Thermoforming 101

For the layman and would-be entrepreneurs

A) Introduction

A practical guide to anyone interested to know more about THERMOFORMING of plastic sheets and films.

Written by specialist, readers will be guided through the process of thermoforming, from choice of materials to the economics of making profits.

Major areas of interest are highlighted such as the products we are able to produce and the different equipment that are available from various suppliers.

Mould designs, compounding of resins and latest developments are also discussed.

Feedbacks are welcome!

Contact us at globalspecialtiessg@gmail.com

What is thermoforming?

Thermoforming is the process of softening plastic films or sheets and formed into desired shapes, using vacuum or air pressure.

Moulds are custom-designed, using materials such as metal, alloy, copper, polyester, epoxy and polyurethane.

Products which are thermoformed may be from consumer products, such as metals for packing batteries, disposable lunch boxes and drinking cups to industrial packing trays and clamshells for electronic components.

Thicker materials are used for items such as refrigerator linings, luggage bags, wood patterns and bath tubs.

Why do we thermoform?

Thermoforming: Thermo is to heat and Form is to shape which essentially, is to shape materials by the use of heat and pressure.

- It is cost-effective.
- It is time-efficient as moulds are simpler to produce as compared to injection moulding.
- Designs can be modified by modification of moulds.
- Thermoforming is also environmentally friendly as waste plastic in the process is usually converted back into sheets to be thermoformed.

B) Materials

Choice of plastic materials

Polyvinyl Chloride (PVC)

PVC is transparent, clear and has good chemical resistance thus making it a popular material in thermoforming. PVC can be high frequency welded, making it ideal for stationery products such as file folders, while blister packs and clamshells are commonly formed from this material.

Polystyrene (PS)

PS is easy to form and it softens at lower forming temperatures compared to other materials. It is normally used for deep-drawn drinking cups, lunch boxes, cookie trays and disposable food packs.
Polystyrene has long been recognized as a versatile and cost-effective solution for rigid packaging and food service disposables. It is also the leading choice for media enclosures, cassette tape housing and clear jewel boxes to protect CD's and DVD's.

http://www.polystyrenepackaging.co.za/index.htm

Polypropylene (PP)

PP is ideal for product that needs to withstand high temperatures such as microwaveable food trays. During thermoforming, PP sheets require preheating before the heater zone to achieve optimal thermoforming.

Polyethylene Terephthalate (PET)

PET is a popular choice for thermoformed packaging products such as blisters, clamshells, and food trays as it is tough with excellent tear strength and impact.

Oriented Polystyrene (OPS)

OPS have superior clarity, sparkle, gloss, excellent stiffness and are recyclable. Barrier properties against gas and moisture are adequate in its intended application, Oriented Polystyrene is an in-expensive clear material used for packaging and print application, and however the product will scratch and tear easily.

C) Applications

The largest application for thermoformed articles is for Food Packaging. However, blister packs are increasingly popular with manufacturers and are used to package products such as toys, electronic and consumer products. Blisters may be sealed to paper cardboard or edge-folded to allow the use of detachable cards, in accordance to regulatory requirements in Europe. Clamshells are designed for a more secure package which can deter theft of expensive items.

What is the range of thickness of materials used?

An advantage of plastic thermoforming is the ability to use thin materials thus products can be made economically.
Thickness range from 0.1mm for disposable trays to 5mm for refrigerator linings, choice of thickness are usually dictated by mould designs and customer specification.

How are plastic sheets heated up for thermoforming?

Thermoforming process uses sheets that are in roll form or cut to size which are then softened using high temperature (150 – 250 degree Celsius)

Thin films

Thickness for thermoforming usually range from 0.1mm – 1.0mm for economic and functionality reasons. Most films are clear and transparent, however colored films are added product differentiation. Blue- drinking cups, White- salad boxes and Maroon- Cake trays. Products thermoformed from thin films include blisters, food trays, medical and electronic packaging.

