Republic of Iraq
Ministry of Higher Education and Scientific Research
College of Materials Engineering
Department of Polymer Engineering and Petrochemical Industries

Project:

Studying The Extrusion Process Of PET Product From Waste To Obtain Good Parameters

Submitted by:
Fatima Salam Makki

Supervised by:
Prof. Dr. Ali Al-Zubiedy

A.D 2023 **1444 A.H**

بسم الله الرحمن الرحيم

{يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ
وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ}

صَدَق الله العظيم

بسم الله الرحمن الرحيم

شكر و تقدير

الشكر والثناء لله عز و جل أولاً على نعمة الصبر و القدرة على إنجاز العمل ، فالله الحمد على هذه النعم

و أتقدم بالشكر والتقدير إلى استاذي الفاضل / الدكتور علي عبد الأمير الزبيدي الذي تفضل بإشرافه على هذا البحث ، و لكل ما قدمه لي من دعم وتوجيه وإرشاد لإتمام هذا العمل على ما هو عليه فله أسمى عبارات الثناء والتقدير .

وقبل أن نمضي نتقدم ب أسمى آيات الشكر الامتنان والتقدير والمحبة

إلى الذين حملوا أقدس رسالة في الحياة...

إلى الذين مهدوا لنا طريق العلم والمعرفة ... إلى جميع أساتذتنا الأفاضل ...

الاهداء

اهداء الى:

إلى صاحب السيرة العطرة، والفكر المُستنير؛

فلقد كان له الفضل الأول في بلوغي التعليم العالي

(والدي الحبيب)، اطال الله بعمره.

إلى من وضعتني على طريق الحياة، وجعلتني رابط الجأش،

وراعتني حتى صرت كبيرًا

(أمي الغالية)، أطال الله فيُ عمرها

إلى إخوتي؛ من كان لهم بالغ الأثر في كثير من العقبات والصعاب.

إلى جميع أساتذتي الكرام؛ ممن لم يتوانوا في مد يد العون لي

أهدي إليكم بحثي

Abstract:

Polyethylene terephthalate (PET) is commonly referred to as polyester. PET is a semiaromatic polymer synthesized from ethylene glycol and terephthalic acid. Is one of the most produced thermoplastics in the world. PET is used extensively in the food and beverage industry,

In this work, a polymeric compound collected from waste was studied and reconstituted to obtain good results. It was mixed with polypropylene to facilitate the extrusion process.

Different samples of the compound were prepared at different speeds and constant temperatures, and this speed was (25.50), and these samples were prepared by a twin-screw extruder, and their mechanical properties were studied through (tensile, hardness, and impact) tests , where the results showed an improvement in properties at a speed 25 by increasing tensile values, increasing impact values, and decreasing hardness values.

Chapter one

Introduction:

Extrusion:

Extrusion is the oldest and simplest way of processing PET. The most common extrusion processes are Extrusion moulding and extrusion to produce foam.

Extrusion moulding:

Extrusion moulding is basically a process whereby molten PET is extruded into a mould where it sets toForm the mould shape then is cut into moulding objects PET extrusion moulding is normally used to produceLarge objects. PET is also easily extruded to product Films, sheeting, pipes and monofilamen.

Extrusion to produce foam

Extrusion processes can be used to produce PET Foam. Multifunctional modifiers are added to PET toAchieve highly branched high MW PET enabling manu

Facturers to produce PET foam by an extrusion process Some of the

Table 3
Examples of intrinsic viscosity for different PET applications

Application	$[\eta]$ (dl g^{-1})
Recording tape	0.60
Fibres	0.65
Carbonated drink bottles	0.73–0.8
Industrial tyre cord	0.85

modifiersFacturers to produce PET foam by an extrusion process Some of the reported In the literature Were pyromellitic dianhydride (PMDA) Bis(oxazoline) triphenyl phosphate and diimidodiepoxides.

Polyethylene Terephthalate:

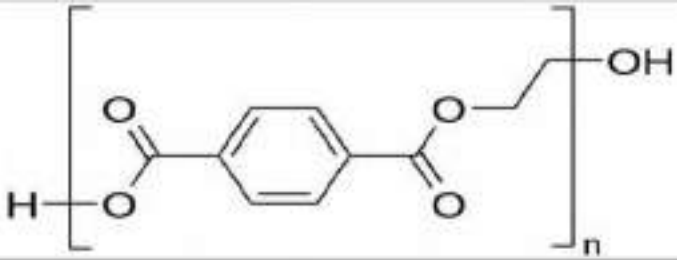
Polyethylene terephthalate (or poly(ethylene terephthalate), PET, PETE, or the obsolete PETP or PET-P), is the most common thermoplastic polymer resin of the polyester family And is used in fibres for clothing, containers for liquids and foods, and thermoforming for Manufacturing, and in combination with glass fibre for engineering resins.

PET applications and processing:

PET is used broadly in products such as bottles, electrical and electronic instruments, automobiles products,House-wares, lighting products, power tools, material Handling equipment, and sporting goods. PET films And fibres are the oldest applications of PET. Films are Produced by biaxial orientation through heat and drawing. PET films are used in photographic applications, Xrays sheets and in food packaging PET films are also

Reported to be used in electrical and for recording tapes PET is also used as an electrical insulator.

PETs Insulating properties are regarded as good due to the severe restriction of the dipole orientation at room temperature that is well below the transition temperature PET fibres are another important application of PET And are produced by forcing molten PET through small Holes in a die. Fibre strength is achieved by applying tension to align the chains through uniaxial stretching.



Names	
IUPAC name poly(ethylene terephthalate)	
Systematic IUPAC name poly(oxyethyleneoxyterephthaloyl)	
Identifiers	
CAS Number	25038-59-9 ✓
Abbreviations	PET, PETE
ChEBI	CHEBI:53259 (https://www.ebi.ac.uk/chebi/searchId.do?chebiId=53259)
ChemSpider	None
ECHA InfoCard	100.121.858 (https://echa.europa.eu/substance-information/-/substanceinfo/100.121.858)
CompTox Dashboard (EPA)	DTXSID10872790 (https://comptox.epa.gov/dashboard/DTXSID10872790)
Properties	
Chemical formula	$(C_{10}H_8O_4)_n$[1]
Molar mass	10–50 kg/mol, varies

Density	1.38 g/cm³, 20 °C[2] 1.370 g/cm³,[1] amorphous 1.455 g/cm³,[1] single crystal
Melting point	> 250 °C (482 °F; 523 K)[2] 260 °C[1]
Boiling point	> 350 °C (662 °F; 623 K) (decomposes)
Solubility in water	Practically insoluble[2]
log *P*	0.94540[3]
Thermal conductivity	0.15[4] to 0.24 W/(m·K)[1]
Refractive index (n_D)	1.57–1.58,[4] 1.5750[1]
Thermochemistry	
Heat capacity (*C*)	1.0 kJ/(kg·K)[1]
Related compounds	
Related Monomers	Terephthalic acid Ethylene glycol

Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa).

