# Ecodesign in food packaging

## UNIT 8: Plastics in food packaging

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# Content unit 7, Ecodesign in food packaging





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# After learning this unit, the student will be able to:

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- Objective 1: To know the main types of plastics used in food packaging;
- Objective 2: To learn the importance and possibilities of recycling, reuse of plastic waste;
- Objective 3: To know basics of technologies for obtaining plastic packaging;
- Objective 4: To be able to use the design knowledge of plastic packaging in the current activity of Ecodesign.



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# 8.1 Definitions, classification, plastics used in packaging food

- Plastic is a synthetic material made from a wide range of organic polymers, such as, polyethylene, PVC, nylon, etc., which can be molded into various shapes and then fixed in a form that is rigid or elastic.
- Plastics are widely used for packaging materials and in the construction of equipment and installations, food processing, because:
  - they are flexible and can mold under certain conditions, for the manufacture of the sheets, different forms and structures
  - they are generally chemically inert, though not necessarily impermeable
  - they are cost effective and meet the needs of the market,
  - are lightweight
  - provides options in terms of transparency, color, thermal insulation, resistance to heat and barrier properties.
- There are two large categories of plastics: thermoplastic (can be melted and formed several times) and heat-resistant (thermo-insulating) (they remain in solid state and can not be poured again)
- **Advantages thermal insulation** (thermoset): a) more resistant to high temperatures than termoplastele, b) the design extremely flexible, c) can achieve thick walls or thin walls, d) excellent aesthetic appearance, e) high levels of dimensional stability, f) lower cost compared to termoplaste.
- **Thermal Insulating Disadvantages**: Can not be recycled, more difficult to finish, can not be poured again or remodel.



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# 8.1 Definitions, classification, plastics used in packaging food II

- **Advantages termoplaste:** a) high recyclable, b) are aesthetically superior, c) high resistance to impact, d) capability of being poured again in different forms, e) chemical resistance, f) options on the surface, can be crystalline or rubbery, g) organic production
- **Disadvantages termoplaste:** generally more expensive than the heat-resistant, it can melt if heated by accident.
- The types of polymers used for food packaging features:

– Polyethylene - polyethylene (PE)
– Polypropylene
– polypropylene (PP)
– Polyesters - polyesters (PET, PEN, PC) (note: sometimes the PET's mark and PETE)
– Polyvinyl chloride - polyvinyl chloride (PVC)
– Polystyrene - polystyrene (PS)
– Ionomers - ionomers
– Ethylene Vinyl Acetate - the Acetate of ethylene-vinyl - ethylene vinyl acetate (EVA)
– Polyamides - polyamides (PA)

- *Policlorura de viniliden - polyvinylidene chloride (PVdC)*
- *Butadien stiren - styrene butadiene (SB)*
- *Acrilonitril Butadien Stiren - acrylonitrile butadiene styrene (ABS)*
- *Etilen vinil alcool - ethylene vinyl alcohol (EVOH)*
- *Polimetil pentan - polymethyl pentene (PMP sau TPX)*
- *Polimeri nitrilici de înaltă polimerizare - high nitrile polymers (HNP)*
- *Fluoropolimeri - fluoropolymers (PCTFE/PTFE)*
- *cellulose-based materials*
- *polyvinyl acetate (PVA).*

- In the EU, the EP accounts for 56% of the total plastics used,
- The rest are mostly PP, PET, PS (including expanded polystyrene EPS) and PVC.
- The other nominated plastics are used to improve barrier properties, heat sealing, adhesion, or heat resistance.


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– **Polietilena (**Polyethylene – PE):

Sealing by hot soldering, PE films show a good barrier to moisture and water vapor, but not to O2, CO2 and other gases, yet the barrier properties increase with the density of the material. It has a melting point of 120 ° C, which also increases with density.Tipuri de polietilenă folosită:

- LDPE - Low density PE (LDPE), generally manufactured in 30 µm films, LLDPE - linear LDPE (linear low density PE film), has a shorter polymer chain and has superior tear strength properties and impact and hot soldering.
- MDPE or medium density PE film. LDPE can be co-extruded with MDPE to combine good tightness of LDPE with MDPE resistance, e.g., for extrusion coating of envelopes for dehydrated soup blends.
- HDPE or PE high density is the most resistant PE polymer and can be extruded into thin films. This film is used for "boil-in-the-bag" applications. HDPE can be co-extruded with LDPE to improve sealing. HDPE is injection molded for closures, boxes, pallets, and can be rotated for intermediate volume containers. A major application of HDPEs is the blow molded milk containers with a capacity of 0.5-3 liters.

