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PACKAGING MATERIAL AND MANUFACTURING

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MECHANICAL ENGINEERING DEPARTMENT

PACKAGING MATERIAL AND MANUFACTURING

FIRST EDITION

PACKAGING MATERIAL AND MANUFACTURING

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AUTHOR'S NOTE

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NUR FARAHAIZAN BINTI IDRIS

OVERVIEW

SYNOPSIS

PACKAGING MATERIAL & MANUFACTURING (DJP40043) is a course which is a compulsory subject to complete Mechanical Packaging Diploma in Polytechnic. In this course basic use in packaging material including paper, plastic, metal and glass as well as covers the conversion process in packaging industry.

In first phase of developing the e book, it only cover two topics which are Paper and the Conversion Process and Plastic and the Conversion process. Topic of **Paper and the Conversion Process** will explain about characteristic of paper, fibre source selection, type of paper and paper properties. It also explain about the machine involve in paper making process.

Topic two which is **Plastic and the Conversion process** will discuss about plastic material and cover the conversion process of injection moulding, blow moulding, extrusion moulding and thermoforming.

In the end of the topic students will be able to :-

- Apply the properties, physical characteristics and conversion process of plastic in packaging.
- Study awareness of all learning activities undertake throughout life in the aim of improving knowledge skill and competency.

Plastic Manufacturing Process For Packaging Material

2.4

1.1 Apply Paper And Paperboard In Packaging

1.2 Apply The Principle Operation Of Papermaking Process

1.3 Explain The Manufacture Of Paper And Paperboard

1.4 Apply Corrugated Board In Packaging

1.1 APPLY PAPER AND PAPERBOARD IN PACKAGING

PAPER is very important in our daily life and have been used for many years from now. Papers are made with the pulp of the woods, which is an Eco-friendly product.

Paper is a matted or felted sheet usually composed of plant fibres and has been commercially made from such fibre sources as rags (linen), bagasse (sugar cane), cotton and straw

Modern paper is almost exclusively made from "cellulose fibres" derived from wood.

Source: https://unsplash.com/s/photos/paper-colourfull

PAPERBOAD is a thick paper, printed with brand-enhancing graphics, and cut/folded into unique structures to engages. Paperboard is a durable, recyclable and environmental friendly material.

PAPER is a versatile material that used for printing, packaging, decorating, writing, cleaning, filter paper, wallpaper, book endpaper, conservation paper, laminated worktops, toilet tissue, and for industrial and construction processes.

Source: https://unsplash.com/s/photos/paper-colourfull

TERMINOLOGY OF PAPER AND PAPERBOARD.

ISO (International Standards Organisation)

- Paperboard =
  Paper with a basis weight > 250 g/m2

General U.S. practice

- Paperboard
  Paper with thickness > 300 µm

1.1 APPLY PAPER AND PAPERBOARD IN PACKAGING

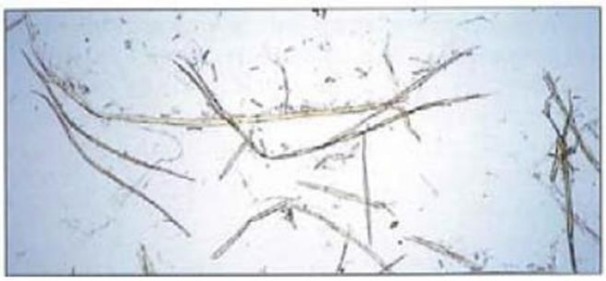
FIBRE is the main source of making paper. Different types of fibres can be used for producing paper and the most well-known is the wood fibre. Wood fibre are usually cellulosic elements that are extracted from trees. Each fibre have their on characteristic in determining paper properties. Fibre are described in two categories which are long fibre and short fibre.

Long Fibre are normally proportionately higher in:

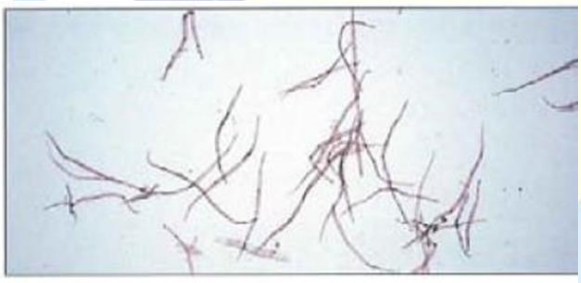
- Tensile strength
- Tear strength
- Fold strength
- Puncture strength
- A rougher surface texture

Short Fibre are normally proportionately higher in:

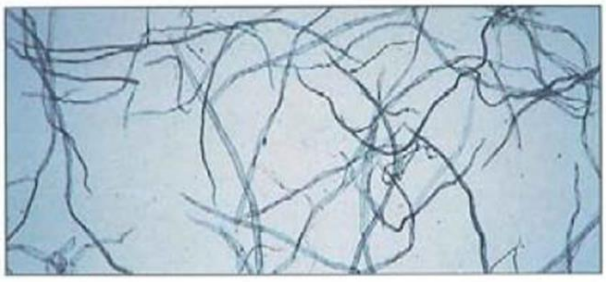
- Tensile strength
- Tear strength
- Fold strength
- Puncture strength
- A rougher surface texture



Spruce fibre-Long and flat



Birch fibre – short and cylindrical



Pine fibre – Long and flat

Mixed Fibres of spruce, pine and birch

Type of Fibre

Source:
https://iforest.sisef.org/contents/?id=ifor3230-013

1.1.2 PROPERTIES OF PAPER AND PAPERBOARD

The properties of paper and paperboard depend on included:

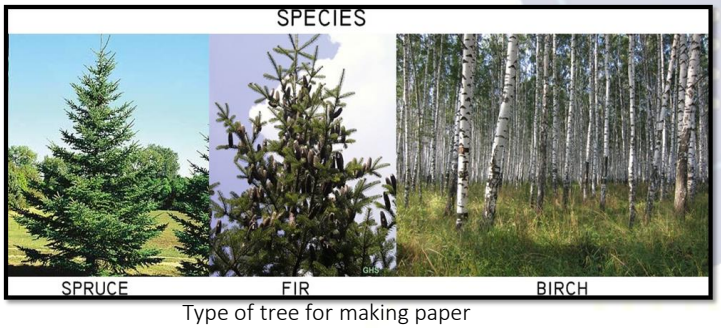
- Type and source of fibre.
- Mechanism of fibre extracted from the source.
- Amount of treatment, additives, bleaching and process aid of fibre during the pulping process.
- Process of converting the fibres into paper and paperboard.
- Number of plies used to make paper or paperboard sheet

Properties of paper and paperboard varies depending on the grade and specification used. The main properties to be considered in packaging applications are as follows:

- Stiffness
- Printing surface
- Absorbency
- Burst strength
- Tensile strength
- Tear resistance and compression strength
- grease resistance.

1.1.3 RAW MATERIALS OF MAKING PAPER AND PAPERBOARD

The main raw material used to make paper and paperboard is cellulose fibre sourced from trees and recycled waste.



Type of tree for making paper

Source:
http://www.pickyourownchristmastree.org/NYxmasli.php

The process of making paper and paperboard are by mixing fibres with additives to improve performance.

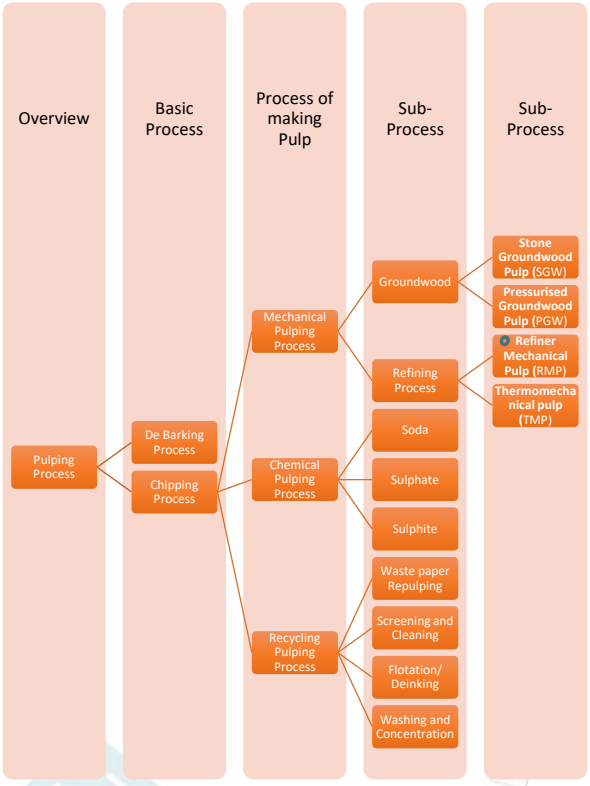
Length used in papermaking are:

- Short hardwood fibres: 1–1.5 mm in length
- Long softwood fibres: 3–4 mm in length

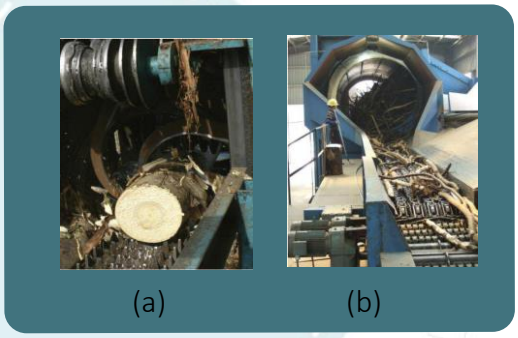
1.1.4 PAPER PULPING PROCESS

Timber is used for papermaking which comes from well managed forests whereby more trees are planted than harvested to ensure sustainable growth. Only parts of tree that have no value to other commercial industries is used for making paper.

Pulp is a lignocellulosic fibrous material prepared by mechanically or chemically to separate cellulose fibre from wood, fibre crops, waste paper, or rags. Pulp is the major raw material used in papermaking.



Paper Pulping Process



(a) (b)

a) De Barking Process
b) Chipping Machine Process

Source: *https://www.wbpionline.com/features/to-debark-or-not-to-debark-and-how-to-do-it/*

Source: *https://paper-pulper.com/how-paper-pulp-is-made/*

DE BARKING PROCESS

- In this process bark is stripped from the logs by using knife, drum, abrasion or hydraulic barker. Log also Can be press using grindstones which is why this process is also known as groundwood pulp.
- The stripped bark is then used for fuel or as soil enrichment.