Young's modulus, *E*	2800–3100 MPa
Tensile strength, σ_t	55–75 MPa
Elastic limit	50–150%
Notch test	3.6 kJ/m²
Glass transition temperature, T_g	67–81 °C
Vicat *B*	82 °C
Linear expansion coefficient, *α*	7×10^{-5} K^{-1}
Water absorption (ASTM)	0.16

PET consists of repeating (C10H8O4) units. PET is commonly recycled, and has the digit 1 (♳) as its resin identification code (RIC). The National

Association for PET Container Resources (NAPCOR) defines PET as: "Polyethylene terephthalate items referenced are derived from terephthalic acid (or dimethyl terephthalate) and mono ethylene glycol, wherein the sum of terephthalic acid (or dimethyl terephthalate) and mono ethylene glycol reacted constitutes at least 90 percent of the mass of monomer reacted to form the polymer, and must exhibit a melting peak temperature between 225°C and 255°C, as identified during the second thermal scan in procedure 10.1 in ASTM D3418, when heating the sample at a rate of 10°C/minute.

Depending on its processing and thermal history, polyethylene terephthalate may exist both as an amorphous (transparent) and as a semicrystalline polymer. The semicrystalline material might appear transparent (particle size less than 500 nm) or opaque and white (particle size up to a few micrometers) depending on its crystal structure and particle size.

Uses:

PET has SPI resin ID code 1

PET preform for injection stretch blow moulding of a bottle

A finished PET bottle

A PET bottle which has been heated by a candle and has recrystallized, making it opaque.

PET clamshell packaging, used to sell fruit, hardware, etc.

Polyester yarn

Textiles

Polyester fibres are widely used in the textile industry. The invention of the polyester fibre is attributed to J. R. Whinfield.[1] It was first commercialized in the 1940s by ICI, under the brand 'Terylene'.[2] Subsequently E. I. DuPont launched the brand 'Dacron'. As of 2022, there are many brands around the world, mostly Asian.

Polyester fibres are used in fashion apparel often blended with cotton, as heat insulation layers in thermal wear, sportswear and workwear and automotive upholstery.

Rigid packaging

Plastic bottles made from PET are widely used for soft drinks, both still and sparkling. For beverages that are degraded by oxygen, such as beer, a multilayer structure is used. PET sandwiches an additional polyvinyl

alcohol (PVOH) or polyamide (PA) layer to further reduce its oxygen permeability.

Non-oriented PET sheet can be thermoformed to make packaging trays and blister packs.[3] Crystallizable PET withstands freezing and oven baking temperatures.[4]:1378 Both amorphous PET and BoPET are transparent to the naked eye. Color-conferring dyes can easily be formulated into PET sheet.

PET is permeable to oxygen and carbon dioxide and this imposes shelf life limitations of contents packaged in PET.[5]

Flexible packaging

Biaxially oriented PET (BOPET) film (often known by one of its trade names, "Mylar") can be aluminized by evaporating a thin film of metal onto it to reduce its permeability, and to make it reflective and opaque (MPET). These properties are useful in many applications, including flexible food packaging and thermal insulation (such as space blankets).

Photovoltaic modules

BOPET is used in the backsheet of photovoltaic modules. Most backsheets consist of a layer of BOPET laminated to a fluoropolymer or a layer of UV stabilized BOPET.[6]

PET is also used as a substrate in thin film solar cells.

Thermoplastic resins

PET can be compounded with glass fibre and crystallization accelerators, to make thermoplastic resins. These can be injection moulded into parts such as housings, covers, electrical appliance components and elements of the ignition system.[7]

Other applications

- A waterproofing barrier in undersea cables.
- As a fibre, spliced into bell rope tops to help prevent wear on the ropes as they pass through the ceiling.

- Since late 2014 as liner material in type IV composite high pressure gas cylinders. PET works as a much better barrier to oxygen than earlier used (LD)PE.[8]
- As a 3D printing filament, as well as in the 3D printing plastic PETG.
- Film for tape applications, such as the carrier for magnetic tape or backing for pressure-sensitive adhesive tapes. Digitalization has caused the virtual disappeance of the magnetic audio and videotape application.
- Water-resistant paper.[9]

Physical properties:

PET in its most stable state is a colorless, semi-crystalline resin. However it is intrinsically slow to crystallize compared to other semicrystalline polymers. Depending on processing conditions it can be formed into either amorphous or crystalline articles. Its amenability to drawing makes PET useful in fibre and film applications. Like most aromatic polymers, it has better barrier properties than aliphatic polymers. It is strong and impact-resistant. PET is hygroscopic.[10]

About 60% crystallization is the upper limit for commercial products, with the exception of polyester fibers. Transparent products can be produced by rapidly cooling molten polymer below Tg glass transition temperature to form an amorphous solid.[11] Like glass, amorphous PET forms when its molecules are not given enough time to arrange themselves in an orderly, crystalline fashion as the melt is cooled. At room temperature the molecules are frozen in place, but, if enough heat energy is put back into them by heating above Tg, they begin to move again, allowing crystals to nucleate and grow. This procedure is known as solid-state crystallization.

When allowed to cool slowly, the molten polymer forms a more crystalline material. This material has spherulites containing many small crystallites when crystallized from an amorphous solid, rather than forming one large single crystal. Light tends to scatter as it crosses the boundaries between crystallites and the amorphous regions between them, causing the resulting solid to be translucent.

Orientation also renders polymers more transparent. This is why BOPET film and bottles are both crystalline to a degree and transparent.

Amorphous PET crystallizes and becomes opaque when exposed to solvents such as chloroform or toluene.[12]

PET is stoichiometrically a mixture of carbon and H2O, and therefore has been used in an experiment involving laser-driven shock compression which created nanodiamonds and superionic water. This could be a possible way of producing nanodiamonds commercially.[13][14]

Absorption/scalping

PET has an affinity for hydrophobic flavors and drinks sometimes need to be formulated with higher dosage compared to glass to offset the flavor taken up by the container.[15]: 115 Heavy gauge PET bottles are sometimes returnable for re-use and is practiced in some EU countries, however the propensity of PET to absorb flavors makes it necessary to conduct a "sniffer" test on returned bottles to avoid crosscontamination.[16]

Intrinsic viscosity

Different applications of PET require different degrees of polymerization, which can be obtained by modifying the process conditions. The molecular weight of PET is measured by solution viscosity. The preferred method is intrinsic viscosity (IV).[17]

IV is a dimensionless measurement. It is found by extrapolating the relative viscosity (measured in (dℓ/g)) to zero concentration.

Fibers

- 0.40–0.70: textile
- 0.72–0.98: technical eg tire cord

Films

- 0.60–0.70: biaxially oriented PET film
- 0.70–1.00: sheet grade for thermoforming **Bottles**
- 0.70–0.78: general purpose bottles
- 0.78–0.85: bottles for carbonated drinks **Monofilaments**,

engineering plastics

- 1.00–2.00

Recycled PET :

The POSTC-PET recycling industry started as a result of environmental pressure to improve waste management. The other aspect that acts as driving force For PET recycling industry is that PET products have A slow rate of natural decomposition [18]. PET is a Non-degradable plastic in normal conditions as there is No known organism that can consume its relatively large Molecules. Complicated and expensive procedures need To be operated in order for PET to degrade biologically [19].