– **Polipropilena (**Polypropylene -PP).

The polymer is a harder and denser resin than PE and more transparent in its natural form. PP has the smallest density and the highest melting point (160 ° C) and has a relatively low cost. It does not stand below 0 ° C. OPP or BOPP (Oriented PP film), on the other hand, is suitable for use in freezing storage. Acrylic-coated OPP has good performance, including hot sealing. Acrylic coating also provides a good barrier to odors. An improved barrier for gas and water vapor is obtained by coating with PVdC.



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# 8.1 Definitions, classification, plastics used in food packaging IV

- **Polyesters:**

- PET (PETE) results from the polymerization of terephthalic acid with ethylene glycol alcohol. It may be: blown, molded, foamed, extruded on cardboard or extruded into thermoforming sheets, it may be biaxially oriented. The film thickness is between 12 µm, up to 200 µm in laminated composite films. PET additives do not use additives.
- PET has a higher resistance than other polymers, and by fiber orientation it has high breaking strength. It has several radicals that bind to other chemicals, giving the surface more reactivity with the inks.
- PET melts at high temperatures of 260 ° C and does not contract below 180 ° C. This makes PET good for use in high temperature applications such as steam sterilization, boil-in-the-bag and for baking or reheating in the microwave or conventional oven. The film is flexible up to -100 0C.
- It is an average barrier for O2, but aluminum foil metallisation has high barrier properties for O2 and water vapor and is thus used in vacuum coffee bags and laminated on both sides with EVA is used in liquid bags with high sealing properties. PET extruded carton is used in the manufacture of food heating trays. PET is used in the manufacture of bottles for all carbonated beverages and mineral waters.

- **Polyvinyl chloride (PVC) -** A thermoplastic material composed of polyvinyl chloride polymers. PVC is a colorless solid with a high resistance to water, alcohols, as well as concentrated acids and alkali. The polymer is usually delivered in powder form, unstabilized. Finished finished products are hot, causing degradation of the unstabilized polymer - release of chlorine, HCl, color change etc. - as a result necessarily requires the addition of stabilizing agents. Various other additives are also added to the formulation, such as plasticizers, lubricants, dyes, s.a. fillers, which allows for a wide variety of products with multiple properties.



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**Polystyrene (PS)**

Polystyrene is a polymeric, slightly transparent, amorphous or partially crystalline material, heat-treated. It is made of styrene (monomer stirol), a simpler liquid hydrocarbon made from petroleum. It is a thermal and electric insulator.

- PS has many packaging uses and can be extruded as a monolayer or co-extruded plastic film as thermoformable, injection molded and foamed foil to provide a range of packaging types.
- It is also co-polymerized to expand its properties. It has good transparency. It is stiff, with a characteristic curl, suggesting freshness.
- A white pigmented film is used for the labels. The movie is printable.
- It has low barrier properties for water vapor and common gas, is suitable for packaging fresh products that need to breathe.

- The main disadvantage is that PS gives rise to a rigid or semi-rigid and fragile container. Therefore, it can be mixed with a butadiene styrene copolymer, SB or SBC. The mixture is known as high impact polystyrene or HIPS. Mixing produces a tougher material. It is translucent and is often used in pigmented white form.
- HIPS is used in the extrusion of multilayer films with a variety of other polymers, PE, PP, PET, PVdC and EVOH. Food products packaged with these materials include dairy products such as yogurt cream and desserts, UHT milk, cheese, butter, margarine, jam, fruit compote, fresh meat, pasta, salads etc. Many of these products are aseptically packed .

Additives: Plastic products would be a commercial failure without additives. These are organic or inorganic chemicals that allow the processing of plastics, the shaping of their use and the enhancement of their end-use performance. The plastic composition may range from 0.05% to 20% by weight of additives. About 75% of all additives are used in PVC.