CHIPPING MACHINE PROCESS

- Stripped logs are chipped into small pieces by knives mounted in massive steel wheels (used in chemical pulping process).
- The chips pass through vibrating screens, whereby both undersized chips, dust and oversized chips are rejected.
- Accepted chips are then stored in huge bins ready for the next process

1.1.4 (a)

MECHANICAL PULPING PROCESS

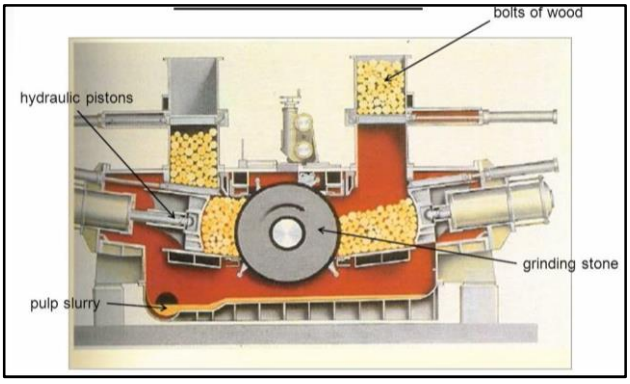
MECHANICAL PULPING PROCESS is a process where wood is separated or defibrated mechanically without involving any chemical into pulp. It divided into two main process which are:

- Groundwood
- Refining Process

GROUNDWOOD PROCESS is a process of mechanical pulping which not suitable for papers in high whiteness. It is only suitable for newspaper and other low cost printing papers. This process involved two process such as:

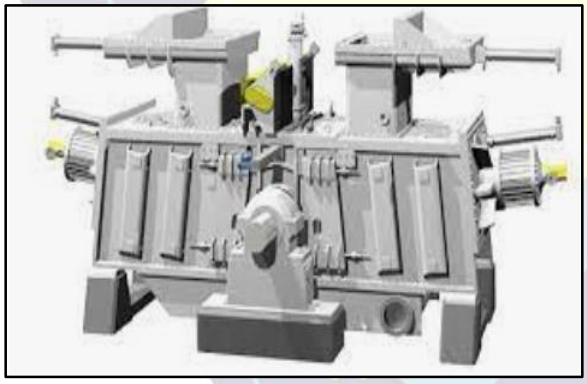
- Stone groundwood pulp
- Pressurised groundwood pulp.

STONE GROUNDWOOD PULP (SGW) is a process when log or wood is pressed by a rotating grinding stone. The grinder will grits the surface and penetrate into the surface of wood and separate the fibres by combination of compression, heat and shear.



Stone Groundwood Pulp (SGW)

Source: https://slideplayer.com/slide/9416588/



Pressurised Groundwood Pulp (PGW)

Source: https://www.valmet.com/pulp/mechanical- pulping /refining-and-grinding/pressure-groundwood-pgw/

PRESSURISED GROUNDWOOD PULP (PGW) is likely a same process as SGW but the grinding process is performed on a pressure steam chamber. This process is more efficient, cost effective and reduce energy consumption.

Trees contain up to 30% lignin, which is sensitive to light, degrades and turns brown when exposed to sunlight example newspaper. Mechanical pulp can also be bleached to increase the brightness, but retaining the lignin.

1.1.4 (b)

CHEMICAL PULPING PROCESS

CHEMICAL PULPING PROCESS

is a chemical process involves the extraction of cellulose from wood by dissolving the lignin that binds the cellulose fibre together. Lignin is a complex organic polymers that form key structural to support tissues of most plants. Lignin in paper pulp will reduces paper permanence and contributes to the yellowing of paper over time.

This process is divided into two process which are:

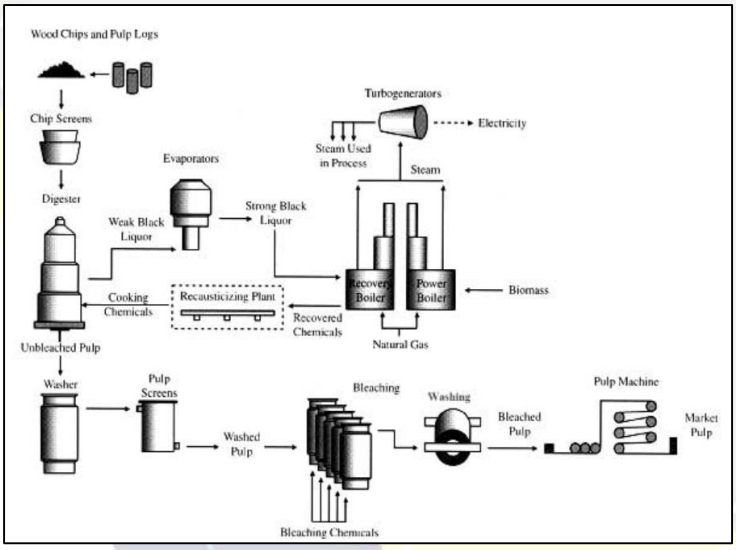
- The Soda Process
- The Sulphite Process
- The Sulphate process

THE SODA PROCESS

- The first commercial production of soda pulp was in 1851, and is used infrequently due to the superiority of newer processes.
- The soda process is useful for digesting softwood and hardwood chip by using caustic soda containing lye (NaOH), produced by adding sodium carbonate (Na2CO3) to lime (CaO).

Chemical pulping Machine

Source: http://www.paperpulpermachine.com/process/chemical-pulping-process.html



Chemical pulping Process

Source: http://www.paperpulpermachine.com/process/chemical-pulping-process.html

THE SULPHATE PROCESS

- The sulphate process is extension of traditional soda process by adding sodium sulphate (Na2SO4) to strengthen the pulp.
- The process is known as Kraft Process. In this process bleaching system is added to increase the brightness and decrease lignin.
- The term "Kraft" is used to refer to paper or paperboard made using unbleached pulp produced include brown wrapping paper, paper bags, envelopes

THE SULPHITE PROCESS

- The sulphite process is a process to produce sulphite pulp. It is a soft, flexible and moderate strength.
- In this process wood chip is cook in sulphurous acid combined with limestone to produced calcium bisulphite to resolved lignin.
- White and bleach paper is produced in this process such as book paper, tissue paper and others.

1.1.4 (c) RECYCLE PULPING PROCESS

RECYCLE PULPING PROCESS is a process of waste paper convert into new paper products. Three type of recycle paper can be used in this process are:

- Mill broke

Paper scrap from paper manufacturer and will be recycle in paper mill.

- Pre-consumer waste

Paper which left in the paper mill but was discarded before it was ready for consumer use.

- Post-consumer waste.

Paper that have been discarded after consumer use example old boxes, old magazines, and newspapers.

Waste Paper Recycling

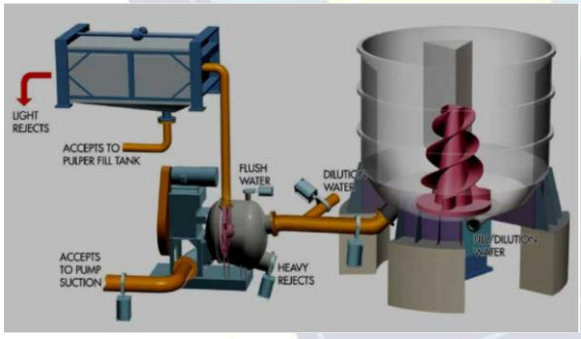
Source: http://www.paperpulpermachine.com/process/chemical-pulping-process.html

Recycle Pulping process is consists into three main Process such as:

- Waste Papar Repulping.
- Screening and Cleaning.
- Flotation.
- Washing and Concentration.

WASTE PAPAR REPULPING.

- Waste paper repulping include deflaking and defibering process.
- Deflaking Process is a process to breakup fibre bundle into single fibre and maintain the fibre strength.
- Defibering is the continuous process of deflaking where the single fiber is separated without any damage.
- The common paper pulper is hydra pulper. In this process waste paper is loaded into conveyor and passed into a circular tank containing water. Agitator at the bottom of the tank will breaks up the bales into small pieces.
- The pulp mass created begins to look like thick porridge.
- Unwanted contraries such as wire, plastic, paper clips is removed in hydra pulper tank.



Hydra pulper Tank

Source: http://www.paperpulpingmachine.com/applications/waste-paper-pulp-production-process/

SCREENING AND CLEANING

- Screening and cleaning process are used to treat and separate big-size impurities from the pulp.
- Then the pulp is forced through screens with holes of various shapes and sizes to remove small contaminants such as bits of plastic and glue.

1.1.4 (c) RECYCLE PULPING PROCESS

FLOTATION/ DEINKING

- Flotation is also known as deinking. It involve a process to remove ink or sticky material example glue or adhesive from paper fibre from the waste material.
- In this process involved a combination process of mechanical and chemical action. Pulp is being shredded and a chemical is added in this process.
- Small particles of ink are rinsed with water while large and sticky particle is removed by air bubbles. This process is known as flotation.
- In flotation process, paper pulp in the flotation cell is injected with chemicals call Surfactant.
- Surfactant will effect the ink and the sticky particles remove from the pulp and stick to the air bubbles that floating on the surface of the mixture.

Washing and Concentration Tank

Source: http://www.paperpulpingmachine.com/applications/waste-paper-pulp-production-process/

Paper Pulping Process

Source: http://www.pickyourownchristmastree.org/NYxmasli.php/

WASHING AND CONCENTRATION

- In this process chemical is added to removes dyes from the recycle paper. If white paper is produce, another process will be added call bleaching process.
- In bleaching process, hydrogen peroxide, chlorine dioxide and oxygen is added to make the paper whiter and more brighter.
- In the large stage of recycle paper is cleaning up the pulp. To give extra strength and smoothness to the recycle pulp, new virgin fibre will be added.
- Common washing equipment includes are vacuum drum washer, twin roll press, single screw press and disc filter.