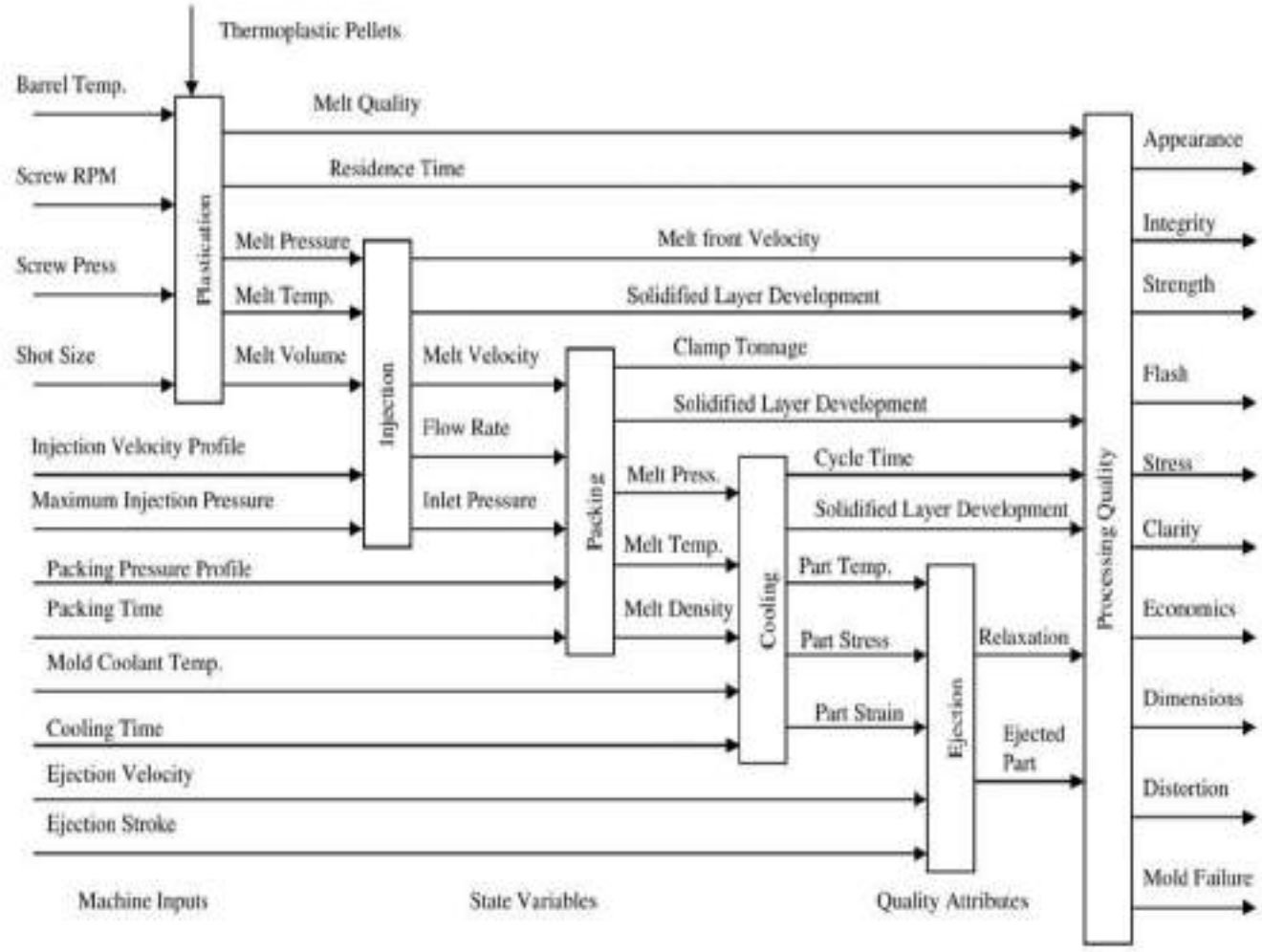


Fig. 4. Injection moulding process variables.

Recycling processes are the best way to economically Reduce PET waste [20–21]. On the other hand, as the Price of virgin PET remains stable, new and cheaper Technologies for recycling PET give an added value to The PET recycling industry by providing industry with Relatively cheaper PET. The first recycling effort of POSTC-PET bottles in The world was in 1977 [22]. The total consumption of PET in Australia for the year 2000 was 88,258 tonnes,

Table 4
Minimum requirements for POSTC-PET flakes to be re-processed

Property	Value
$[\eta]$	>0.7 dl g^{-1}
T_m	>240 °C
Water content	<0.02 wt.%
Flake size	0.4 mm < D < 8 mm
Dye content	<10 ppm
Yellowing index	<20
Metal content	<3 ppm
PVC content	<50 ppm
Polyolefin content	<10 ppm

In which 28,113 tonnes were recovered demonstrating a Recovery rate of about 32% [19].Many researchers reported that in order to achieve Successful PET recycling, PET flakes should meet certain Minimum requirements [23,24,25]. Examples of the minimum requirements for the POSTC-PET flakes are summarized in Table 4. The major factor affecting the Suitability of POSTC-PET flake for recycling is the levelAnd nature of contaminants present in the flakes.

Contamination

Contamination of POSTC-PET is the major cause of Deterioration of its physical and chemical properties during re-processing [26]. Minimizing the amount of these Contaminants leads to better R-PET quality [27].POSTC-PET is contaminated with many substances Such as:

Acid producing contaminants

The most harmful acids to the POSTC-PET recycling Process are acetic acid, which is produced by poly(vinyl Acetate) closures degradation, rosin acid and abietic acid That are produced by adhesives and hydrochloric acid That is produced by PVC. The acids act as catalysts for The chain scission reactions during POSTC-PET melt Processing [24,28,29]. Paci and La Mantia [30] investigated the influence of small amount of PVC during the Melt processing of POSTC-PET. They reported that The presence of PVC (as little as 100 ppm) would increase POSTC-PET chain scission due to the catalytic Effect of hydrogen chloride evolving during the degradation of PVC. The presence of PVC also results in discoloration of POSTC-PET during processing.

Water

Water reduces MW during POSTC-PET recycling Through a hydrolysis reaction. Moisture contamination Should be below 0.02% to avoid the MW reduction [24].Most water content comes from the flake washing process but can be reduced substantially by proper drying.

Colouring contaminants

Fragments of coloured bottles and printed ink labels Cause undesirable colours during processing. Enhancement of sorting and washing processes in bottle recycling may reduce colouring contaminants.

Acetaldehyde

Acetaldehyde is present in PET and POSTC-PET. It is A by-product of PET degradation reactions. The migration of acetaldehyde into food products from PET containers was a major concern in the early stages of Developing the POSTC-PET recycling process. The high Volatility of acetaldehyde means that it can be minimized By processing under vacuum or by drying [9]. Stabilizers Such as (4-aminobenzoic acid, diphenylamine and 4,5-Dihydroxybenzoic acid) are added to PET in order to Minimize the amount of the generated acetaldehyde [31].

Other contaminants

The public use of PET bottles for storing other substances such as detergents, fuel, pesticides, etc. The remains of these substances could be a health hazard if Traces of these substances remain after POSTC-PET Recycling [32]. The increase of peoples awareness of The danger of storing the materials inflicts to public Health has minimized the amount of these contaminants Significantly.

POSTC-PET conventional recycling processes

Two major processes have been applied in order to Recycle POSTC-PET flakes. These processes are chemical recycling and mechanical recycling.

Chemical recycling

Chemical recycling (chemolysis) of POSTC-PET is Achieved by total depolymerisation into monomers or Partial depolymerisation into oligomers. The chemicals Used for the depolymerisation of PET include water (hydrolysis), methanol (methanolysis) and EG (glycolysis) [33,34–35].

