



Plasticisation of thermoforming foils

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Successful thermoforming requires, at the most basic level, two elements - firstly pressure, either directly from an external supply or by utilisation of atmospheric differentials (vacuum units) and secondly, a thermoformable material in the correct plastic state to allow for adaptation and retention of the final form.

While the first parameter (thermoforming pressure) is determined by the choice of thermoforming unit used, the measurement of foil temperature is more diverse.

There are three methods of introducing the correct amount of energy (heat) into the foil to obtain the optimum plasticity (material temperature) to thermoform - user determined; time-based systems; and foil temperature sensor systems. While all can produce excellent results they each differ in the skill levels required, margins for error and ease of use.

User determined

This method is characterized by the absence of machine control given to the amount of heat introduced to the foil prior to forming. The basic square type, single column vacuum unit and early pressure units are good examples of machines that rely on this technique.

These types of machines require the operator to watch the foil as it heats, plasticises and sags, then manually enable the pressure source and thermoform the mate-



Figure 1. Typical Time based thermoforming unit: Note the simple control sequence and closed heating chamber to minimise atmospheric influences.

rial when deemed appropriate. This method has been in use since the 1940's and in skilled hands can certainly give good results. Unfortunately the operation of these machines is often delegated to operators without the required training or skill levels, often leading to under heating or more commonly over heating of the materials. This can lead to less than optimal thermoforming results as well as degradation of the material properties and wastage.

As a guide, the following should be considered as the good approximations for identifying the correct temperature when thermoforming with this method.

- **EVA's** (Mouthguard and bleach tray materials): Heat until the foil sags slightly (1cm) then thermoform.



Figure 2. Thermoforming unit with foil temperature sensor system. The sensor in the base of the unit reads actual foil temperature; software programming and general operation is via the touchscreen on the right side of the machine.

- **Copolyesters** (Retainer and splint materials): Foil will sag, rise, ripple and sag again. At this point, test the softness of foil with a blunt instrument. If a permanent impressions result, thermoform. Overheating of these materials will result in less durable appliances.
- **SBS/EVA and Copolyester/Polyurethane Combinations** (Dual laminate splint materials): Heat the hard surface of the foil until a permanent impression remains when impressed with a blunt instrument. Then thermoform. Take care not to overheat.
- Allow all materials to completely cool in situ to room temperature before removing from the thermoforming unit.

Time-based systems

For over a decade, time-based systems have been present on quality thermoforming machines. A major step forward in terms of consistency and reduction of user error, the premise is simply that a heating time is assigned to each material and its various thicknesses and the foil remains under the heating element(s) for this predetermined time before thermoforming.

However with this system, in order to effectively commence the foil timing cycle, it is preferable for the heating elements to be at full power so either an element pre-heating time must be added to the thermoforming cycle or a rapid start-up heating element used. Local electricity supply variations and ambient temperatures can also affect the accuracy of these systems, however generally they remove the need for operator discretion of the plasticising phase and produce far more consistent results than user determined heating times.

Foil temperature sensor systems

Foil temperature sensor systems have been made commercially available over

the past two years. The ability to directly read the foil temperature has long been a possibility, however the high cost and availability of the temperature sensor units and associated software development has excluded this system from commercial viability.

The most accurate of all methods, the system operates independently of ambient temperatures, voltage fluctuations or heating element status, only suggesting thermoforming when the foil is at the exact predetermined temperature. This leads to markedly superior consistency and thermoforming results. Coupled with user programmable thermoforming specific software, comprehensive customising and control of the entire heating and cooling cycle is possible.

It should be noted that in many ways the cooling cycle is as important as the heating phase when thermoforming. Programmed cooling times under the control of vacuum lets us assign longer times to thicker materials holding more heat, again reducing the possibility of discretionary operator behaviour.

Which system?

Unless being used by an extremely skilled operator for limited applications, machines with no control of the plasticisation phase are difficult to recommend. Thermoforming materials are becoming ever more specific to their heating and cooling requirements than in the past and to anecdotally judge this from day to day is both time consuming and inconsistent. Time-based systems are proven to give much more consistent results and provide much greater ease of use. Foil temperature sensor systems now offer the greatest levels of accuracy and control over the plasticisation and cooling process and this makes for the most consistent thermoforming results and operator ease of use.

About the author

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