Lets study about the paper pulping process process: https://www.youtube.com/watch?v=UwJGizHtWXo

1.2

APPLY THE PRINCIPLE OF PAPER MAKING PROCESS

PRINCLPE OF PAPER MAKING PROCESS

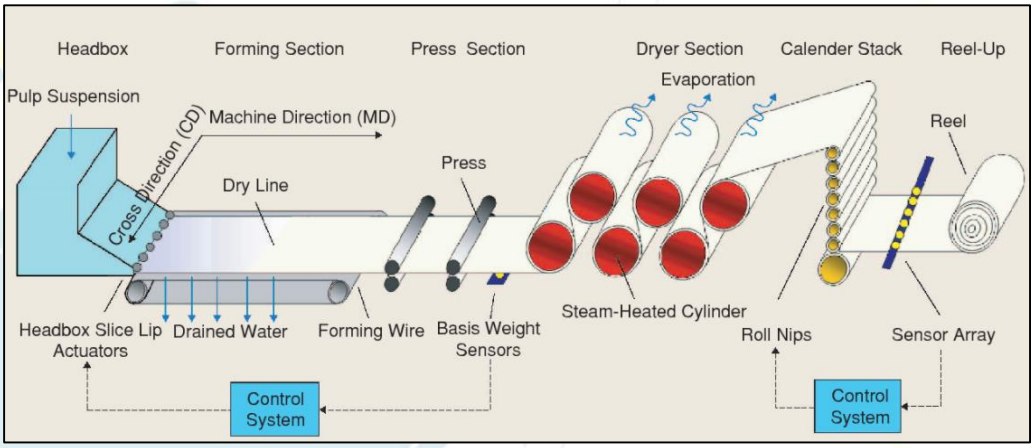
- Paper is a material use for n communication and gathering information. In addition, paper and paperboard provide a wide usage such as wrapping, packaging, insulating, and photography.
- Papermaking is a process which produced from pulp, water, filler, and chemicals. The aim in papermaking process is to produce paper with specified quality by minimizing costs. The process consists of several sub processes by preparing raw materials, mixed and diluted with water, the paper web is formed and water is removed.
- There are four type of paper making machines which are:
    i. Fourdrinier Machine
    ii. Cylinder Machine
    iii. Twin Wire Former
    iv. Press and Dry

i. FOURDRINIER MACHINE

- **Fourdrinier machine** is the most traditional paper-forming equipment.
- Mechanism of fourdrinier machine is by using a wide jet of dilute furnish from head box onto the surface on a continuously moving wire screen.
- Water then is removed by gravity with the help of hydrofoils or table-roll and vacuum boxes.
- A dandy roll (screen cylinder) also known as top-wire is been used to make the sheet more uniformly.

A Fourdrinier Machine
Source: ulpmakingmachine.com/paper-machine/Fourdrinier-Paper-Machine.html

Lets study about the paper making process (Foudrinier Machine: https://www.youtube.com/watch?v=tuR6JZCWu6E

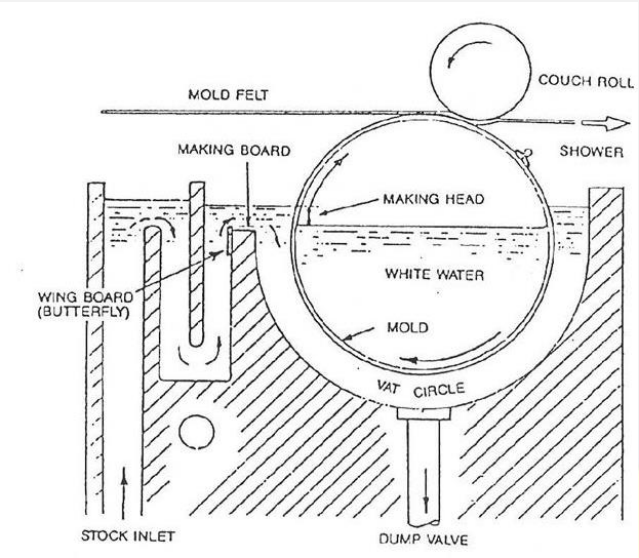


A Fourdrinier Machine Mechanism
Source: https://www.semanticscholar.org/paper/Model-based-control-in-the-pulp-and-paper-industry-Mercangoz-Doyle/2cb79a71965ca00c4cbea56b0f3ec92b93abe1d0/figure/3/

APPLY THE PRINCIPLE OF PAPER MAKING PROCESS

ii. CYLINDER MACHINE

- In 1802 John Dickinson from London has started experimented a paper making machine and has patented a continuous paper making machinery on June 1809 known as Cylinder Machine.
- Cylinder machine is a device that utilizing a rotating wire-belt-covered cylinder which producing paper, paperboard, and other fibreboards. It consists of one or more tubes of wire screen partially immersed and rotated in a containing a mixture of pulp and water.



A Cylinder Machine Mechanism

Source: https://slideplayer.com/slide/9416588/28/images/57/Cylinder+papermaking+machine.jpg

A Cylinder Machine

Source: https://slideplayer.com/slide/9416588/28/images/57/Cylinder+papermaking+machine.jpg

The mechanism is same as fourdrinier machine which the water drains, leaving a wet sheet that is transferred from the cylinder onto a felt in a continuous web. **The fibres are then transferred to the underside of a moving felt belt. As the fibre mat travels along this belt, additional cylinders add further layers of fibrous mats.**

- This process is slow compared to foudrinier machine process and suitable for variety thickness of paper and inexpensive paperboard. It also easy to adjust the composition and number of plies. It is not suitable for printing purpose and cost effective process.

Lets study about the paper making process (Cylinder Machine: https://www.youtube.com/watch?v=bAyKF2nJ3cU

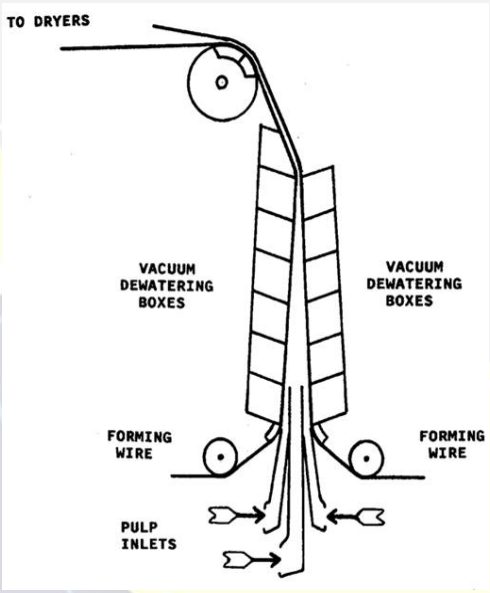
APPLY THE PRINCIPLE OF PAPER MAKING PROCESS

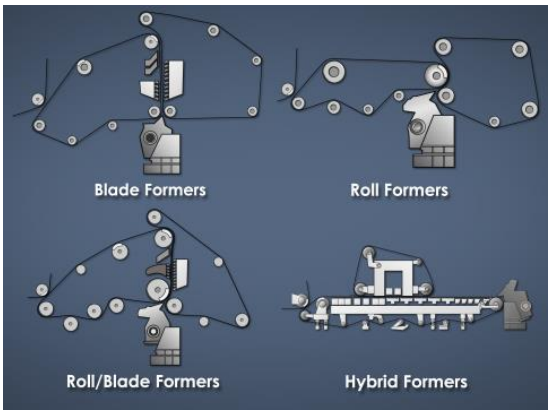
iii. TWIN WIRE MACHINE

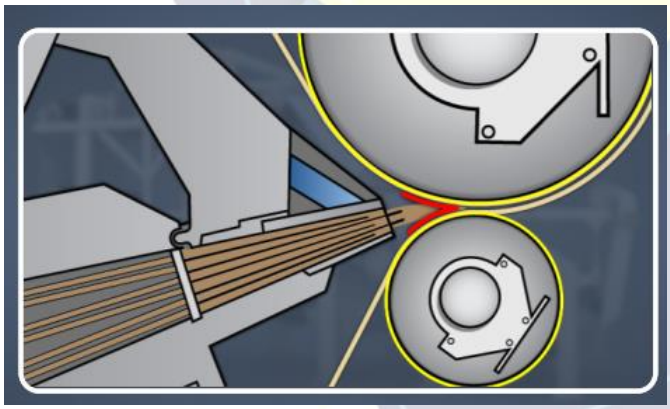
- Twin wire process, is the modification of Fourdrinier process using two wire mesh belts instead of one to form the pulp into paper.

A Twin Wire Machine

Source:
https://www.vectorsolutions.com/course-details/paper-machine-twin-wire-formers/ebb1ce9a-9583-e811-a985-02ec32550f44/







A Twin Wire Machine Mechanism

Source:
https://www.vectorsolutions.com/course-details/paper-machine-twin-wire-formers/ebb1ce9a-9583-e811-a985-02ec32550f44/

- A twin-wire former captures the stock jet in the converging nip between two fabric-covered rolls referred as "gap" formers.
- There are four types of twin-wire formers - blade, roll, hybrid and roll/blade.

Lets study about the paper making process (Twin Wire Machine: https://www.youtube.com/watch?v=Z4lN1iNwB8k

1.3 MANUFACTURING PAPER AND PAPERBOARD

CONVERSION PROCESSES FOR PAPER

The term "GSM" stands for "grams per square meter." Paper is measured from a sample sheet cut to one square meter in size and known as GSM (grams per square meter).

- Below are the example of paper according to GSM.
  - i. **35-55 GSM** – The lightest type of paper, ranging from translucent tracing paper to newsprint.
  - ii. **75-90 GSM** –Paper for sketchpads or notebooks. It's thick enough to draw on with pencil, but heavy ink or marker may bleed through.
  - iii. **90-100 GSM** – This is the weight of most types of household printer paper.
  - iv. **120-140 GSM** – The weight of your average promotional poster. Think movie posters hanging on a teenager's bedroom walls or product posters hanging in store windows.
  - v. **210-300 GSM** – This thicker type of paper is stiffer but still bendable. You'll see it used for some magazine covers and higher-quality flyers. This is also the weight of most paper used for water colors or painting.
  - vi. **350-450 GSM** – The highest GSM paper is pretty much cardstock. This is the stiffest, sturdiest paper and is used for business cards and invitations.

Source: https://www.banana-print.co.uk/blog/what-is-gsm-paper/

Paper Packaging < 250 GSM

Source: https://www.facebook.com/SaigonPaperPackaging/

Paperboard Packaging > 250 GSM

Source: https://www.bobst.com/usen/industry/corrugated-board/

1.4 APPLY CORRUGATED BOARD IN PACKAGING

INTRODUCTION TO CORRUGATED FIBREBOARD.

- Corrugated fibreboard consisting of a fluted corrugated sheet with two flat linerboards. It is made by flute lamination machines. Corrugated fibreboard is made for making cardboard boxes. The corrugated medium sheet and the linerboards are made of kraft containerboard. A paperboard material is normally 0.01 inches (0.25 mm) thick. Corrugated fibreboard is also known as corrugated cardboard.
- Several characteristics is measured for corrugated board such as:
  a) **Moisture content**: Moisture content range from 6.5-9.5% will determined the strength of the corrugated board. If the moisture is under a certain limit it will cause cracking the board and if it is above the value it will reduce the compression strength of board.
  b) **Edge crush test**: It measures the force per unit width of the compression strength. It is in KN/m or lb/inch.
  c) **Burst strength:** It is pressure required to rupture corrugated board. It is in KPa or lb/inch2.
  d) **Box Compression Strength:** It is measure performance of corrugated boxes and the unit is in N.
  e) **Flat crush test:** It measures flutes rigidity and reported in KPa.
  f) **Bending resistance**
  g) **Impact resistance**
  h) **Cushioning, shock absorption**
  i) **Tear resistance**
  j) **Grammage:** Measurement of weight per meter square of any material is called grammage. It is reported in g/m2.