Thick Sheets

The thicknesses of thick sheets are between 1.0mm – 5.0mm. They are used when requirements for stronger and durable plastic products that thin sheets will not provide. Designs that have a large depth also require thick sheets to be used in production. Products that are thermoformed using thick sheets include refrigerator lining, toy boats and large signboards.

Colourants

While most thermoformed products are clear or transparent, plastic films and sheets may be colored for aesthetics and to customer's requirements. Masterbatches or concentrated colours in pellets are commonly available nowadays from reputable suppliers.

D) Equipment

Different types of moulds used in thermoforming

Wood patterns

Wood patterns are usually the first type of mould used in any thermoforming project as they are cost effective and can be produced within short lead times. Wood patterns cannot be used for high output production and are mainly used as a tool to spot design flaws for improvements to be made for future moulds.

Aluminum Moulds

Aluminum is commonly used due to its physical property of being a good thermal conductor. This allows a quick and consistent cooling cycle for high productivity, however it is also the most expensive choice of material for thermoforming moulds.

How to color your finished products.

Thermoforming processes use films and sheets extruded to various widths and thicknesses. Colors are incorporated in the extrusion process using pigments. Organic pigments which are brighter are commonly used, but they may fade after prolonged exposure to air and sunlight. Inorganic pigments such as red iron oxide are dull, but they are cheaper and last longer. As pigments are usually in the form of fine powder, master batches are used as it eliminates dust in the extrusion process. Master batches are concentrated pigments in a base of resins or wax. 1%-5% of colorant is usually adequate to achieve the coloring effect.

White masterbatches use titanium dioxide.

Black masterbatches use carbon blacks.

E) Moulds

Wastage is inevitable and arise from inability to utilize 100% of raw materials, due to:

Clamping on both sides (10% wastage). The plastc sheet is clamped both sides on the machine and the clamped space cannot be used.

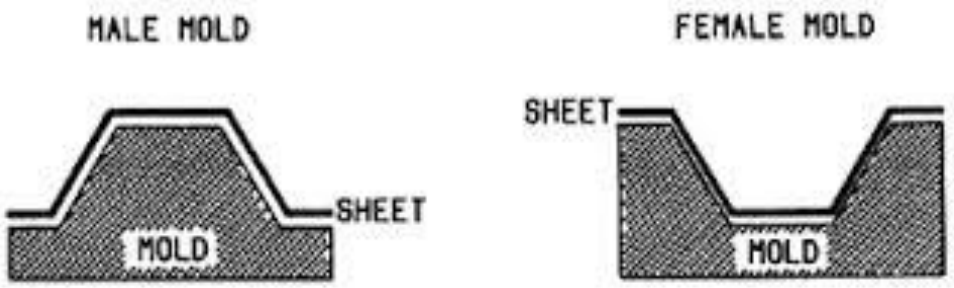
Webs between products (10-30% wastage). The moulds are spaced out and there is a limited number of moulds that a sheet can be formed on. Clamping the front and back of the sheet results in 5% wastage.

Test runs, initial runs and rejects are due to trimming and forming which also contribute to wastage. Finally, running a whole roll of material makes it economical and convenient for the company. Problems arise when customers do not take everything that is produced. Leftovers are unavoidable if whole rolls of materials are used. Overruns result in losses.

Usually, there are two main types of molds used in thermoforming, the Male and Female molds.

Male molds are concave forming devices which have glossy surfaces on the exterior with the bottom of the mold walled as the thickest and most uniform section. Male molds are designed in such a way that the rim walls are thinnest. The interior measurements should be more precise as less thinning is required.

