Deep drawing or thermo forming

Deep drawing is a long-proven and highly developed technology used to shape plates, trays and similar products from paperboard. However, it places very high demands on the paperboard. Deep drawing is also used for other materials such as paper and metal (aluminium).

Provided that the paperboard is very strong and consistent in all relevant parameters, deep drawing is today a most economical way of producing functional and attractive consumer food packs in large volumes. Very high production rates, which contribute to low production costs, are possible.

Printing the paperboard before deep drawing adds consumer appeal. The deep drawing process gives an unlimited choice of sizes. Deep drawing also offers great freedom in shape, for example rounded containers and multi-cavity constructions, which makes it possible to produce paperboard plates with shapes similar to those of conventional tableware.

Deep drawing is often performed with a plastic-coated paperboard. A range of plastic coatings is available to suit all types of applications. The most common application is the use of PE/PP-coated paperboard for paper plates. However, another interesting development is the use of PET-coated paperboard for deep-drawn/pressed single and multi-cavity trays for:

- Pizza – to be baked on the tray
- Pastry – baked or to be baked in the mould
- Ready-made meals in single or multi-cavity packages for microwave or convection oven heating.

A container produced with deep drawing can use several closure possibilities:

- A plastic-coated paperboard top, which is sealed onto the flange. The cover is often scored to facilitate opening.
- A transparent plastic film is sealed to the flange. The seal is often of the peel-seal type.
- A transparent snap-on lid, which can be used as a reclosure.

Description of the deep drawing tool and method

Deep drawing means the shaping of paperboard into rigid, hollow shapes, sometimes with several cavities. Paperboard properties like tear strength and high elongation-to-break determine the depth of forming.

A paperboard container often has a flange to facilitate the use of the tray. The flange will also increase the stiffness, which is important since stiffness is reduced in the creased and shaped areas.

The raw material for deep drawing is often a one-side plastic-coated paperboard. The printing operation is reel fed and the paperboard is rewound after printing.

Depending on the depth of the tray, the forming process is performed in one or two steps.

A normal plate is about 25 mm deep. The forming process requires only one step and no premoistening is necessary. The maximum depth is about 45–50 mm and must be carried out in two steps. In the illustration a plate is shown as a one-step forming operation.
The paperboard is cut into round blanks, which are fed into the machine. In this case the press operation lasts for two seconds and the tool has a temperature of 80 °C. A ready-made plate is pushed out of the tool and a new paperboard blank is fed in.

In a two-step operation, the second tool is heated to lock the shape (compare with ironing a shirt). During pre-moisturing the paperboard is softened by adding water up to about 13% total moisture. The reels are well wrapped in plastic during the maturing period until cutting, creasing and deep drawing operations are performed.

Finally the edges are trimmed to provide neat and even edges on the flange.

**Key paperboard characteristics**

Different paperboard constructions behave in different ways during deep drawing. The following general conclusions about deep drawing and two common types of boards can be made:

If the paperboard is pigment coated, the coat weight should be low to minimise the tendency for surface cracking during the forming operation. The coating formulation should be such as to give good release of the product from the heated forming tool.

**Key properties**

Since the deep drawing operation performs a mechanical deformation the following strength properties are vital:

- strong, tough paperboard with high elongation-to-break
- high tear strength
- hygiene and low odour
- very good adhesion of plastic coating.

**Thickness**

The thermoforming process depends on three main parameters: pressure, dwell time in the pressing stage and sufficient heat transfer. These parameters can be adjusted individually but are interdependent. Paperboard

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<table>
<thead>
<tr>
<th>Paperboard type</th>
<th>Deep drawing conditions</th>
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<tbody>
<tr>
<td>Solid Bleached Board (pure chemical pulp)</td>
<td>Suitable for all kinds of deep drawing operations, even deep shapes.</td>
</tr>
<tr>
<td>Folding Box Board (mechanical pulp in centre ply)</td>
<td>Most suitable for shallow shapes, otherwise delamination might occur.</td>
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characteristics play an important role in ensuring good heat transfer because good contact between the tools and the paperboard is essential; this is achieved by maintaining uniform thickness throughout the run. Because tools are manufactured to match the thickness specification of the chosen material, it is difficult to change to a different material thickness without also changing the tools. When an inappropriate material thickness results in poor heat transfer, the operator may be forced to increase one of the other two parameters (pressure or dwell time). However, the resulting thermoforming may be sub-optimal due to the inappropriate material thickness.

Deep drawing in practice
Consistency in strength properties and moisture content from one consignment to the next is important so that machine settings can be adjusted according to documented experience.

Converters specialising in deep drawing invest in high-speed machinery and exchange tools for 20–40 different sizes.
The following factors are essential for good deep drawing:
- No coating or light coating on the outside for minimum surface cracking.
- An optimised container design to obtain maximum stability.

Testing the deep drawing result
The deep drawing result is subjectively evaluated for defects, cracks etc. (see below).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
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<tr>
<td>The blanks tear during the deep drawing operation.</td>
<td>Too brittle or too dry blanks due to a variation of moisture content. They must be remoistened to give a satisfactory result.</td>
</tr>
<tr>
<td>Finished articles warp during drying in storage.</td>
<td>Blanks too moist.</td>
</tr>
<tr>
<td>The pigment coating cracks and partly peels during forming.</td>
<td>A brittle pigment coating has been used.</td>
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</table>