Corrugated Box

Source: https://www.indiamart.com/proddetail/partition-corrugated-box-13120152473.html

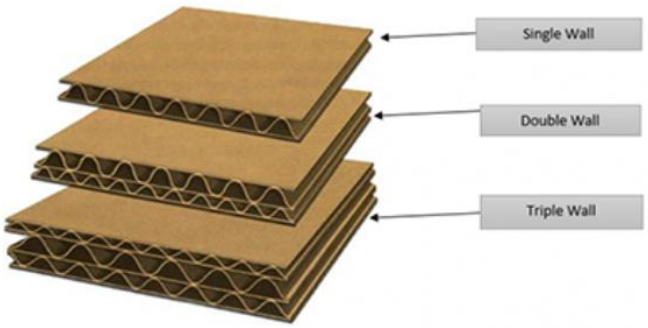
Corrugated Board

Source: https://www.indiamart.com/proddetail/corrugated-paper-board-14908125697.html/

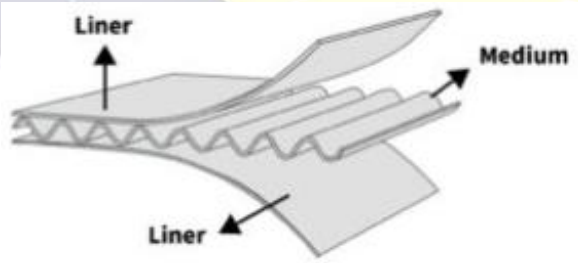
1.4 APPLY CORRUGATED BOARD IN PACKAGING

TYPES OF CORRUGATED FIBREBOARD.

- Corrugated fibreboard consist of three types of board such as:
  - **a) Single-wall** (one fluted medium with two liner plies): It is a standard type for most product type.
  - **b) Double-wall** (two fluted medium plies and three liner plies). It is used for heavier and bulky products such as machinery, large appliances or furniture, display stands, or for products which are stored for extended time period.
  - **c) Triple-wall** (three fluted medium plies and four liner plies) used for particularly heavy-duty applications such as a substitute for wooden containers for pallet boxes or bulk bins.



Type of Corrugated Board
Source: https://akpkg.com/product/cardboard-slip-sheets/



Basic Material of Corrugated Fibre Board
Source: https://kh-pack.com/sustainable-packaging/corrugated-cardboard//

MATERIAL FOR CORRUGATED FIBRE BOARD.

- Basic components of corrugated consist of three main item which are:

a) Liner or facing materials (from Kraft paper): It is used as the inner and outer facings of a corrugated sheet. Liners are made from chemical process and normally made from softwoods like which have the longest fibres(pine tree) that will produce the strongest board. It also made can be produced from recycled resources.

b) Adhesive: It is made from starch and for the purposed of joining outer liner and flutes.

c) Flutes: Flutes cardboards are the wavy piece of board sandwiched between the liners. It will gives the box its strength and protection from knocks and impact damage.

1.4

APPLY CORRUGATED BOARD IN PACKAGING

TYPES OF FLUTE IN CORRUGATED FIBREBOARD.

- Corrugated board can be divide into several types of flute such as:

a) A flute (5mm):

A flute have greater vertical compression strength and cushioning. It is suitable for packaging fragile items, such as fruits and glass.

Flutes per linear meter:

108 / + -10

b) B flute (3mm):

It has flat pressure resistance and high strength, and it is suitable for packaging products that are resistant to backlog items, such as beverages and food cans.

Flutes per linear meter:

154 / + -10

c) C Flutes (4mm):

Most comman corrugated boxes.

Flutes per linear meter:

128 / + -10

d) E Flutes (1.5mm):

It provides an excellent printing surface. it is commonly used for consumer goods boxes, trays and countertop displays.

Flutes per linear meter:

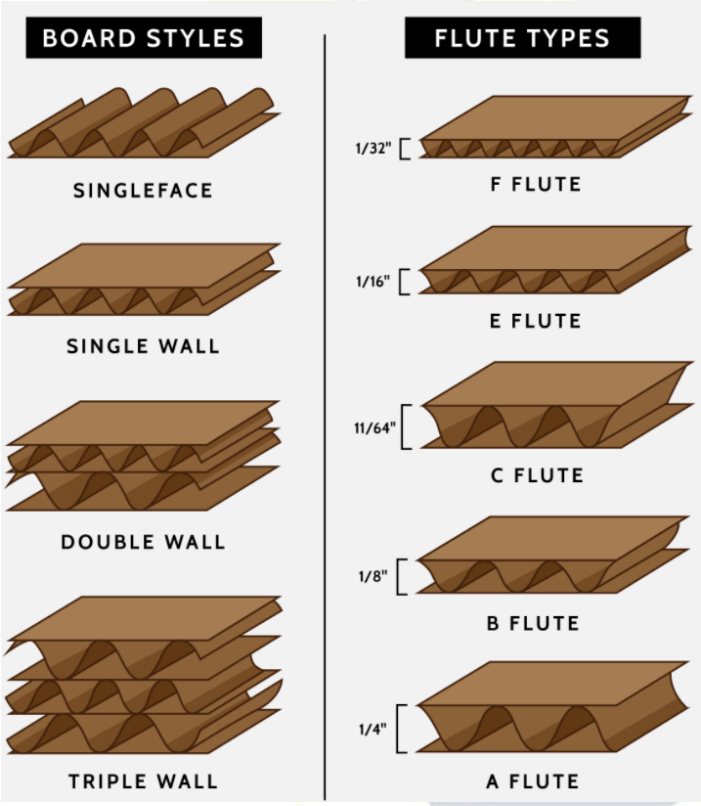
295 / + -13

e)F Flutes (0.8mm)

It has an better printing surface than E flutes. It also have an excellent crush resistance. The thin flutes allows for stiffer boxes with less fibre. It is used for fast food clamshell containers and packaging for consumer goods such as cosmetics, jewellery, and shoes.

Flutes per linear meter:

420 / + -13



Type of Flute

Source: https://kh-pack.com/sustainable-packaging/corrugated-cardboard/

1.4 MANUFACTURING OF CORRUGATED FIBREBOARD

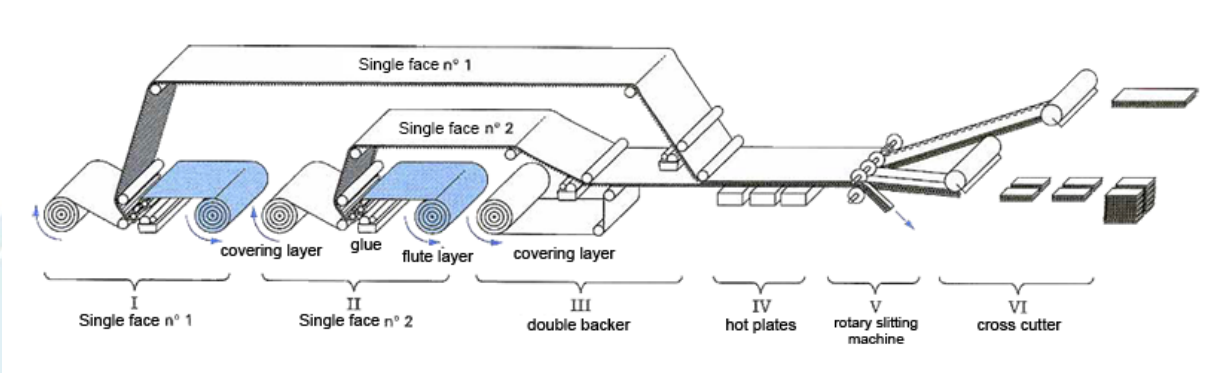
Corrugating Machine

Source:
https://www.corrugationmachines.in/corrugation-machines.html

Lets study about the Corrugating Machine:
https://www.youtube.com/watch?v=C5nNUPNvWAw

CORRUGATING MACHINE

- A corrugator is a machine that combines two different kinds of paper to create cut sheets of corrugated fibreboard.
- The facing flat sheets are referred to as liners, while the wave-like, fluted layers are known as the corrugating medium.
- The corrugator takes large rolls of paper produced on paper machines.
- Flutes were glues to the liners, one at a time, and delivers stacked, cut, and scored sheets of corrugated board to various converting machines.
- The converting machines convert the sheets of corrugated board into “box blanks,” which are ready to be made into boxes, and other corrugated board products.



Corrugating Machine Diagram

Source:
https://www.cartononduledefrance.org/en/product-and-innovation/product/

QUESTION 1

State Five (5) properties of paper and paperboard.

- Stiffness
- Printing surface
- Absorbency
- Burst strength
- Tensile strength
- Tear resistance and compression strength
- grease resistance.

QUESTION 2

What are the material of corrugated fibre board?

- Liner or facing materials
- Adhesive
- Flutes

QUESTION 3

Explain the definition pulp in paper making process.

- Pulp is a lignocellulosic fibrous material prepared by mechanically or chemically to separate cellulose fibre from wood, fibre crops, waste paper, or rags

2.0 PLASTIC AND THE CONVERSION PROCESS

2.1 APPLY POLYMER IN PACKAGING INDUSTRY

2.2 APPLY THE COMMAN TYPE OF PLASTIC

2.3 APPLY THE BIO-BASED POLYMER

2.4 PLASTIC MANUFACTURING PROCESS FOR PACKAGING MATERIAL

2.1 APPLY POLYMER IN PACKAGING INDUSTRY

POLYMER are a group of substances that can be easily folded and can be moulded into any shape.

Main source of synthetic plastics is crude oil. Coal, natural gas, petrol, paraffin, lubricating oils and high petroleum gases are bi-products, produced during the refining of crude oil which broken into monomers. Monomers are chemical substances consisting of a single molecule.

Polymerisation occurs when thousands of monomers are linked together and compounds formed as called polymers. Combining the element carbon with one or more other elements such as oxygen, hydrogen, chlorine, fluorine and nitrogen makes most polymers.