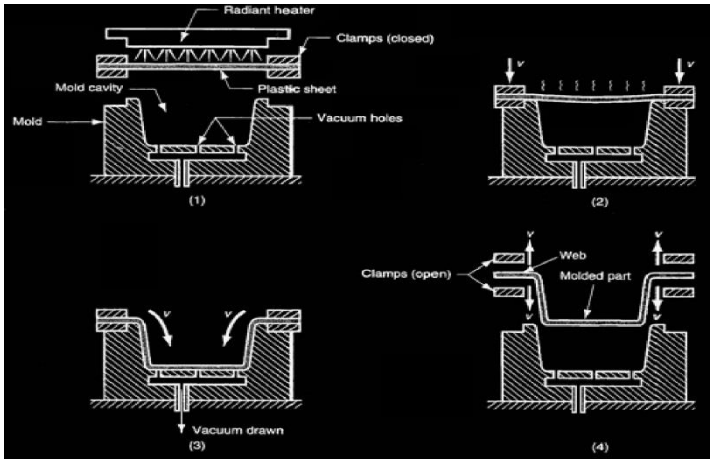
Female molds are convex forming devices with glossy interior finishing. Plain sheets may be used to texture these parts. They have thick rim walls but very thin base. Unlike male molds, it is possible for female molds to have a closer proximity in terms of the spacing between one mold and another. Female molds produce mostly food trays that are used in bakeries. They are preferably used to produce drinking cups, cookie trays and single plastic boxes for cakes. It is used widely than male molds.



F) Types of forming

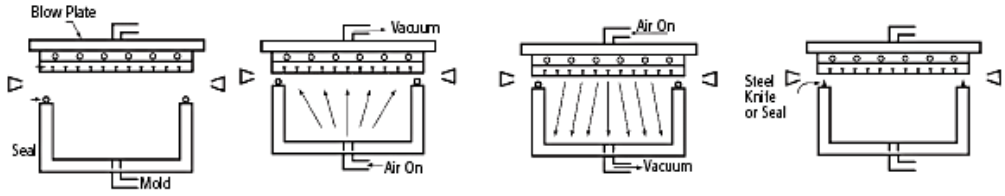
There are many ways for plastics to form. The ones that are mostly used for industries and factories are vacuum forming, pressure forming and mechanical forming. Vacuum Forming is the most common method of thermoforming to make most plastic products. It is the process whereby a plastic sheet is heated to the right temperature and applying vacuum between the mold surface and the sheet that has already been stretched onto and held against a single surface mold.

Vacuum Forming



Trapped-Sheet Contact-Heat Pressure Forming

Figure 19: Trapped-Sheet Contact-Heat Pressure Forming



A. A flat, porous plate allows air to be blown through its face.

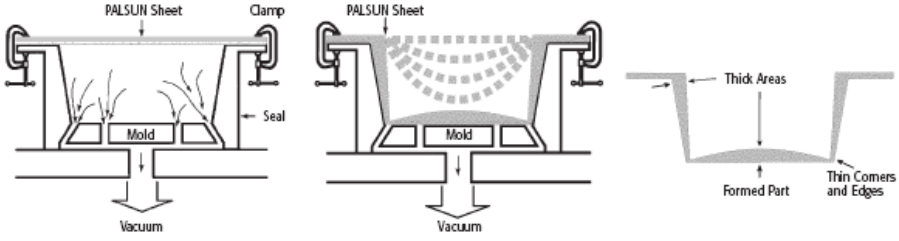
B. Air pressure from below and a vacuum above force the sheet tightly against the heated plate.

C. Air is blown through the plate to force the PLSUN into the mold cavity.

D. After forming, additional pressure may be exerted. Steel knife can be used for seal and subsequent trim if additional pressure is exerted at this stage.

Straight Vacuum Forming

Figure 17: Straight Vacuum Forming



A. A clamped, heated sheet is forced down into the mold by air pressure after a vacuum is drawn in the mold.

B. Plastic sheet cools as it contacts the mold.

C. Areas of the sheet that touch the mold last are the thinnest.

G) Recycling

Why recycle?

Recycling helps to reduce the cost of material. For example, unused material is of no cost as the customer has already paid for the material. Thus the next time the customer wants the product, there is leftover materials to be used. Cost saving can be passed onto the customer, in addition, being environmentally friendly is required of the manufacturer.

How are plastic recycled?

Webs are broken up into smaller pieces or flakes of between 3mm to 8mm. It may be mixed with virgin materials or compounded into pallets before extruding them again into required width and thicknesses.

