumvents this limitation. The approach builds on the mortar finite element method and the theory of Lagrange multipliers which enables models of geometrically unsteady coating processes. The algorithm allows for the optimal mechanics treatment of moving solid parts (like rolls and blades) based on a computational Lagrangian formulation, and also a natural treatment of the fluid mechanics with an ALE or Eulerian formulation. The key elements of the algorithm include contact boundary conditions between two independent meshes that are required for proper enforcement of kinematic and dynamic constraints. The algorithm is demonstrated with blade and gravure roll-coating related applications.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Engergy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.