Source:
https://www.jagranjosh.com/what-is-the-difference-between-polymer-and-plastic-1524555827-1general-knowledge

Fig 1: The polymerisation of ethene in to poly(ethene)

Source:
https://en.wikipedia.org/wiki/Polymer

TYPE OF POLYMERS FROM NATURAL PLASTICS

- Animals horns - Casein (glue)
- Animals milk - Formaldehyde (glue)
- Insects - Shellac (French polishing)
- Plants - Cellulose (table tennis balls), Cellulose acetate (cloth, photographic film, handles), Cellophane (wrapping), Bitumen (roads, flat roofs)
- Trees - Latex (rubber)

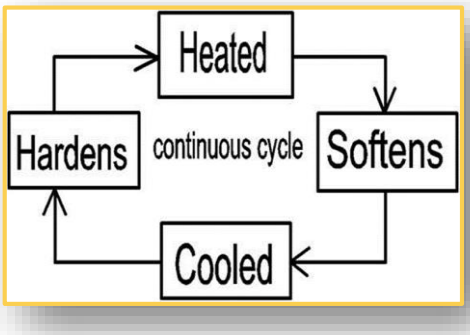
Lets study the polymerisation process:
https://www.youtube.com/watch?v=1leoAPibb38

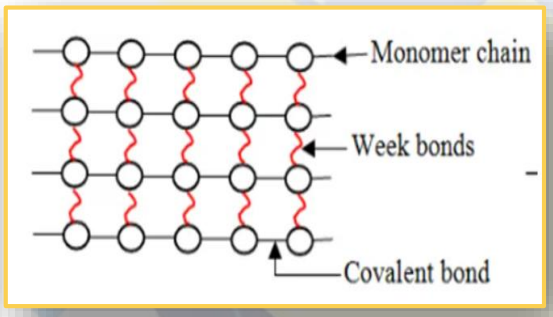
2.1 THERMOPLASTICS AND THERMOSETTING

THERMOPLASTICS are long chains with very few entanglements. When heat is applied the molecules will move apart and increases distance causing to become untangled. Each time a thermoplastic is reheated it will try and return to its original shape, unless it has been damaged due to overheating or overstretching. This property is called **plastic memory**.

Thermoplastics

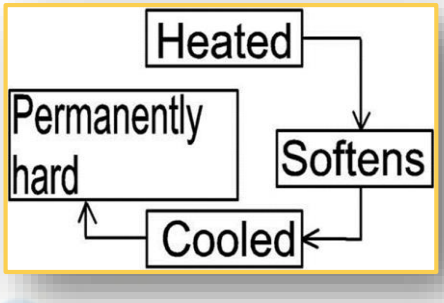
.

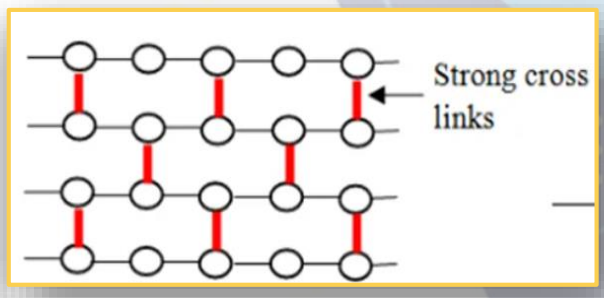




Source:
https://www.mechanicalbooster.com/2019/01/difference-between-thermosetting-and-thermoplastic.html

THERMOSETTING plastics are heavily cross-linked. They Cross-linked molecules form a rigid molecular structure. Thermoplastics remain rigid and nonflexible even at high temperatures. Polyester resin and urea formaldehyde are examples of thermosetting plastics.





Source:
https://www.mechanicalbooster.com/2019/01/difference-between-thermosetting-and-thermoplastic.html

Lets learn more about Thermoplastics and thermosetting
Thermoplastics vs Thermosetting Plastics - YouTube

Example of Thermoplastic and Thermosetting Material
Source:
https://www.mechanicalbooster.com/2019/01/difference-between-thermosetting-and-thermoplastic.html

2.2

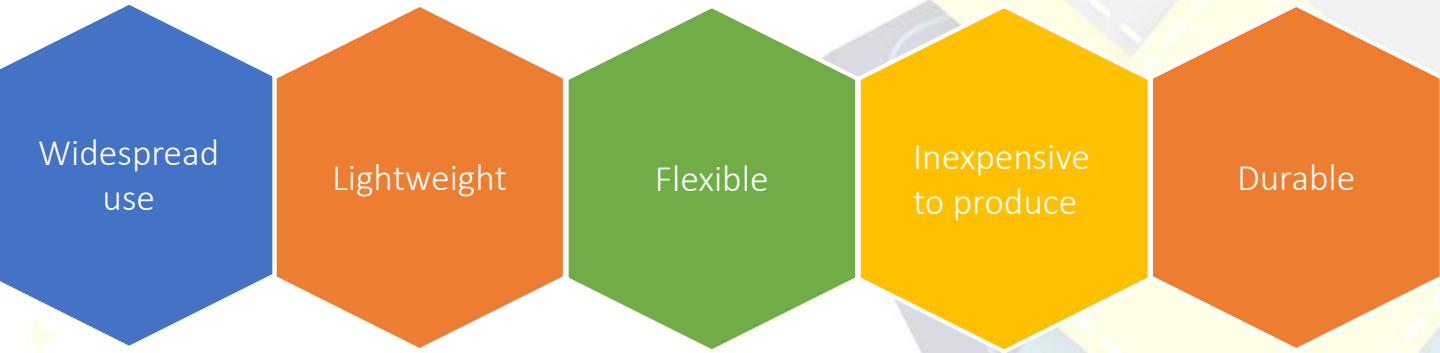
APPLY THE COMMAN TYPE OF PLASTIC

WHAT IS THIS TOPIC ABOUT?

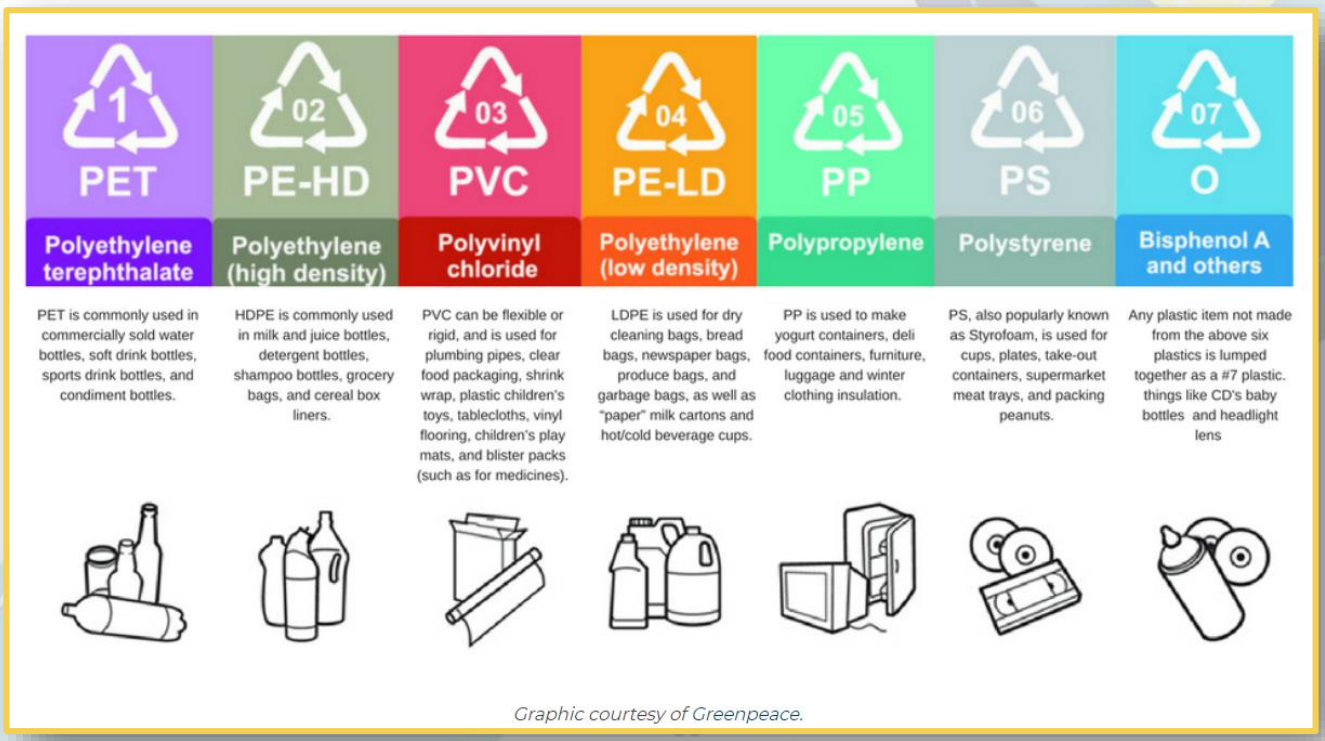
PLASTICS are a wide range of synthetic or semi-synthetic materials that use polymers as dominion ingredient.

Their characteristic of plastic makes it possible for it to be :

- Mould
- Extrude
- Press into solid objects of various shapes



The Characteristic Of Plastic



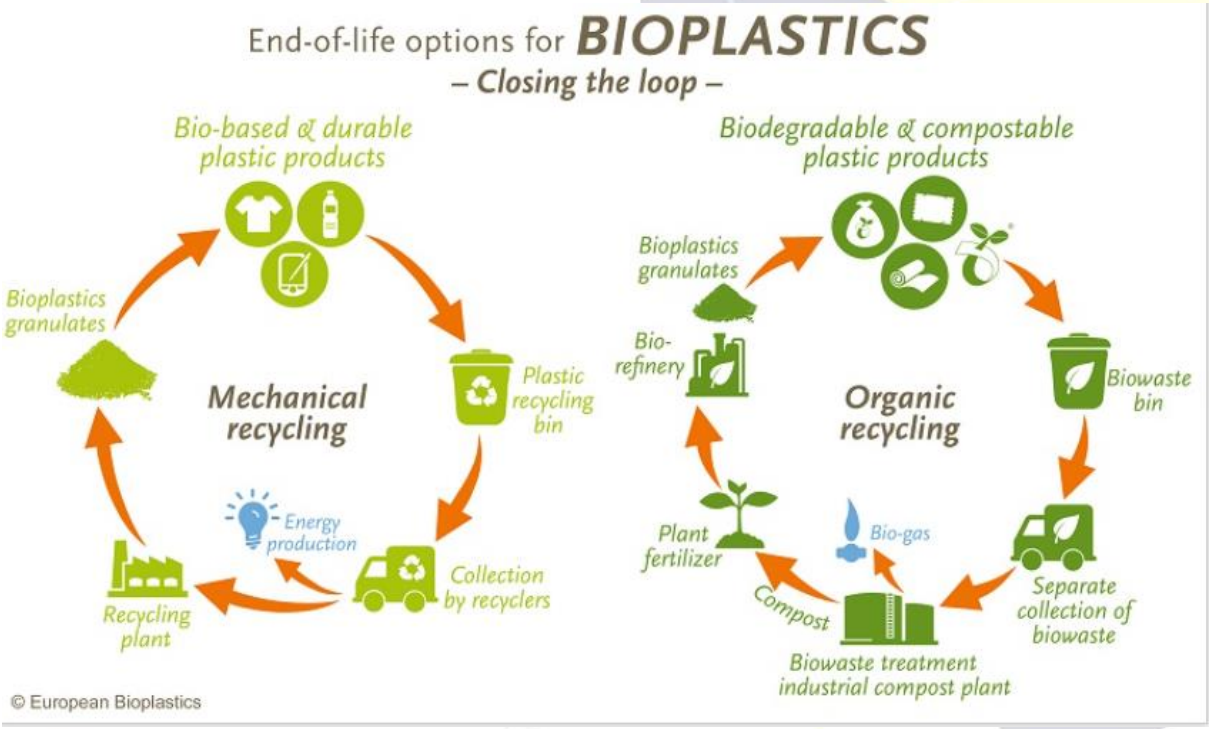
Type of Plastic
Source:
https://plasticoceans.org/7-types-of-plastic/

2.3 APPLY THE BIO-BASED POLYMER

WHAT IS THIS TOPIC ABOUT?