Who are the parties involved?

It starts from anyone who generates scrap-in-house starting from the extrusion process, thermoforming and quality control.

All wastages should be reduced to the minimum and unutilized materials should be recycled into finished products again.

Recycling of Polystyrene and Polypropylene is a simple process. APET (Polyethylene terephthalate) needs to be recrystallized and moisture removed.

Polyvinyl Chloride needs to be compounded with stabilizers and the process is more complex than Polystyrene and Polypropylene.

H) Recycling Symbols

Polyethylene Terephthalate (PET, PETE)

PET is clear, tough and has good gas and moisture barrier properties. Commonly used in soft drink bottles and many injection molded consumer product containers. Other applications include strapping and both food and non-food containers. Cleaned, recycled PET flakes and pellets are in great demand for spinning fiber for carper yarns, producing fiberfill and geo-textiles. It is also known as Polyester.

Main use: Plastic soft drink, water, sports drink, beer, mouthwash, catsup and salad dressing bottles. Peanut butter, pickle, jelly and jam jars.

High Density Polyethylene (HDPE)

HDPE is used to make bottles for milk, juice, water and laundry products. Unpigmented bottles are translucent, have good barrier properties and stiffness, and are well suited to packaging products with a short shelf life such as milk. Because HDPE has good chemical resistance, it is used for packaging many household and industrial chemicals such as detergents and bleach. Pigmented HDPE bottles have better stress crack resistance than unpigmented HDPE bottles.

Main Use: Milk, water, juice, cosmetic, shampoo, dish and laundry detergent bottles; yogurt and margarine tubs; cereal box liners; grocery, trash and retail bags.

Vinyl (Polyvinyl Chloride or PVC)

In addition to its stable physical properties, PVC has excellent chemical resistance, good

weatherability, flow characteristics and stable electrical properties. The diverse slate of vinyl products can be broadly divided into rigid and flexible materials. Bottles and packaging sheet are major rigid markets, but it is also widely used in the construction market for applications such as pipes and fittings, siding, carpet backing and windows. Flexible vinyl are used in wire and cable insulation, film and sheet, floor coverings synthetic leather products, coatings, blood bags, medical tubing and many other applications.

Main Use: Clear food and non-food packaging, medical tubing, wire and cable insulation, film and sheet, construction products such as pipes, fittings, siding, floor tiles, carpet backing and window frames.

Low Density Polyethylene (LDPE)

Used predominately in film applications due to its toughness, flexibility and relative transparency, making it popular for use in applications where heat sealing is necessary. LDPE is also used to manufacture some flexible lids and bottles where it is used in wire and cable applicatins.

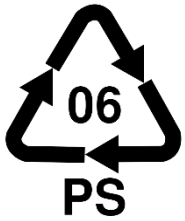
Main Use: Dry cleaning, bread and frozen food bags, squeezable bottles.

Polypropylene(PP)

Polypropylene has good chemical resistance, is strong, and has a high melting point making it good for hot-fill liquids. PP is found in flexible and rigid packaging for fibers and large molded parts containing automotive and consumer products.

Main Use: Catsup bottles, yogurt containers and margarine tubs and medicine bottles.

Polystyrene (PS)



Polystyrene is a versatile plastic that can be rigid or foamed. General purpose polystyrene is clear, hard and brittle. It has a relatively low melting point. Typical applications include protective packaging, containers, lids, cups, bottles and trays.

Main Use: Compact disc jackets, food service applications, grocery store meat trays, egg cartons, aspirin bottles, cups, plates, cutlery.