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# 8.2 Recycling of plastics

## 8.2.1 Importance of recycling

- Plastics are used today very commonly, but they have a long lifetime of over 500 years of environmental resistance without decomposing. That's why recycling and recovery of these materials at the end of their product life has become an essential factor required by the EU.
- EU legislation now permits the use of recyclable plastics in new packaging for food. Recycling a ton of plastic bottles saves 1.5 tons of carbon and a plastic bottle saves enough energy for a 60 watt bulb for 6 hours. (Plastics packaging / www.bpf.co.uk).
- The use of mono-materials or mixed materials of the same type are the materials suitable for the recycler
- Combinations of different types of plastic with similar densities should be avoided whenever possible.
- PET is harder than water and will sink. In the PET washing process, caps or labels made from polypropylene (PP) or high density polyethylene (HDPE) will float and can be easily removed.
- Fillers modifying plastic density should be avoided and / or their use minimized as they reduce the quality of the recycled material.
- PET contamination with low levels of PVC (50-200 ppm) with close densities being heavier than water, causes a significant deterioration in chemical and physical properties. For this reason, the use of PVC components of any kind in the manufacture of PET containers should be scrupulously avoided.



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# 8.2.1 Importance of recycling II

- The use of PLA (a biodegradable material) with PET should be avoided. The two polymers are incompatible and can not be easily separated (both have a density> 1 g / cm 3). The presence of very low levels of PLA in PET causes container opacity and a deterioration of the physical properties of recycled PET. In addition, PLA causes processing problems in the dryer because it melts at the drying temperature.

**Specific gravity of various plastics**

| Plastics | Specific gravity |
|---|---|
| LDPE | 0.91~0.93 |
| HDPE | 0.94~0.97 |
| PP | 0.90~0.91 |
| PS | 1.04~1.07 |
| PVC | 1.35~1.45 |
| ABS | 0.99~1.10 |
| Polyester | 1.38~1.39 |
| PC | 1.2 |
| Nylon 66 | 1.13~1.15 |
| Teflon | 2.1~2.2 |

Source: "Polymer dictionary" by Taiseisha Co., Ltd (1970)

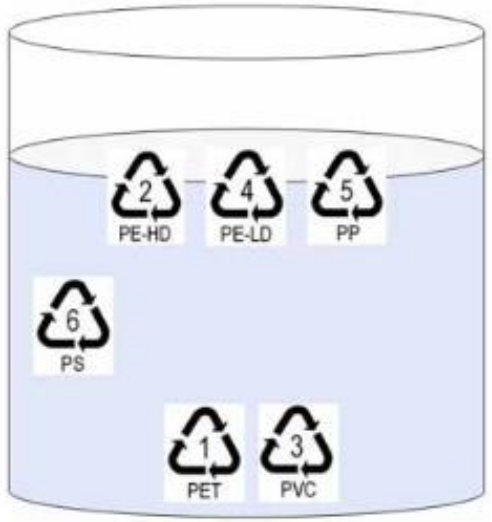


Fig. 1. Densities of polymers used in packaging

## 8.2.2 SPI plastic identification system.

In order to facilitate the correct sorting of bottles and plastic containers for recycling, the SPI (The Society of Plastics Industry) in 1988 created the SPI Resin Identification Symbol System ), also known as the coding system for plastic container material. The symbol must be visible and preferably poured on the surface of the container or, in the case of films, repeatedly printed on the material. Identifiers generally have to be graded at the base of the container. Exceptionally, the identifier can be located near the base or printed on the label.



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# 8.2.2 SPI plastic identification system. II

| Symbol SPI | Characterization E | Recycling |
|---|---|---|
| PET/PETE  | PLASTIC # 1 - POLYETHYLENE TEREPHALATE (PETE or PET). Containers made of this plastic sometimes absorb smells and flavors from foods and beverages that are stored in them. They are used for: soft drinks, water and other beverage bottles, peanut butter and other containers for detergents and cleaning containers, etc. | PET waste is recycled into: new bottles, polyester for fabrics and carpets, car bumper filler and sleeping bag and jacket fibers. |
| HDPE  | PLASTIC # 2 - HIGH DENSITY POLYETHYLENE - HDPE POLYETHYLENE. HDPE products are very safe and there are no known cases of transmission of chemicals in food or beverages. They are used for: milk and water containers, some plastic bags, etc. | Transparent HDPE containers are easy to recycle in new containers. Colored HDPE waste is converted into plastic lumber, garden curbs and lawns, pipes, ropes, and toys. |
| I  | PLASTIC # 3 - POLYVINYL CHLORIDE - PVC OR V) The monomer content of vinyl chloride by which PVC is polymerized is recognized as a carcinogen and has been drastically limited, besides other dangerous chemicals are commonly used as PVC additives, which are not chemically bound, and can therefore infiltrate during use and disposal as waste. This type of plastic should not come into contact with food. It is used as a wrapping film due to tensile strength. In food packaging this material tends to be replaced. | Recycling is not technically and financially feasible. Thermal recycling can not be done due to the particularly dangerous noxes emitted by PVC heating. Pressure recycling is used. Currently, only 3% is recycled, old PVC products requiring mixing with virgin material to recreate quality material. Most of the collected waste is used for inferior quality products such as park benches or road noise barriers. |