Bioplastics are plastics derived from renewable biomass sources, such as vegetable fats and oils, corn starch, or microbiota.

- Bioplastic can be made from agricultural and also from used plastic bottles and other containers using microorganisms.
- Common plastics, such as fossil-fuel plastics (also called petro based polymers), are derived from petroleum or natural gas.
- Production of such plastics tends to require more fossil fuels and to produce more greenhouse gases than the production of bio based polymers (bioplastics).
- Bioplastics are designed to biodegrade and can break down in either anaerobic or aerobic environments, depending on how they are manufactured.

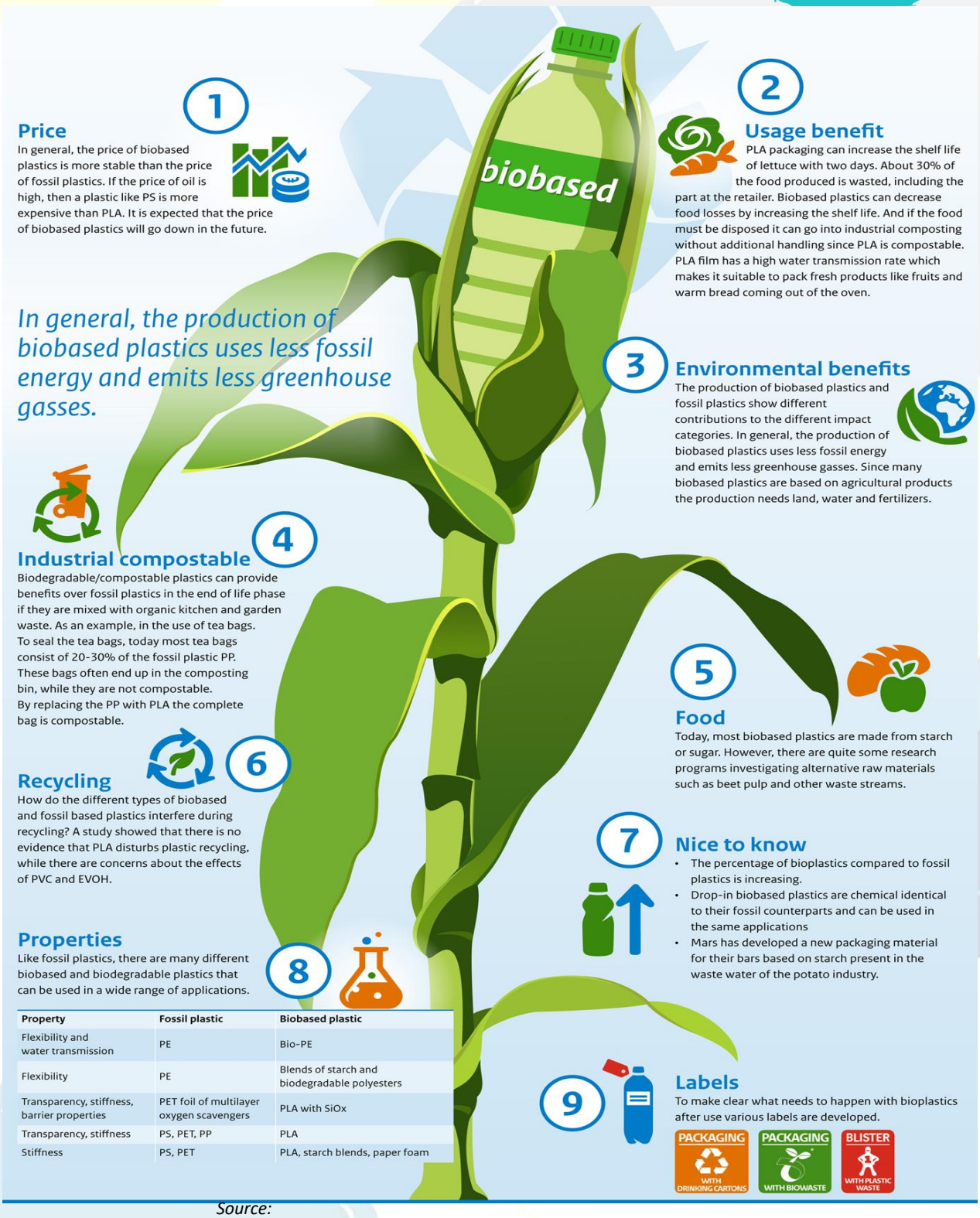


Bio-Plastic Diagram
Source: https://renewable-carbon.eu/news/how-to-dispose-of-bio-based-plastics/

2.3

APPLY THE BIO-BASED POLYMER

WHAT IS THIS TOPIC ABOUT?



1 Price

In general, the price of biobased plastics is more stable than the price of fossil plastics. If the price of oil is high, then a plastic like PS is more expensive than PLA. It is expected that the price of biobased plastics will go down in the future.

In general, the production of biobased plastics uses less fossil energy and emits less greenhouse gasses.

2 Usage benefit

PLA packaging can increase the shelf life of lettuce with two days. About 30% of the food produced is wasted, including the part at the retailer. Biobased plastics can decrease food losses by increasing the shelf life. And if the food must be disposed it can go into industrial composting without additional handling since PLA is compostable. PLA film has a high water transmission rate which makes it suitable to pack fresh products like fruits and warm bread coming out of the oven.

3 Environmental benefits

The production of biobased plastics and fossil plastics show different contributions to the different impact categories. In general, the production of biobased plastics uses less fossil energy and emits less greenhouse gasses. Since many biobased plastics are based on agricultural products the production needs land, water and fertilizers.

4 Industrial compostable

Biodegradable/compostable plastics can provide benefits over fossil plastics in the end of life phase if they are mixed with organic kitchen and garden waste. As an example, in the use of tea bags. To seal the tea bags, today most tea bags consist of 20-30% of the fossil plastic PP. These bags often end up in the composting bin, while they are not compostable. By replacing the PP with PLA the complete bag is compostable.

5 Food

Today, most biobased plastics are made from starch or sugar. However, there are quite some research programs investigating alternative raw materials such as beet pulp and other waste streams.

6 Recycling

How do the different types of biobased and fossil based plastics interfere during recycling? A study showed that there is no evidence that PLA disturbs plastic recycling, while there are concerns about the effects of PVC and EVOH.

7 Nice to know

- The percentage of bioplastics compared to fossil plastics is increasing.
- Drop-in biobased plastics are chemical identical to their fossil counterparts and can be used in the same applications
- Mars has developed a new packaging material for their bars based on starch present in the waste water of the potato industry.

8 Properties

Like fossil plastics, there are many different biobased and biodegradable plastics that can be used in a wide range of applications.

Property	Fossil plastic	Biobased plastic
Flexibility and water transmission	PE	Bio-PE
Flexibility	PE	Blends of starch and biodegradable polyesters
Transparency, stiffness, barrier properties	PET foil of multilayer oxygen scavengers	PLA with SiOx
Transparency, stiffness	PS, PET, PP	PLA
Stiffness	PS, PET	PLA, starch blends, paper foam

9 Labels

To make clear what needs to happen with bioplastics after use various labels are developed.

Source: https://www.european-bioplastics.org/facts-on-bio-based-plastics-made-simple/

Plastic Manufacturing Process For Packaging Material

2.4

Injection Moulding

Blow Moulding

Injection Blow Molding
Extrusion Blow Molding

Extrusion Moulding

Sheet extrusion
Film extrusion

2.4.1 INJECTION MOULDING

INJECTION MOULDING is a manufacturing technique for making parts from thermoplastic and thermoset materials.

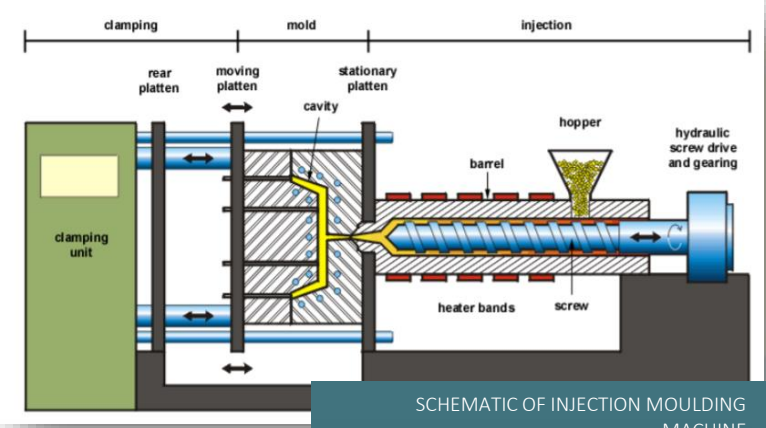
Molten plastic is injected at high pressure into a mould, which is the inverse of the desired shape.

Injection moulding make discrete parts (with complex and variable cross section).