Mechanical recycling

The mechanical recycling of POSTC-PET normally Consists of contamination removal by sorting and washing, drying and melt processing. In this section theMechanical recycling of PET flakes originating from POSTC-bottles is described.

Extrusion molding :

Extrusion molding: It is a method that relies on continuous annealing of polymeric materials in the annealing system of the extrusion machine and pushing it forward, then it is extruded through a channel called the mold or die. Push and extrusion head. The idea of extrusion started in 1879 from the inventor: M. Graye in England/United Kingdom.

The extrusion process plays a prominent role In forming thermoplastic polymeric products, thermosets, and rubber. Extrusion, unlike injection molding, is a continuous process, and can be adapted to produce a wide range of finished or semifinished products, including tubes, sheets, films, and wire sheathing [36, 37, 38, 39].

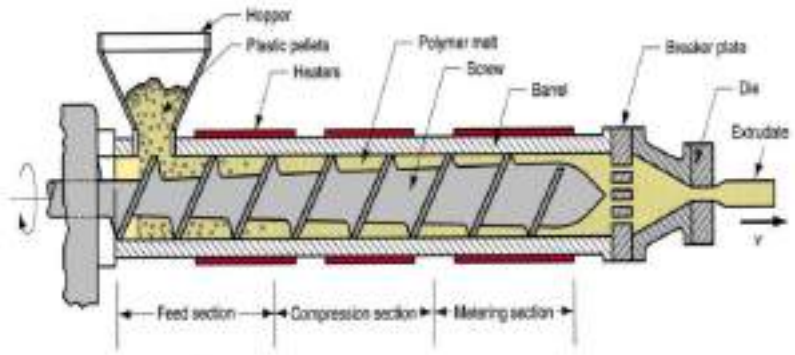


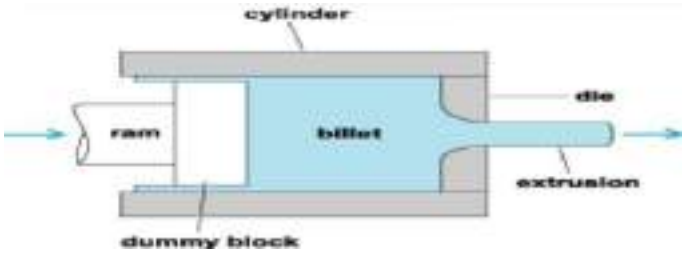
Fig. 1.3 Components and features of a (single-screw) extruder for polymers and elastomers

WHAT IS EXTRUSION?

-Extrusion is the process by which a block/billet of metal is reduced In cross section by forcing it to flow through a die orifice under high Pressure.

- In general, extrusion is used to produce cylindrical bars or hollow Tubes or for the starting stock for drawn rod, cold extrusion or Forged products.Most metals are hot extruded due to large amount of forces required In extrusion. Complex shape can be extruded from the more readily Extrudable metals such as Aluminium.

- The products obtained are also Called extrusion.

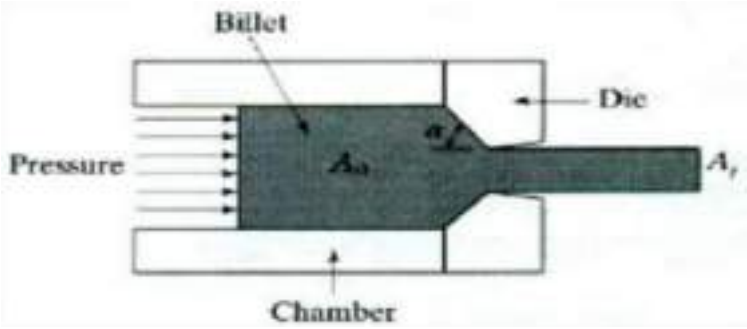


- The reaction of extrusion billet with the container and die results in high Compressive stresses which are effective in reducing cracking of Materials during primary breakdown from the ingot.

- This helps to increase the utilization of extrusion in the working of Metals that are difficult to form like stainless steels, nickel-based alloys, And other high temperature materials.

- Similar to forging, lower ram force and a fine grained recrystallized Structure are possible in hot extrusion.

- However, better surface finish and higher strengths (strain hardened Metals) are provided by cold extrusion.



Polymers Extrusion Process:

In the series of extrusion processes, the screw (snail) is responsible for mixing homogeneity and pushing the molten material into the mold. For the annealing system, it is the same as in the injection process, except for the presence of additional fans to regulate the heating process. At the end of the cylinder there is a filter, and in some extrusion machines there is In the cylinder is a relief valve to expel excess gases and vapors. The

important quantities (variables) in the extrusion machine are degreesspeed and time, when the product comes out of the mold it falls into a basin of water for purpose Refrigeration, and there are other ways to cool the product, such as: air fans. Heat,

The extrusion process is easy, but there are some problems when extruding some materials, such as:

Thermosetting materials and rubber, the polymeric material takes the shape of the mold according to the section to be produced. It is the ideal way to manufacture shapes of standard sizes such as rods, tubes, strips and plates. It is also suitable for thermosets, such as the process of manufacturing pipes and films mentioned above.

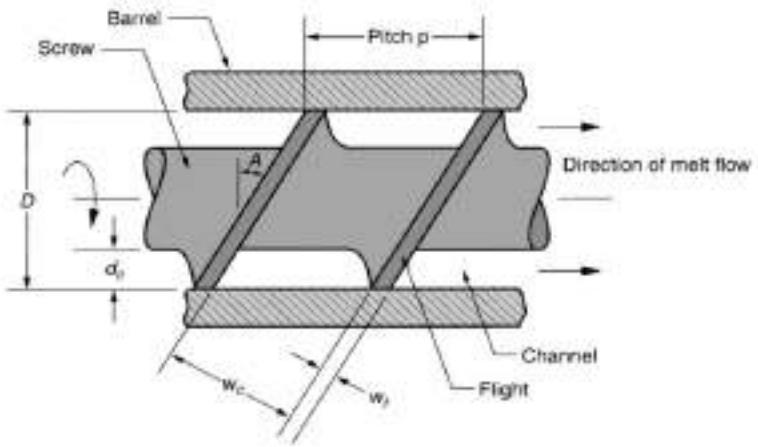


Fig. 2.3 shows a section of a single-screw extruder [40]

When talking about systems operating in extrusion machines, some basics must be addressed, including the propulsion system in these machines, so the following conditions must be met in it:

- Good stability.
- Wide limits of circular speed change = 1:10 with high efficiency.

of the circular speed of the screw when loads change from (0-100).

- Stability or little change in the circular torque In terms of the circular speed.
- choosing the angle of inclination of the snail roll according to the properties of the material.
- ease of maintenance and repair, and low costs.

Extrusion Process Variables:

There are several important variables for the extrusion process, including (temperature, speed, time) and others according to the physical properties of the material, especially fluidity and flow, and each variable is determined by laboratory tests.