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# 8.2.2 SPI plastic identification system. II

| | | |
|---|---|---|
| **LDPE**  | PLASTC # 4 - Low-Density Polyethylene-LDPE Polyethylene. It is a very healthy plastic that is both durable and flexible. Stretch-wrapped food packaging films, sandwich bags, frozen foods, pressure bottles, and plastic food bags are made from LDPE. | LDPE is not normally recycled but is recyclable in certain areas. Recycled LDPE is used to make garbage cans, timber, furniture, etc. |
| PP  | PLASTIC # 5 - POLYPROPYLENE (POLYPROPYLENE - PP). This type of plastic is strong and can usually withstand higher temperatures. Among many other products, packing films, margarine containers, yogurt boxes, syrup bottles, caps and yarns are used to obtain bags for packaging vegetables and cereals etc. Shows good gloss and clarity, being an ideal print material. | PP has difficulty in recycling. Thus, obtaining different materials on the type or quality is difficult to achieve. Recycled PP is used to make ice scrapers, rakes, battery cables, etc. |
| PS  | PLASTIC # 6 - POLYSTYRENE (PS POLYSTYRENE). Styrofoam. Two shapes are used: Rigid polystyrene for cutlery; Polystyrene formed (Styrofoam) used in food containers, packaging, insulations, egg cartons, disposable glasses, plastic food cans, packing foam and peanut packaging. | Although its theoretical recycling is possible, it is still not economical. PS Recycle is used to make insulations, license plate frames, rulers, etc. |
|  | OTHER (OTHER). The SPI code 7 is used to designate different types of plastic that are not defined by the other six codes. Polycarbonate and Polylactic Acid (PLA) are included in this category. Polycarbonate or PC is used for baby bottles, large bottles of water, compact discs and medical storage containers. Polylactic acid is a thermoplastic aliphatic polyester produced from renewable resources, such as corn starch (in the United States) or sugar cane in the rest of the world. | These types of plastics are difficult to recycle. PLA, is biodegradable in the presence of oxygen, and is difficult to recycle. Recycled materials in this category are used, among other products, for the manufacture of plastic lumber. |



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# 8.2.2 SPI plastic identification system. III

Some publications provide useful guidance on the safety of the use of plastics. (Http://modernsurvivalblog.com/preps/safe-plastics-for-food-and-drink). So:

# 1 PETE (Typical polyethylene terephthalate) Typical water bottles, soda and juice not intended for re-use or storage due to the possibility of bacterial build-up, if you reuse them, make sure that you have cleaned them properly.

Generally, plastics considered safe for food and drink are:

- # 2 HDPE (high density polyethylene) food grade;
- # 4 LDPE (Low Density Polyethylene);
- # 5 PP (polypropylene).

Materials considered dangerous are not safe for food and drink. They may infiltrate or contain hazardous ingredients:

# 3 PVC (polyvinyl chloride) carcinogen during manufacture and incineration;

# 6 PS (polystyrene) possibly carcinogenic;

# 7 Other (usually polycarbonate, sometimes labeled, PC can infiltrate BPA (Bisfenol-A), a synthetic organic compound used in the manufacture of plastics, has hormone-like properties and is not suitable for use in food packaging.



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# 8.3 Packaging technologies in plastic.

The main technologies for obtaining polymer packaging are:
- extrusion
- injection
- compression

## 8.3.1 Extrusion

The first important step in converting plastic resins into films, sheets, containers, etc. is to transfer the solid phase polymer granules to the liquid or melt phase in an extruder.
Plastic is melted by a combination of high pressure, friction and external heat applied. This is done by pressing the granules along the cylinder of an extruder using specially designed screws of polymers under controlled conditions that ensure the production of a homogeneous melt prior to extrusion.
The molten plastic is finally pressed through a molding of the finished product to the technological lines of use.

