Using Abaqus/Explicit to model polymeric thin-film mechanical property changes due to embossing

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Abstract: *Embossing of polymeric films destined for usage in the personal care marketplace is an industrial process that produces a very fine pattern, barely discernible to the naked eye, yet has a significant influence on some market-driven properties; more bulk, a soft and smooth touch, reduced crinkling noise and lower gloss. However this comes at a cost to the mechanical properties such as stiffness and ultimate strength capability. Since the feature size of the embossing pattern is so small, it is difficult to obtain all the information from an experiment alone, making the Finite Element Method an ideal analytical tool to help gain additional insight into the effects of some of the design and process parameters. The paper discusses the computational approach, presents results of simulations performed in Abaqus/Explicit for an example 16 micron film and compares to experimentally measured values.*

Keywords: *Constitutive Model, Damage, Experimental Verification, Forming, Fracture, Heat Transfer, Plasticity, Polymer, Residual Stress, Springback, Thermal Stress, Tissue, Visualization.*

1. Introduction

Off-line cold embossing is a stand-alone unit operation that consists of unwinding previously blown and slit film, contact-heating it with a roll to a semi-molten state, passing it through a cold nip formed between a hard engraving roll in contact with a soft backup roll and re-winding the structured film as schematically shown in Figure 1. Embossing produces a very fine pattern on the film, which is barely discernible to the naked eye, yet has significant influence on its properties. Compared to the flat precursor film, the embossed film has more bulk, has a soft and smooth touch, and reduced noise – all much desired in hygiene tissue films used for diapers. Furthermore the film has very low gloss, and features a reduced modulus, along with improved dart impact strength.

In addition to the analysis reported in [Kamal, 1988], these authors have been involved in additional studies along the same lines [Kamal, 1985; Kamal, 1992] that together form a good basis for the analysis conducted here. Since the time of these investigations, the capability to analyze these kinds of problems, using commercially-available Finite Element programs, has advanced significantly [Nagarajan]; Dow has chosen to analyze the problem using the capabilities available within Abaqus/Explicit from SIMULIA. Our analysis does not cover material structure-property relationships or in-depth analysis of toughening effects; we perform an analysis using the