The following abstract is from a presentation related to plug assist thermoforming presented at the 2003 ANTEC Conference held 5 May 2003 at the Nashville Convention Center, Nashville, TN.

POLYMER-POLYMERIC FRICTION AT TEMPERTURES AND RATES SIMULATING THE THERMOFORMING PROCESS

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Plug assist thermoforming is one of the most important process variants for the thermoforming industry. The purpose of the plug assist is to pre-stretch the heated polymer sheet prior to the application of pressure and/or vacuum during the final part formation onto the tool. Parametric studies performed on simulation models of the thermoforming process have shown friction between the polymer and the plug assist to be critical in predicting material distribution in the thermoformed part.

This report presents the results of investigating the friction behavior of a polymer to plug assist material at thermoforming conditions. A new measurement technique for friction coefficients will be shown and explained in detail. This technique allows for the characterization of the friction coefficient as a function of temperature and rate and shows the sensitivity respectively.

The following abstracts are from two presentations related to plug assist thermoforming presented at the 2002 SPE Thermoforming Conference held 14-17 September 2002 at the Nashville Convention Center, Nashville, TN.

INVESTIGATION OF PLUG ASSIST MATERIAL PROPERTIES RELATIVE TO THE THERMOFORMING PROCESS

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As thermoforming becomes more sophisticated in both process and product, the role of the plug assist becomes more critical. Currently, plug assist materials, geometry and process conditions are chosen based on the thermoformer's experience and their equipment capability. There is little technical information on the important properties of the plug assist material for thermoforming. This paper presents the results of an evaluation of the plug assist effects that control material distribution in a thermoformed part. Plug assist material properties are measured at thermoforming conditions.

VERIFICATION ANALYSIS OF A PLUG ASSIST THERMOFORMED PART DESIGNED THROUGH T-SIM, COMPUTER SIMULATION

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Plug assist thermoforming is an art which thermoformers have developed through many years of experience. As the industry becomes more competitive and expands into increasingly difficult products, modeling of the process holds the potential to dramatically shorten development time, increase process and materials efficiencies and lead to new market opportunities. The accuracy of any computer model is dependent on the modeling parameters for the processed materials under process conditions. In the past, the modeling parameters for thermoformed materials have been estimated from data generated under conditions that are not representative of the thermoforming process. The objective of this effort was to determine if modeling parameters developed under thermoforming conditions would improve the computer model's predictions. T-SIM, a commercially available computer simulation software package for the thermoforming process, was chosen for these evaluations because it is currently being used to design and develop new thermoformed products. This paper presents the verification results of the computer simulation modeling of a HDPE thermoformed part. The test methods, improved model parameters and comparisons between the results of the T-SIM computer simulation and the actual thermoformed part are presented.

The following abstract is from a presentation related to plug assist thermoforming given at the WorldPak 2002 Conference held 23-28 June 2002 at Michigan State University, East Lansing, MI.

PROCESS SIMULATION MODELING PARAMETERS FOR PLUG ASSIST THERMOFORMING OF HIGH DENSITY POLYETHYLENE

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High density polyethylene (HDPE) is one of the most difficult polymers to thermoform. Improvements in the processing of HDPE will afford the thermoformer additional opportunities to use this low cost polymer in new applications.

Process simulation of the plug assist thermoforming of HDPE has not been effective in providing improved thermoforming conditions for this polymer. These simulations are dependent on modeling parameters for the polymer's elongation characteristics and the polymer to plug assist interactions during forming. These parameters have been limited in the past to values that are not measured under thermoforming conditions.

The paper reports the development of process simulation modeling parameters for HDPE and the plug assist interactions under thermoforming conditions. The test methods for developing the modeling parameters are described and the improved parameters are reported. Finally, the value of this technology is illustrated by its application to the development of a thermoformed, deep drawn, HDPE food service container.

The following abstract is from a paper and presentation at the 2002 ANTEC held 4 May 2002 at the Moscone Convention Center and San Francisco Marriott, San Francisco, CA

VARIOUS PLUG ASSIST MATERIALS AND THEIR EFFECT ON THE THERMOFORMING CHARACTERISTICS OF POLYMERIC SHEET

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Plug assist thermoforming is an art which thermoformers have developed through many years of experience. As the industry becomes more competitive and expands into increasingly difficult products, modeling of the process holds the potential to dramatically shorten development time, increase process and materials efficiencies and lead to new market opportunities.

This report presents the results of investigating the force-deformation characteristics of a HDPE polymer sheet when formed with different plug assist materials with the aim towards developing modeling parameters. The variables investigated were plug material, plug temperature, plug speed, plug shape, plug surface roughness and polymer sheet thickness and temperature.

The following abstract is from a presentation related to plug assist thermoforming presented at the 2004 SPE Thermoforming Conference held 18-21 September 2004 in Indianapolis, IN.

NEW DEVELOPMENTS IN PLUG MATERIALS

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The development of new plug materials is the result of communicating and applying the insight of thermoformers, toolmakers, machine builders, plastic material suppliers and thermoforming research centers. These new plug materials have improved the forming of products across a broad range of applications. This paper will present applications optimized by these new plug materials, recent efforts in measuring and understanding the coefficient of friction effects at the plug/sheet interface and application of this new understanding towards the next generation of plug materials.