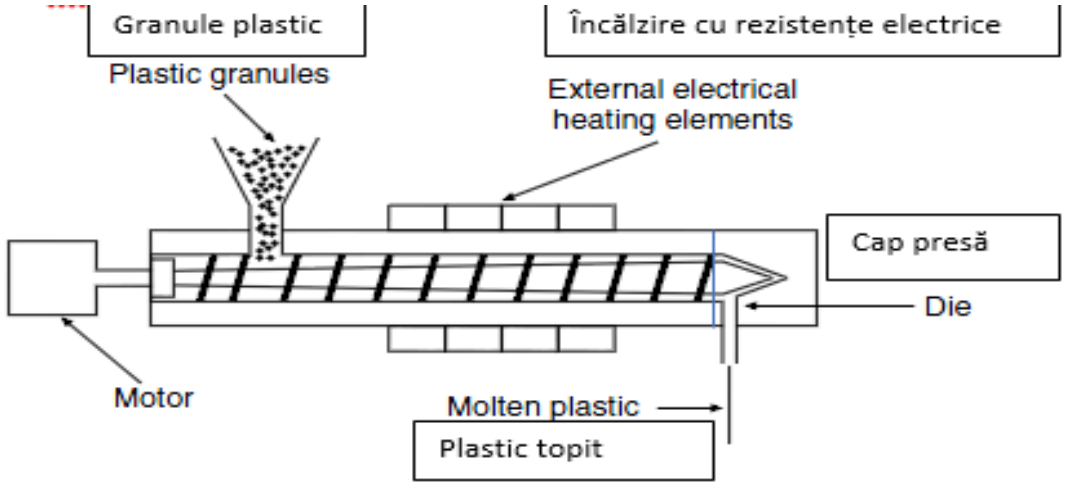


Fig 2 Extruder
Usage: - obtaining films, films, plates and tubes.
RICHARD COLES, DEREK MCDOWELL, MARK J. KIRWAN FOOD PACKAGING TECHNOLOGY, Blackwell Publishing Ltd, 2003


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# 8.3.1 Extrusion II

❑ **Film extrusion:**

- are obtained by extrusion with a wide nozzle spinning head;
- the polymer is extruded at as high temperatures as possible to minimize the viscosity of the melt;
- Cooling is carried out with air, by direct immersion in water, on cooled inner cylinders or combinations of these variants.
- sheet thickness - up to 0.1 mm
- **Easing**: Performing at the transition temperature to the glassy state of the polymer by stretching the polymer with a value of 200-600% relative to the initial size increasing the tensile strength and decreasing the elongation at break of the foil with thinning. Two longitudinal and transverse axes can be erected.
- **Etiated film** (also called thermo-shrinkable), when heated, releases internal tensions and tightens over the packed object.

❑ **Plate extrusion:** Used for plates of different thicknesses up to 0.2 mm, using different polymers such as PS, PP, PE, etc.

❑ **Co-extrusion of foils and plates**: Consists in using a suitable number of extrusions to feed different plastics, by means of a combining device or a feeding unit, to a common nozzle, multilayer structures of different materials with properties different. Multilayer films or sheets of 2-9 layers with a minimum thickness of 30-120 µm can be obtained. Polymers: PET, HDPE, LDPE, PS, etc.

❑ **Coating and extrusion lamination**: used to: • protect against moisture, • barrier to water vapor, oxygen, aroma, etc. • grease resistance • hot sealing • attraction for sale eg making glossy surfaces .



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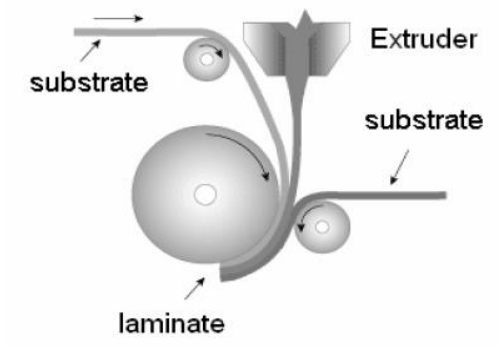


Fig.3 Coating and lamination by extrusion, according to Rory Wolf, A technology decision – Adhesive lamination or Extrusion Coating/Lamination

- The use of cardboard treated by extrusion and lamination offers remarkable promotional benefits in terms of the visual appeal of consumers.
- Carton wrapped on a roll passes in front of a pre-treatment device surface, corona discharge type at low temperature to secure the printing inks, coatings and adhesives, and then is coated with a molded polymer, PE, PP or PET, with a controlled quantity and temperature, providing resistance to grease and moisture and, where appropriate, resistance to the heat.