Other

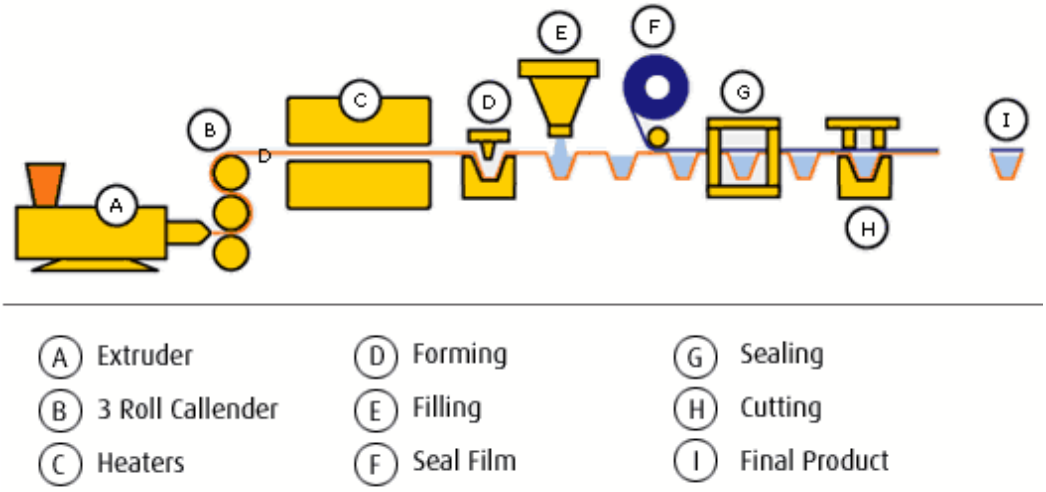
Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination. Includes polycarbonate.

Main Use: Three and five gallon reusable water bottles, some citrus juice and catsup bottles.

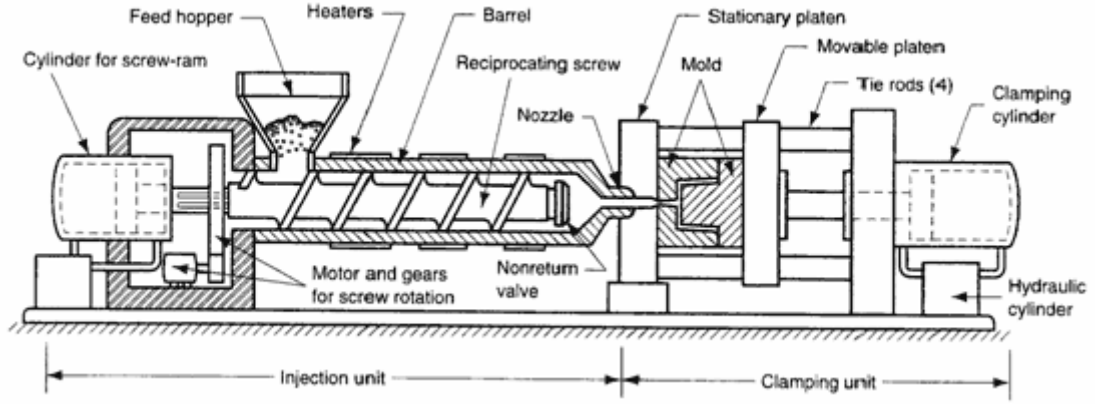
I) Thermoforming Extrusion Process

Thermoforming Extrusion Process. The extrusion thermoforming process is a well-established manufacturing process that is used to produce items with a predefined shape from a heated material. First the material is extruded to create a single sheet. Then it heats to a pliable temperature. After that it is formed to a specific shape in a mold. Finally the molded shape is trimmed to create the product.

Due to the capability of producing large thick sheets, one of the advantages of extrusion/thermoforming is the ability to produce extremely large parts on an economical basis. The cost to produce these same parts via injection moulding would be restricted due to moulds and injection moulding machine costs.



Link: http://plastics.sabic.eu/technical/_en/extrusionthermoforming.htm



Link: http://www.sunrisethermoforming.com/author/admin/page/7/

One of the premier thermoforming machine in the world, is MEAF machines. Its' inline production of a PP flat-rim cup can extrude up to 40,000 cups per hour and the process can be viewed in the link below.

Link: http://www.youtube.com/watch?v=FLIUpfgHAHU&list=UUilxJx4MnOltpspgUkjzvVw

J) Specialties & New Developments

Additives are used to modify the propeties of the resins to fulfill specific requirements.