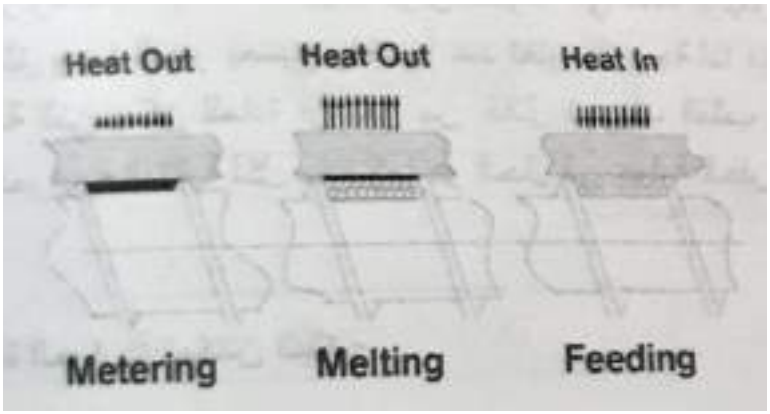


Figure 3.4 shows a section of the screw and its three divisions: feeding zone, melting zone and zone Calibration [36]

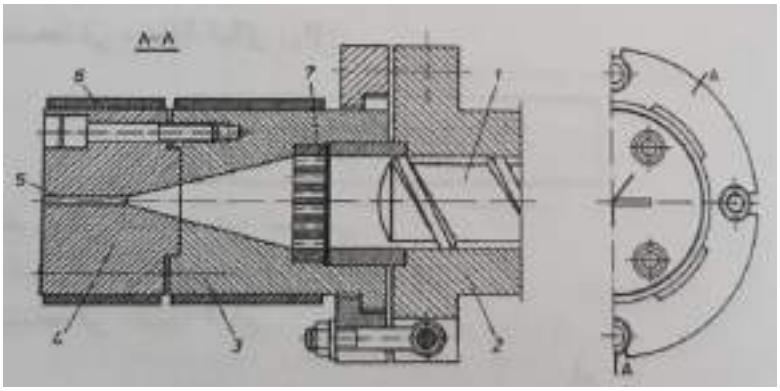


Figure 3. 5. Extrusion Die Shows 1. Screw, 2. Roller, 3. Head Cover, 4. Head End, 5. Buffer, 6. Heaters, 7. Filter [38]

There are other types of extrusion, including:

1- Piston formation: It is done by pushing a piston for polymeric materials in the form of powders

(pressing method), especially for PTFE,

2- Thermoforming: that is, the plasticization of polymeric materials through friction,

3- Mixed forming: two or more materials are extruded,

4- Forming with a twin-screw extruder: it is done with two screws in one cylinder,

5- Covering: It is covered with electrical wires and others.

6- Vacuum formation: by compressing or pushing a gas or a liquid substance polymeric.

There are two types of extruders: single-screw (snail) extruders and twin-screw (snail) extruders, as the two-screw machines are usually used for PVC.

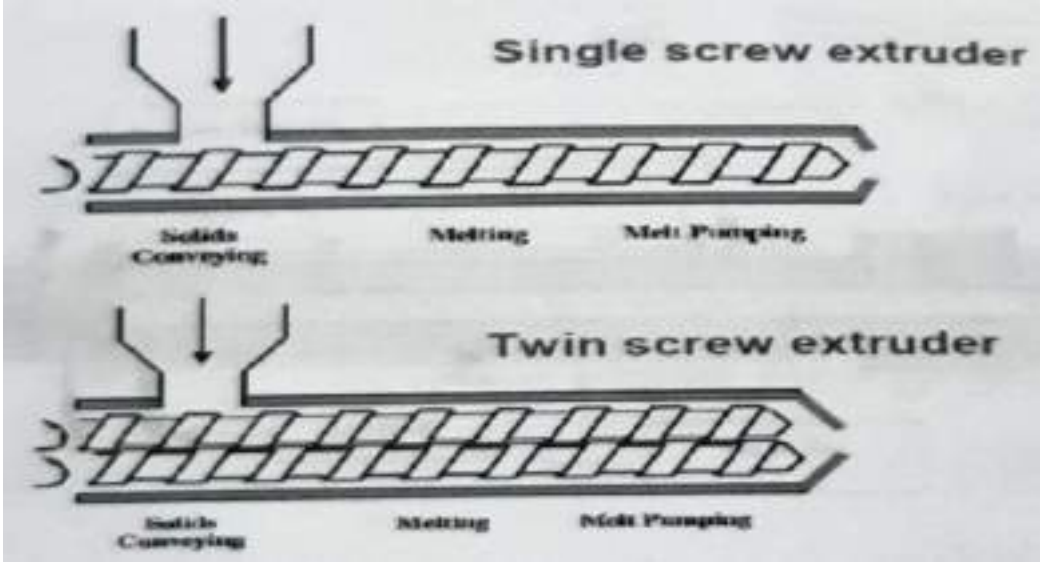


Figure 3.8. Shows a section of single and twin extruders [40]

The most important basics of the extrusion process:

There must be some design conditions and formation conditions that determine the type and quality of the product, so we have to study them in detail, because we studied the process techniques in general above. [36, 37, 38, 41]

Alqalb (Istanbul):

It is the most important element in extrusion machines, and it determines the shape of the product, so the molten material must pass through the nozzle (mold) with specific pressure (push), viscosity, and temperature, according to the extrusion specifications, and it continues until the end of the mold, i.e. until the material exits the mold, if These variables correlate with the time to supply a constant source of molten material polymeric materials to the mold through a pre-mould filter material with a cooling system unit.

Important note: When the molten polymer comes out of the mold, many of its molecules are oriented in a direction parallel to the axis of the mold opening, then the molecules are no longer bound by the heart wall. Die Swell at the end of the die, unless the product is made more frequently and continuously, extruded and shown with cross-sections greater than those in the die opening, in the die the thermoplastic polymer particles consist of long chains that tend to be coiled randomly,

when flowing this material or paid Through the die, the particles become straight or partially oriented.
Under normal circumstances, Die Swell can be reduced as follows:
- reduce extrusion rate.
- Increase the melt temperature (keep the extrusion rate constant).
- increase the length of the template area.
- Increase the extrusion rate (ratio of extrusion to normal extrusiorate) without affecting the The resulting.

Filtration Unit (Filter Filter):
There is often a strainer or filter disc installed between the drum and the mould.
The filter disc has the following functions:
A. helps to increase back pressure.
B. It converts the rotary flow of melt into a flow parallel to the axis of the screw.
C. prevents the passage of impurities.
D. Unplasticized materials are prohibited.

Withdrawal unit:
Its function is to pull the products out of the extrusion so that the above phenomenon does not occur. The pulling of the extrusion product must be at a uniform speed without slipping. This ensures that we can pull the dimensions unchanged after the mold, and this is related to the final size of the product.