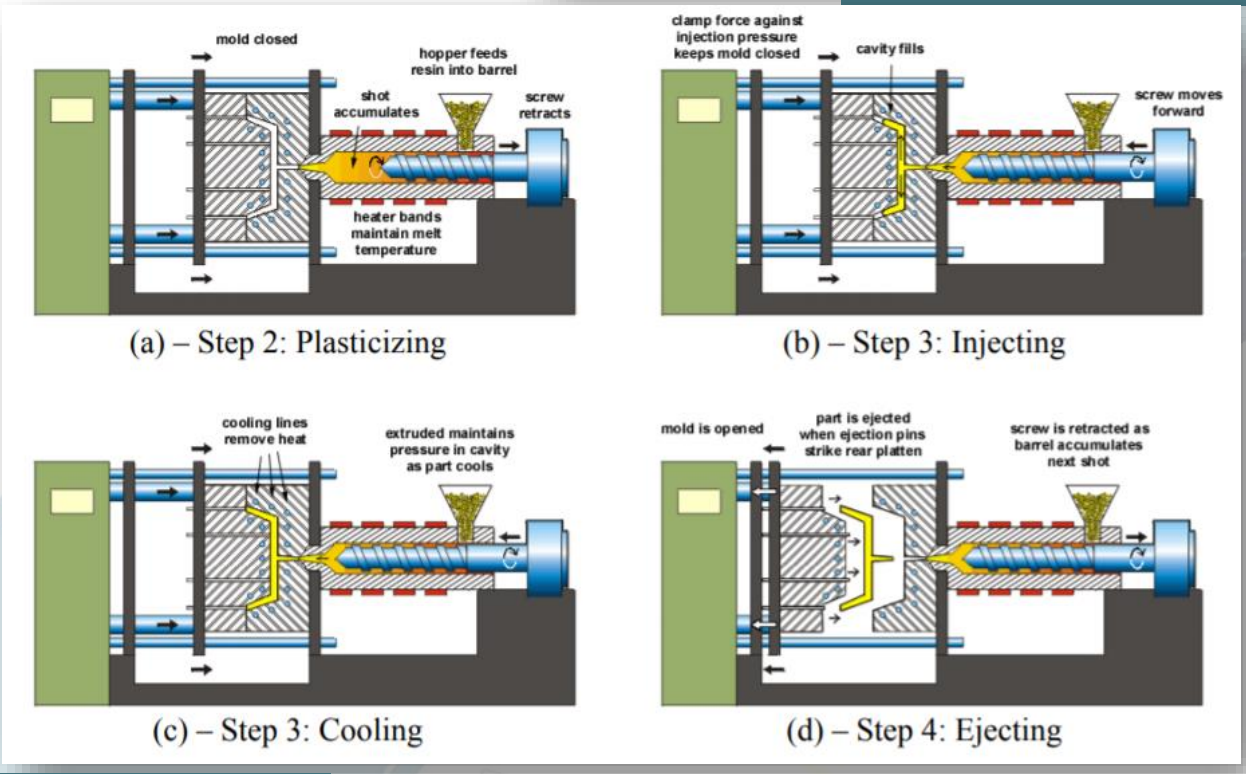
Molten plastic is injected at high pressure into a mould, which is the inverse of the desired shape.

PHOTO OF INJECTION MOULDING MACHINE

http://www.idsa-mp.org/proc/plastic/injection/injection_process.htm



SCHEMATIC OF INJECTION MOULDING MACHINE

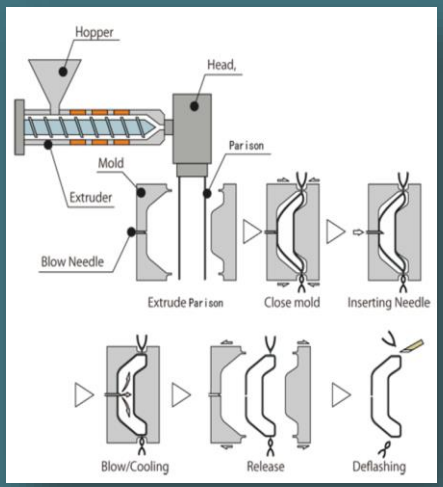


INJECTION MOULDING PROCESS

Source: http://www.idsa-mp.org/proc/plastic/injection/injection_process.htm

2.4.2 BLOW MOULDING

Blow Molding

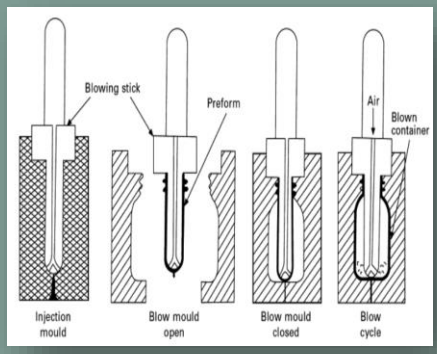


BLOW MOULDING is a manufacturing process for forming and joining together hollow plastic parts or forming glass bottles and other hollow shapes.

Form the molten resin into a cylinder or tube is called parison.

https://www.krk.co.jp/en/tech/blowmolding.html

Injection Blow Molding



INJECTION BLOW MOLDING is process that combine process of inject and blow.

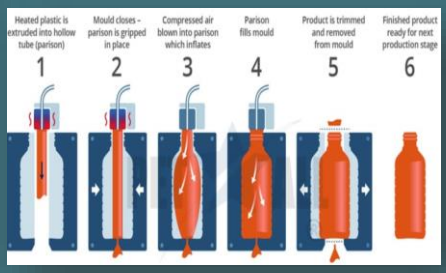
The parison is formed by the injection of molten resin into a mould cavity then the blow process.

Parison made by injection moulding is called a preform.

Injection blow moulding is often used for containers that have close tolerance threaded necks, wide mouth openings, solid handles, and highly styled shapes.

https://www.sciencedirect.com/topics/engineering/injection-blow-molding

Extrusion Blow Molding



EXTRUSION BLOW MOLDING is process that combine process of extrude and blow.

Plastic is melted and extruded into a hollow tube called parison.

Air is then blown into the mould shaping it into the desired shape of the bottle or container.

In some extrusion blow moulding operations, the air is extrude from the bottom through an inlet

https://www.petallmfg.com/blog/how-extrusion-blow-molding-differs-from-injection-molding/

Lets learn more about Blow Molding Process
Blow molding - YouTube

2.4.3 EXTRUSION MOULDING

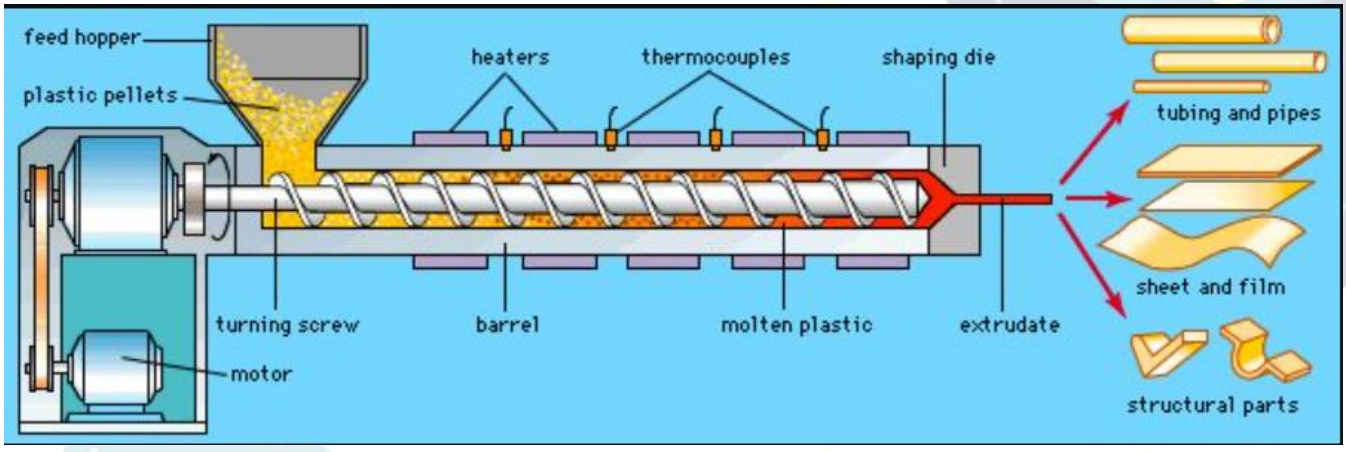
PLASTICS EXTRUSION is a high-volume manufacturing process where raw plastic is melted and formed into a continuous profile.

Examples of Extrusion Moulding products such as pipe/tubing, fencing, deck railings, window frames, plastic films and sheeting, thermoplastic coatings, and wire insulation.

Click here for more info about extrusion molding: https://www.youtube.com/watch?v=Tp2Rdx69SSo

The granules melt into a liquid which is forced through a die, forming a long 'tube like' shape. The extrusion is then cooled and forms a solid shape. The shape of the die determines the shape of the tube.

SCHEMATIC OF INJECTION MOULDING MACHINE



Extrusion Moulding process

Source:
https://www.blendspace.com/lessons/Gq9tJqjmCBbCRQ/polymer-processes

2.4.4 CONCEPT OF THERMOFORMING

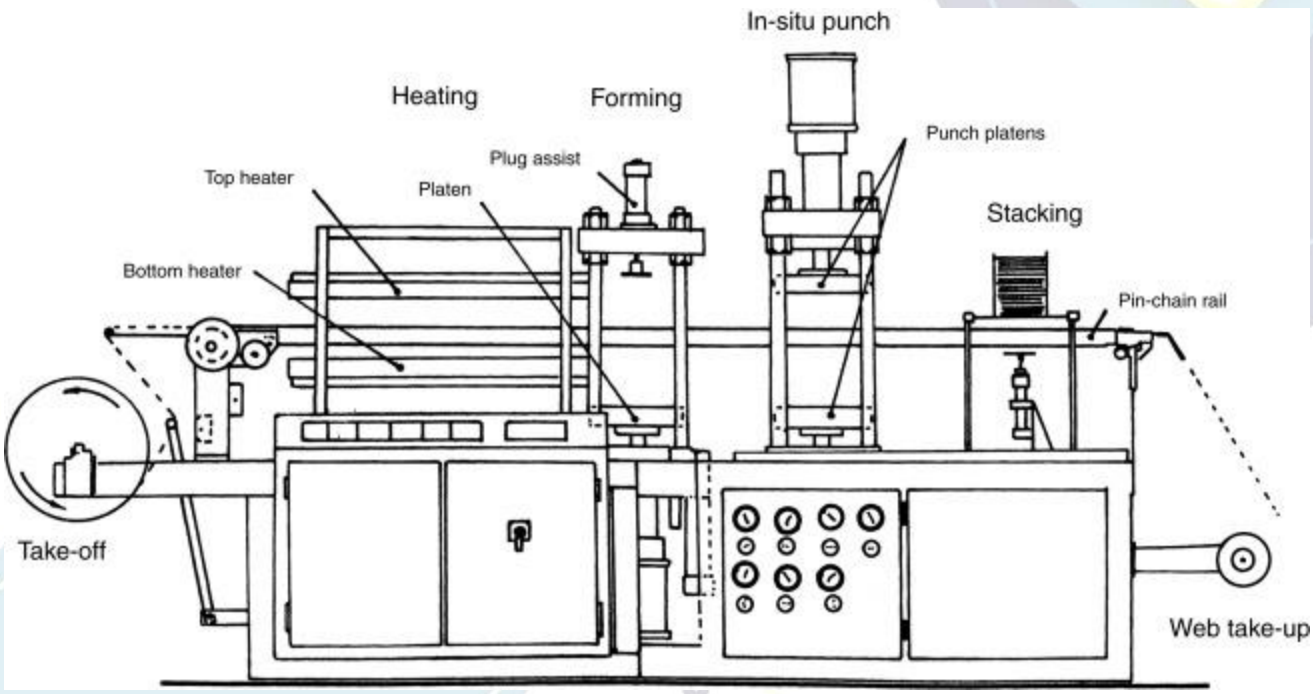
Thermoforming is a manufacturing process where a plastic sheet is heated to a pliable forming temperature, formed to a specific shape into a mould, and trimmed to create a usable product.