UV absorbers can protect plastic materials from degradation under sunlight

Antistatic agents provide protection against accumulation of static charges, as plastic materials are nonconductive agents in nature.

Conductive blacks compounded into the resins will give insulative plastics the ability to conduct electrical charges and protect sensitive components such as microchips.

Anti-fogging agents help to prevent moisture droplets from accumulating on the surface. Silicone coatings help in denesting of finished products.

Why Compounding?

Compounds, which incorporate fillers and other additives, are increasingly common due to rising raw material costs.

Fillers include, wood-flour, minerals such as talcum and calcium carbonate, reinforcing glass fibred are also used for special applications. Plastics well compounded can help to achieve cost reduction, improve physical, chemical and even fire retardancy.

Why biological plastics?

They are increasingly popular for customers who are environmentally conscious. Biological plastics that will decompose under suitable conditions are being specified. Currently, high costs prohibited the widespread use of such materials. As technology advances, prices are expected to go down to a level that improves widespread use.

K) Economics

It is important that the price of products must be sufficient enough to cover the cost of production. Ideally, prices should be higher than the cost of production for the company to be profitable.

In thermoforming, cost of production fall into 2 main categories:

Raw material cost- amount spent on raw materials such as plastic sheets, resins,fillers and colorants.

Processing cost- Difficult to ascertain as compared to raw material cost as they include incident costs such as energy consumption, packaging, transport, labour and financial charges.

10 ways to make a profit from the thermoforming of plastic sheets.

1)Good Customers. One would need enough customers to support the business. The customer base is built up over time, with consistent aggressive marketing efforts focused on targeted demands.

2)Lower the raw material cost. As material cost accounts for up to 40% or 60% of the selling price, cost control or lack thereof, can make or break the enterprise.

3)Keep overheads low. Rental and labor costs are 2 examples of overheads. Efficient usage of labor is key.

4)Automate your processes. Reducing manual processes translates into lower labor costs. Mechanisation in the long run will increase profits.

5)Maximise equipment utilisation. Run the machines as long as possible and increases the number of moulds in a sheet. These are some ways to ramp up production of thermoformed items.

6)Recycle in-house. Webs and rejects and scrap can be recycled several times. Added to new materials, quality extruded sheets and films may still be produced.

7)Tighten quality control. Decrease in rejects results in lower costs, which correspond to high profit. Replace knives when it become blunt promptly as it can reduce rejects.

8)Reduce wastage. Unneccessary expenses are to be avoided. Tailor the moulds to fit more products so as to maximize the usage of it. Control over the checkbooks is extremely important.

9)Pricing. Price to make profits from the products. Costs incurred, competition and customer acceptance are factors determining pricing.

10)Focus on creativity and innovation. New ideas, designs and applications will widen the customer base, increase cstomer satisfaction and reduce the competition.

L) Production Orders

These are written orders issued by the production manager for goods to be produced by the factory. The quantity of items is usually based on customers' orders. The goods can then be stored as stock to be sold at a later date.

Production orders includes 3 parts:

1. Date

2. Product code

3. Bill of Material- quantity of materials

After completion, the operator needs to provide feedback on the order form to report actual output and raw materials used.

Your Logo Here	Form No. FZ/001 Rev. No: 00 Effective Date: 00/00/0000

PRODUCTION ORDER

Country / Institution: Proforma Invoice / Order No: Date:

Order Received Date: Delivery Date:

Marking / Special Packing (if any):

		Commercial		Bonus		Physician Sample		
S. No.	Product Name	Pack Size	Qty	Pack Size	Qty	Pack Size	Qty	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Special Instruction For Export:

S. No.	Contents	Remarks
	For Export	Commercial pack of each product should be sent to Lahore for approval before packing.
1	Product Reg. #	Required or Not
2	Distributor Name	Required
3	Packing List	Required
4	COA	Manually Signed
5	Form 7	Manually Signed
6	NOC	From ADC Peshawar

Plant Manager: _____ Date: _____

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