Cutting Devices:
Cutting devices are very precise equipment because some products need Cutting to a specific length.
The most important thing to know about extrusion molding is: Understand the annealing system temperature path and the material forming temperature.
Optimal screw design to handle the required polymer Understanding the function of the material filter Understanding the molten shrinkage rate by decreasing temperature.
Uniform cooling around (or along) the exit area of the mold is very important.
Usually, the extrusion process is processed by mixing some additives with the material to improve its workability for manufacturing. In order to obtain a high quality product, it is necessary to have a stable

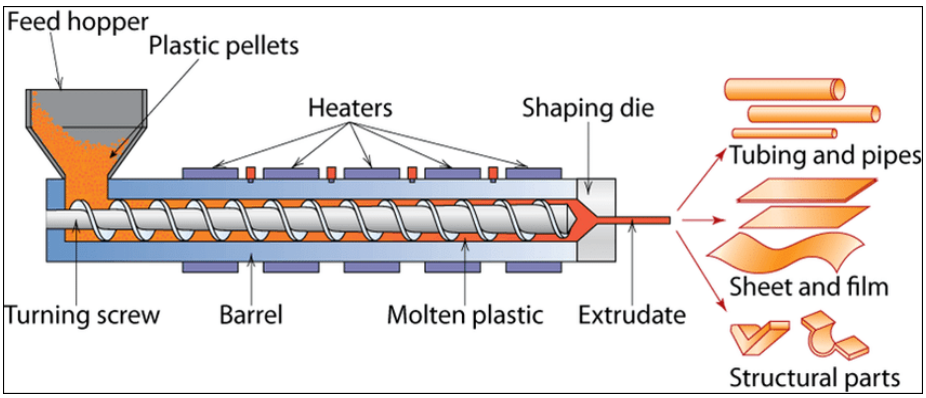
heat transfer and transfer uniformly on the granules to soften them (forming temperature) by pressing with a rotating screw at a specific speed and this circular motion is derived in the inside of the cylinder by making the resulting molten have the ability to flow under some pressure The material is gear box and electric motor.

Melting temperature control:

In order to melt the granules, heat is generated either internally by friction or by applying external heat through heaters (electrical resistance around the cylinder). If the weather is too cold, it will not be sufficiently plastic, resulting in temperature differences also in the occurrence of differences in flow rate, overheating of the cylinder can be prevented by cooling it with water or by pushing air strong around.

Extrusion Products:

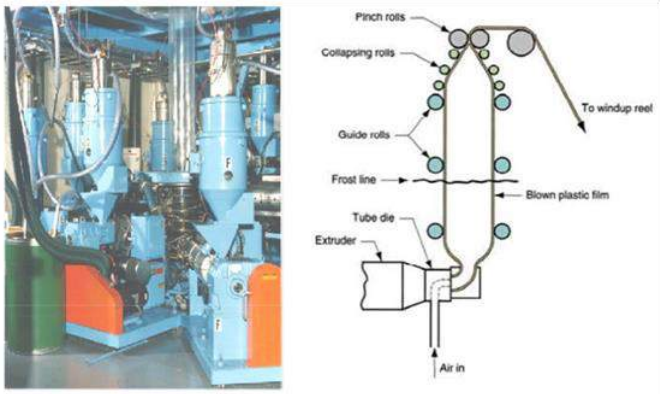
- Compounded polymers:
- Pipes
- Window frames
- Adhesive tapes
- Wire insulation



Inflatable extrusion strips:

This technical method used in the production of the same panels only is that the mold summit will be in the form of tubular cavity in which the strip is stretched by the tape as a cylindrical form called the bubble, and during the hardening of the bubble is pressed from The two sides between two

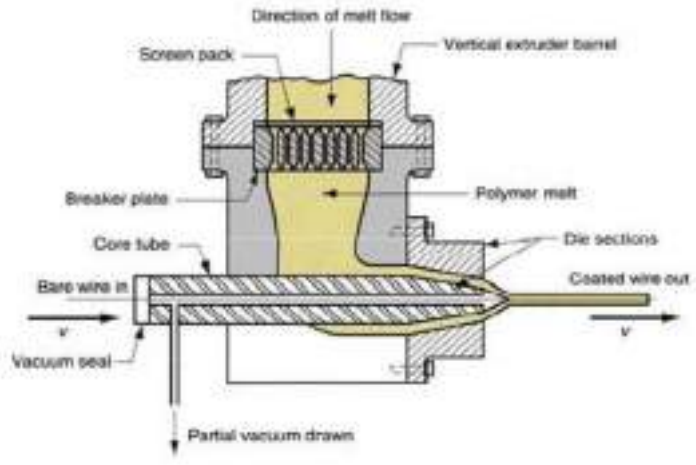
bindings to configure a double fish bar has been practically found to be extruded and received the product from the bottom to the top and then flatten them between the two pokers and carry them into the roller roller, and this method is used in the work of polymer strips to use in large body body coverage Relatively as the machines and cars are used for agricultural covers … etc, strips can be cut on short distances and their mother from one end to give us the bags or light bags.



The shape Illustrates the method of producing hollow panels and movies

Extrusion for wire cover:

One of the most important practical applications for extrusion method is covered metal wire and cables with electric polymeric polymeric and corrosion resistant and different weather conditions, practically similar to the extrusion method where the metal wire is passing Covering and during the passage of hot polymeric substance through the mold, it surrounds the hot metal wire (its temperature as a miquacity of the polymer) and goes out as one unit of the mold where it is cold and the cable Requirements with standard reluctance and lengths, and common resins are used to cover wires and cable polyethylene resin, polyethylene and nylon, sometimes used silicon resin for high-resistant cables.



Shape illustrates the electrical wiring method

After research and studies on extrusion of polymeric materials show that improved designs for extrusion machines, including a large diameter design, will give the extrusion process:

1. Improved polymer fusion,
2. Disposal of moisture,
3. Disposal of volatile gases from molten.

The design solutions of the Cylinder Extrusion Machine:

(Extruder Barrel) The extrusion cylinder must be solid to bear high pressure from the polymer molten, a good heat conductor, heat transmission of The steamers to the material by roller, the volume of extrusion machine is determined by the internal diameter of the cylinder, which is (2.5-15 cm, and the rate of length is L / D and is about (5-34), where in case of short means L / D Less than 20 is used for manufacturing elastomers (elastomers) and in the case of large L / D maternels is greater than 20 and used for thermoplastics and is necessary to dry the polymer granules before entering The cylinder, the entry point of nutrition (Hopper) should be cooled using rotary water (Circulating water) to avoid the rise of heat to the so-so in this case the granules will be smelter and are still in force Thus turning into a solid mass leading to the closed of entry, the temperature of the roller is controlled by electric stores that are controlled by (thermocouple) is installed on the inner surface of the cylinder outside the layer The resistance is close to the pulmonary molten, and the temperature of the Thermocouple of another type, the rotation of the Polymri molten around the spiral leads to the heat transfer by delivery from the molten stacks and then To the lamb, it allows the extrusion process to continue even if the workshops are being suspended (tireless-manufactured steel with high thermal conductivity), extrusion cylinders are currently equipped with a heating and cooling system with the same time that allows By reducing heat in case height than the scheduled limit (high temperature can cause change in the matter of polymerism and also reduce its mechanical properties), and the design of pulses attracted significant attention by companies in recent years.