❑ **Extrusion of blown films and films**

- It is the most used method. Through it, high-quality films and films are made. In principle, the method consists in obtaining a tube with thin walls (from a few microns to tenths of a millimeter) which is dilated by an overpressure of air.

- It is applicable to polymers HDPE, LDPE, PP, MDPE (medium density polyethylene: 0.926 - 0.940 g / cm3). The expansion of the foil also results in its cross-sectioning, and pulling on the winding roll produces a longitudinal eyepiece. It is also used co-extrusion of blown films of two polymers eg polyethylene – polyamide, polyethylene – polystyrene.

❑ **Extrusion-blowing cave bodies**

It is used for the manufacture of cylinders (bottles, bottles) and other types of cave bodies (hollow inside).
Polymers used: polyolefins (PE, PP), plasticized PVC, PET, PS, ABS, Nylon (PA), etc.
Extrusion forms a tube in a mold corresponding to the manufactured cavity. Inside the tube, compressed air is blown, and the polymer tube in the
the visco-plastic state is dilated to the walls of the mold in contact with which it is cooled



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## 8.3.2 Thermoforming

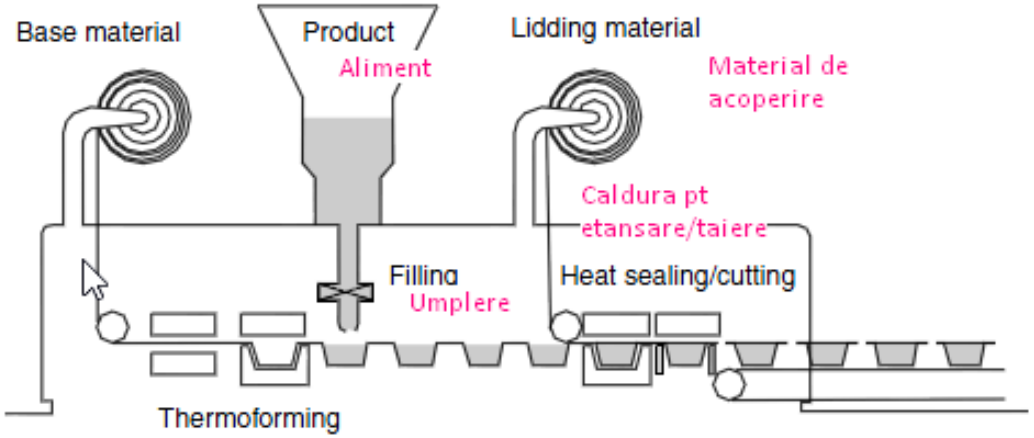


Fig. 4. Line Thermoforming, filling, closing
RICHARD COLES, DEREK MCDOWELL, MARK J. KIRWAN FOOD PACKAGING TECHNOLOGY, Blackwell Publishing Ltd, 2003

The lower foil is fed from a bobbin and heated prior to molding or molding, then the foil is molded by various processes. The cavity thus formed is filled with the food in an open atmosphere or vacuum, after which the upper foil is used for closing, which due to heat and pressure is welded to the airtight lower foil. Cutting devices are used to divide finished products. It follows product labeling and evacuation.

## 8.3.3 Injection formation

The principle of the method is to inject the molten polymer into a cold mold at a high pressure.

## 8.3.4 Compression trening

Method Principle: The molten polymer is pressed into the die



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# 8.4 Design of plastic packaging for recycling.

Here are some concepts of Ecodesign:

- Use compatible plastics.
- Use different density materials.
- Cover with max. 2/3 of the surface of the packaging. In automatic installations an optical separation system classifies plastic packaging. If 67% or more of your packaging is covered, it will be classified based on the label material. If the design of the packaging does not allow you to follow this suggestion, then:
  - Use a label made of the same material as the packaging.
  - Use a label with a different density than the packaging.

a) The black and dark colors interfere with the automatic packaging classification and absorb the light emitted by the optical separation system. Uncolored or opaque packaging after recycling has more applications than colored ones.

b) Ink components used to color the packaging or print it to contaminate the recycled material, so printing inks that are not covered by the EUPIA (European Printing Ink Association) exclusion list must be used.

c) Non-soluble adhesives can contaminate recycled materials with contaminants and will not be disposed of in the washing process, so it is advisable to use soluble hot water or alkaline-soluble high temperature adhesives.

d) Silicon can adhere to recycled material, so if possible, it should be discarded.



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# Thank you!



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