- Thermoforming is different from other plastic process because it is not melted, and lower pressure are required to thermoform.

Basic Principle Of Thermoforming:

- The process of thermoforming is start when thermoplastic sheet is been heated until it softens.
- Then the force have been given to the hot and pliable material by using either mechanical, air or vacuum pressure through the mould
- Allow the mould to be cool.

Click here for more info about thermoforming:
https://www.youtube.com/watch?v=LYfzl8eciG8



Machine of Thermoforming

Source:
https://www.european-bioplastics.org/facts-on-bio-based-plastics-made-simple/

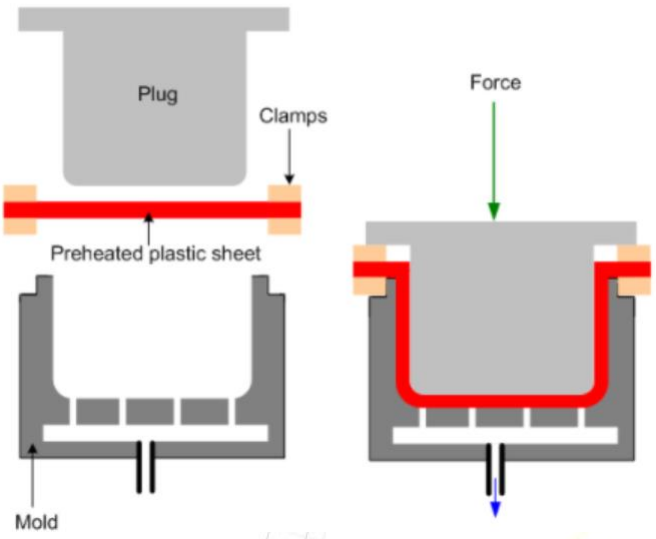
2.4.5 PROCESS OF THERMOFORMING

Thermoforming Principle:

- Thermoforming processes are a very important in making plastic shaping processes.
- In thermoforming process required two important steps include heating the plastic sheet and thermoform it.
- In general of thermoforming process, heat radiators are used to heat the plastic sheet. Sufficient heat must be provided to ensure the plastic sheet can be formed.
- Thermoforming can be divided into 3 types of thermoforming such as:
    a. Mechanical Thermoforming Process
    b. Pressure Thermoforming Process
    c. Vacuum Thermoforming process

Mechanical Thermoforming

- Mechanical thermoforming process is started by heating the plastic sheet
- After the heating, the plastic sheet is clamped both side by using a mechanical force.



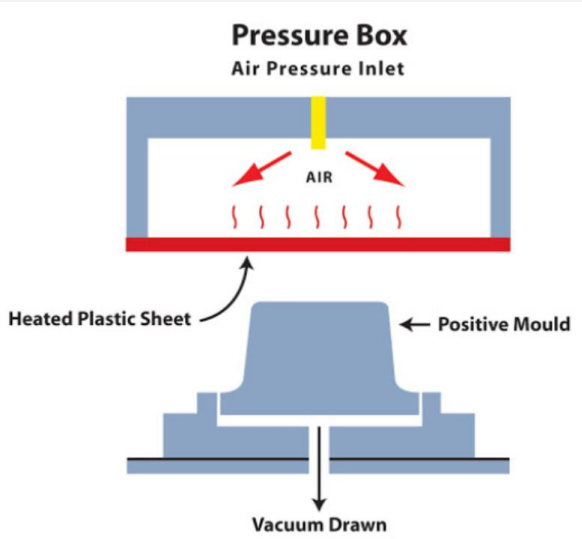
Mechanical Thermoforming Process

Source: https://mechanicalbase.com/3-types-of-thermoforming-operations-and-applications/

2.4.5 PROCESS OF THERMOFORMING

Pressure Thermoforming Process

- Pressure thermoforming process is started by heating the plastic sheet.
- The pressure is used to stretch the plastic sheet upon the mould.
- When the sheet plastic is stretched, the air is blown to obtain pressure effect.
- Thinning is a parameter of the pressure thermoforming process. It shows when a specific thickness of the plastic sheet is stretched on mould, the surface area of the plastic sheet will increase and the thickness will decrease.

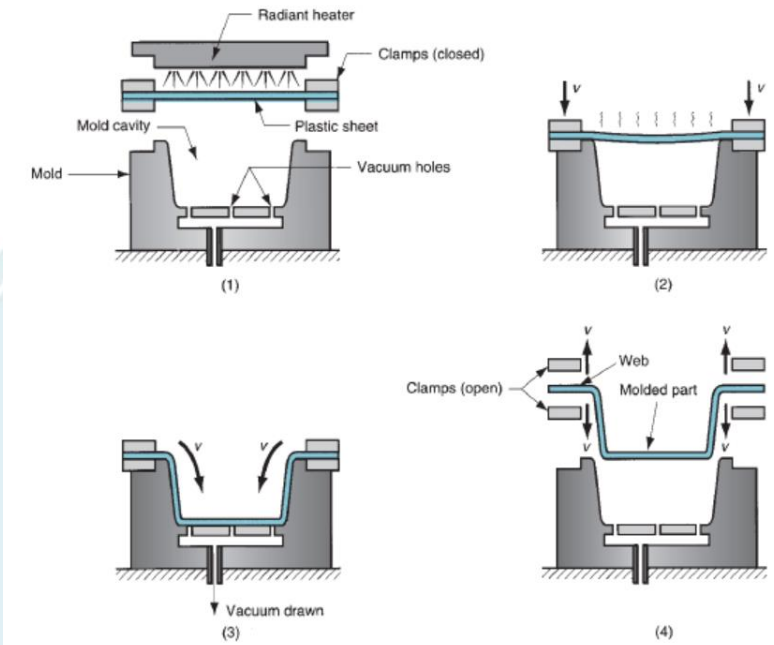


Pressure Thermoforming Process

Source: https://www.euroextrusions.com/pressure-forming/

Vacuum Thermoforming Process

- In vacuum thermoforming process, vacuum is used to stretch plastic sheets on moulds.
- Parameters in vacuum thermoforming are completely the same as the pressure thermoforming process.
- There are small orifices beneath the mould that air is evacuated to obtain the vacuum effect.
- The main disadvantage of the vacuum thermoforming process is negative pressures up to 1 atm can be obtained but in pressure thermoforming processes, 3-4 atm of pressures can be applied.



Source: https://www.engineeringclicks.com/thermoforming/

Pressure Thermoforming Process

QUESTION 1

List FIVE (5) **type of polymers from natural plastics.**

- High Density Polyethylene (HDPE)
- Low Density Polyethylene (LDPE)
- Polyethylene (LLDPE)
- Polyethylene Terephthalate (PET, PETE)
- Polypropylene (PP)
- Polystyrene
- Polyvinyl Chloride (PVC, Vinyl)

QUESTION 2

What are the main processes to produce plastic using injection molding machine?

- Plasticisation
- Injection
- Packing/ Cooling
- Ejection

QUESTION 3

What is the physical properties of plastics?

- Easily formed material
- Plastic is referred to as a self-finishing material.
- Plastics can be easily printed, decorated or painted.
- Plastics are corrosion resistant, and generally waterproof.
- Plastics are lighter than metals.

ASSESTMENT

STUDENT ASSESTMENT QUESTIONS AND ANSWER...

2.5

QUESTION 1 (a)

A Corrugated fibreboard is the most widely used material for secondary packaging material. List and sketch the type of flute size.

QUESTION 1 (b)

By referring to Figure 1 below, determine FOUR (4) main functions of the folding carton packaging.

Figure 1: Folding Carton box

QUESTION 2 (a)

List FOUR (4) processes in plastic conversion process.

Answer 2 (b)

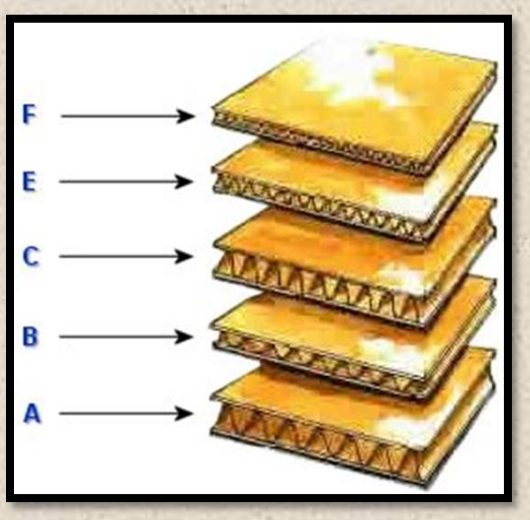
Plastic may be classified as thermosetting and thermoplastic materials. State THREE (3) differences of the following:
i. Thermosetting material
ii. Thermoset material

STUDENT ASSESTMENT QUESTIONS AND ANSWER...

2.5

Answer 1 (a)

A Corrugated fibreboard is the most widely used material for secondary packaging material. List and sketch the type of flute size.



A-flute: the largest size
C-flute: the second largest
B-flute: the third largest
E-flute: the fourth largest
F-flute and other finer flute sizes

Answer 1 (b)

By referring to Figure 1 below, determine FOUR (4) main functions of the folding carton packaging.

i. **Contain**
Packaging needed to contain a product depends on the physical form of the product and the nature of the product itself.

ii. **Protect**
The protection function means guarding against physical damage.

iii. **Transport**
The transport function entails the effective movement of goods from the point of production to the point of final consumption.

iv. **Inform**
As well as communicating factual information, a pack must be effective in promoting the contained product.

Answer 2 (a)

List FOUR (4) processes in plastic conversion process.

Plastic Conversion Process
- Injection Moulding Process
- Compression Moulding Process
- Transfer Moulding Process
- Blow Moulding Process
- Rotational Moulding Process
- Extrusion Moulding Process

Answer 2 (b)

Plastic may be classified as thermosetting and thermoplastic materials. State THREE (3) differences of the following:
i. Thermosetting material
ii. Thermoset material

Thermoset
- More resistant to high temperatures than thermoplastics
- Highly flexible design
- Thick to thin wall capabilities
- Excellent aesthetic appearance
- High levels of dimensional stability
- Cost-effective
- Cannot be recycled
- More difficult to surface finish
- Cannot be remolded or reshaped

Thermoplastic
- Highly recyclable
- Aesthetically-superior finishes
- High-impact resistance
- Remolding/reshaping capabilities
- Chemical resistant
- Hard crystalline or rubbery surface options
- Eco-friendly manufacturing
- Generally more expensive than thermoset
- Can melt if heated

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