General Notes:

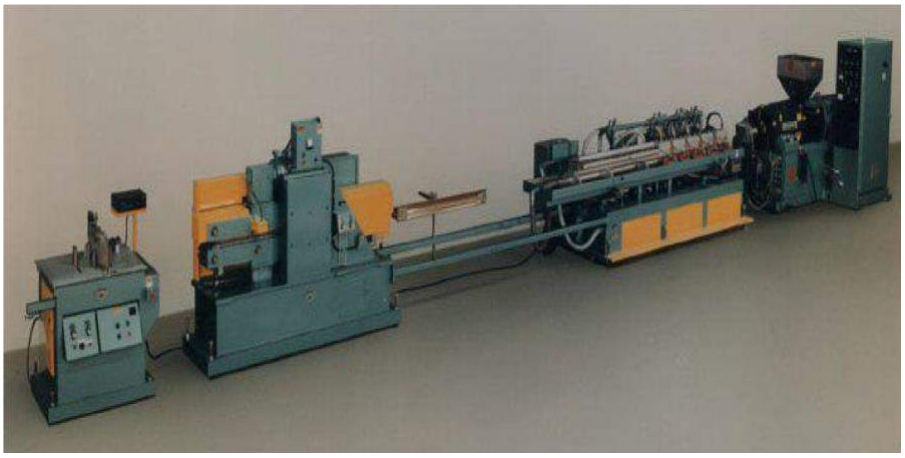
1. Polymer granules, whether in solid or molten, both devoid of emptying between fins and rollers, and is paid along the front edge (Forward Edge) for the driving army (Forward Edge) Pushing Flight), 2. The vacuum (Clearance) between the roller and the fox-finder edge is very small by 0.01 mm and is constant along the spiral, 3. The fins and interior surface of the

cylinder are made of stainless steel to resist wear, 4. The roller must bear the 100 MPA pressure without flexible deformation (elastic deformation) and about 0.15% Strain, which has to crack the plating layer for wear. 5. Solid granules possess greater size than the same amount if they were gum, 6. At a lot of times are also added to colors, antioxidants, antimicrobials and antibucolis at every batch of about 15 – 30%,

The design of the length of each region In the screw varies according to the type of polymeric material to be manufactured as follows:

1. Polymers, such as PVC, which tend to thermally decompose and melt slowly, can be manufactured using a screw whose total length is a compression zone, and sometimes a metering zone is added.
2. For some polymers such as nylon, the transition region in the spiral design has only one bend,

3. For partial fusion polymers, such as LDPE, the total length of the spiral is divided into three equal regions,
4. A three-zone screw with a vent section in which the pressure is reduced to allow gases to escape from the polymer melt by vacuum, or the gases are vented through a vent hole punched on the cylinder walls (relief valve)



Determination of residence time distribution:

The distinctive and important factor is the impact of relaxing time on product quality and knowing the importance of distributing relaxation time for:

- Sensitive products for heating, destination and fusion.

– The confusion process is inside.

– Time to stay fluid in the flourish.

Incoming raw material inspection:

In these manufacturing process products are constant and resin properties will be critical value for his proof and stability of the manufacturing process. It is very important to be able to measure the physical and manufacturing features of the resin that will be made depending on a regular base. This type of examination gives a good realization and awareness of the regular examination that will believe that resin is used in manufacturing processes which will not turn into useless waste in extrusion line. The properties of resin measured and registered include: resin density, fusion index (fusion manual), shear rate for viscosity and tensile resistance. Other optical scale method is external pressure on slim and smoke resin films Hydraulically, this is an advance look at extrusion for the resin after fused and is formed. This method is characterized by a clear or colored look for quantities of polluted or non-minted minutes in the next resin batch. And that person-based person Extrusion can train to perform these basic exams for resin, however, he is responsible at the end of today about the output of good extrusion at the end of the production line.

Resin handling for moisture content and temperature:

The other Important measurement factor is resin moisture content and resin temperature only before extrusion process. Some resins are professional moisture, hydroscopic which is the material sucks water from the air and ambient environment. But others are unprecedented resins but still gathering and storing superficial moisture which affect the continuity of extrusion. Many existing companies are equipped with dried resins and transport and heating equipment. Most waterproof resins require moisture content about 4 …% of common waterproof resins and include: nylon, polyurethane, polytra floro and ethylene and other materials. Moisture content is changing from resin to another. There are more dry resins but for some certain amount resins of moisture be necessary for efficient and moisture manufacturing process can affect as a millennium. Where dried resins are too dried to make non-melted resin and the manufacturing wife is very high and therefore makes resin non-manufacturing. By heating resin before extrusion, extrusion gives fixed requirements of heat, melting and mixing of resin, and the process starts from the same resin temperature, if

the resin is added to suppress the essence (6. Fahrenheit) Manufacturing is quite different when adding a temperature resin) 0. Fahrenheit.

Resin storage and conveyance:

Usually useful resin storage in dry and clean area and away from pollution source and save them away from ocean temperature changes. Some companies store resin in bags or in warehouses and when resin is initiated for use, it is in a way to suppress the flourish.

Gravimetric resin feeding:

When resin feeds to the flour, there are usually two ways to feed resin used to feed resin, the first called

flood feeding:

any frequent nutrition) FLOOD FEEDING (and the other type is called reformative nutrition The few (Trickle) is the easiest and common way to use and in this nutrition. Resin is added to the suppression of excessive until filling repression and resin falls on a spiral Nutrition by gravity to move down the extrusion pot. Resin and powder pellets will fill nutrition wings How can this.

Trickle, or starve feeding:

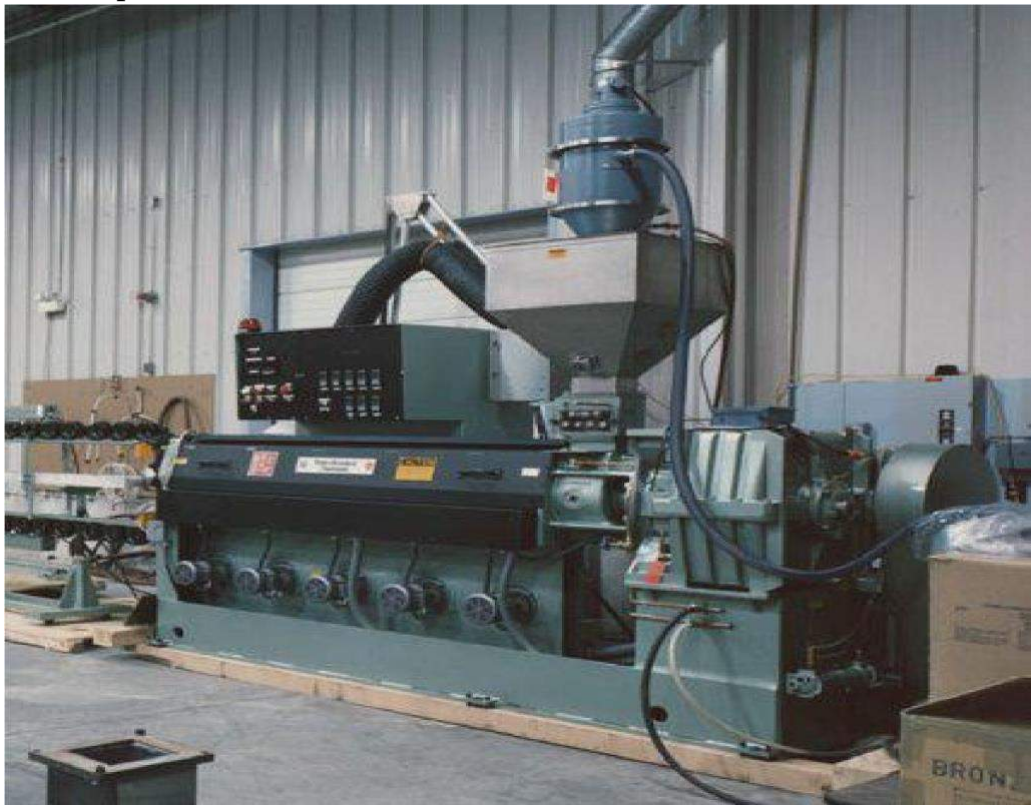
here resin is pellets or powder Added to repression and then to the nutrition screw at a dominant rate and are known and usually governed by weight. The equipment known as gravity nutrients are used to control the resin delivery rate to nutrition. Nothing is used for gravity Manufacturing processes that manufacture multi-layer products especially when resin layers are thin and difficult measurement after extrusion of the product.

Selection criteria :

Performance requirements are successfully satisfied when the product comes with enough fusion of resin and molten combined at a fixed temperature and constant pressure.

When the preacher is determined for the manufacturing process, the factors required to take into account:

Diameter, L / D Ratio L / D RPM RPM (RPM) RPM (, Nutrition, Horse Wood and Disposable Design, Distribution of Population Capacity, Distribution of Cooling Areas, Cooling To vent, need to cool the feeding for nutrition design for nutrition and steel face for potted lining, arrangement of control devices. It is enough to say in this research that the function of the pipe and hoses and channels is delivering a homogeneous material With a regular and static rate and constant vertical pressure and fixed melting temperature. It is easy to say more than the achievements. Many of the work variables lead to large or few changes in the manufacturing process that appears in the quality and quality of your excessive product.



Davis Standard Image.

Controlled and monitored parameters :

The controlled factors typically consist of areas (for nutrition control, extruder pot areas and extrusion connection space. The other dominant factor is) the speed of feeding in RPM (and two working persons must be a bit Access to the condition of the state of the prostitution.

Thermocouples and RTDs:

That compared to the use of thermal duals with the RTDs in the extrusion of pipes, hoses and channels are not endless comparison. Heat detection resistors (RTDs) are more accurate than thermal durables without doubt, and RTDs are usually accurate and reflectable within (0.1 ° F). The traditional type of thermal dysfunction is particularly wrong and For repetition within) ± 1.0 ° F (thermal dormitors are more durable than) RTDs (and without doubt. Thermal and RTDs are used in links and extruders. Dual thermal is more than RTD. RTDs are more expensive than the thermal dual by) 4 – 1. (times as accuracy has a price.

Instrument calibratio :

It is not certain enough that temperature, pressure, RPM, which need to calibrate on bases and regular bases. Readings on tools tend to decrease over time if the tools are not calibrated regularly, and that the majority of extrusion and installations have the control tools and measurements of calibration twice per year.

Product cut-off device or winding equipment :

When producing pipes, hoses and channels, they need at the end of production to cut specific lengths to end up to turn them on a reel. But of course in the case of solid tubular products, the process is specific with special cutting devices that range from cutting knives for small products to extreme saws for large products. If the product is very fast, it can not be wrapped on the reel and therefore should be cut into certain lengths, but if the product is flexible and then we choose chipping or winding. Figure shows a cutter with flexible tubular products where high lengths are required here.

Figure shows a cutter with knives for flexible tubal products, which requires high lengths.

Extrusion techniques:

1.Direct Extrusion:

Direct extrusion, also called front extrusion, is one of the most common processes and involves placing molten granules into a thick-walled hopper and then forcing the molten granules into the die head by means of a piston or screw.

The main disadvantage of this process is that the force required to extrude the molten is higher than the force required in the case of indirect extrusion, and the reason is due to the friction forces required for the need

The granules to move along the warehouse

2.Indirect Extrusion:

In indirect extrusion, also known as back extrusion, the molten particles The warehouse moves with each other while the die bit is fixed in its position by a barrier, which must be longer than the warehouse, and this leads to the following advantages:

1. Must be longer than the warehouse, and this leads to the following advantages.
2. Increased speed, increased extrusion ability of small cross-sections
3. Less prone to cracking due to no heat generation from friction Longevity of use of the warehouse due to less wear and tear
4. Reducing friction by 25-30%, which allows for the production of larger products.
5. The granules used in extrusion are of equal size, so extrusion defects are less likely to occur.

As for its disadvantages, they are:

Deformations on the surface of the granules that lead to the destruction of the product if what is required is a piece with a good surface finish. To get rid of this, the granules must be cleaned or chemically washed before use.

3.Hydrostatic extrusion

The fluid is stabilized using limited heat, the process is carried out using a sealed cylinder in order to maintain the hydrostatic medium, and the seal can be pressurized Using two methods:

-Constant-rate extrusion where a piston is used to compress Fluid in the warehouse .

-Constant-pressure extrusion A high-pressure compressor is used to pump the fluid into the reservoir .

Advantages and disadvantages in hydrostatic extrusion

Advantage

- Pressure = 1400 Mpa (approx.)

- Elimination of large friction force between the billet and the container wall.

- Possible to use dies with a very low semi cone angle (α-200).

- This process can be done hot, warm, or cold, however the temperature is limited by The stability of the fluid used.

Limitations:

- Not suitable for hot-working due to pressurized liquid.

- A practical limit on fluid pressure is around 1.7Gpa currently exists because of the Strength of the container.

- The liquid should not solidify at high pressure this limits the obtainable.

Applications:

- Making wires of less ductile materials

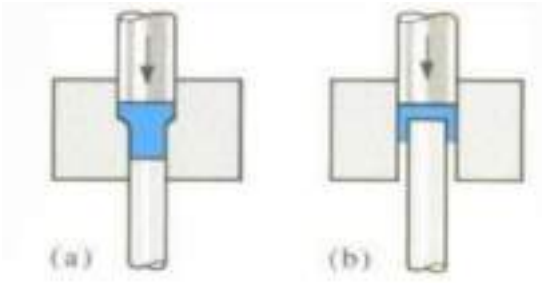
- Nuclear reactor fuel rods

Forward extrusion:

- Metal is forced to flow in the same direction as the punch.

- The punch closely fits the die cavity to prevent backward flow of the

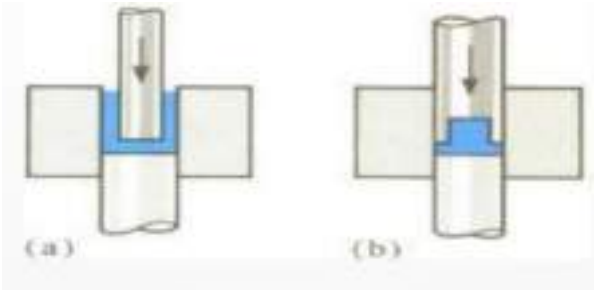
Material.



Backward Extrusion:

- Metal is forced to flow in the direction opposite to the punch movement.

- Metal can also be forced to flow into recesses in the punch, see Fig



Cold extrusion:

- Cold extrusion is the process done at room temperature or slightly elevated Temperatures. This process can be used for materials that can withstand the Stresses created by extrusion.

- Materials that are commonly cold extruded include: lead, tin, aluminum, Copper, zirconium, titanium, molybdenum, beryllium, vanadium, niobium, And steel. Examples of products produced by this process are: collapsible Tubes, fire extinguisher cases, shock absorber cylinders and gear blanks.

Advantages

-No oxidation takes place.

- Good mechanical properties due to severe cold working as long as the Temperatures created are below the re- crystallization temperature.

-Good surface finish with the use of proper lubricants

Hot Extrusion:

-Hot extrusion is a hot working process, which means it is done above the Material's recrystallization temperature to keep the material from work

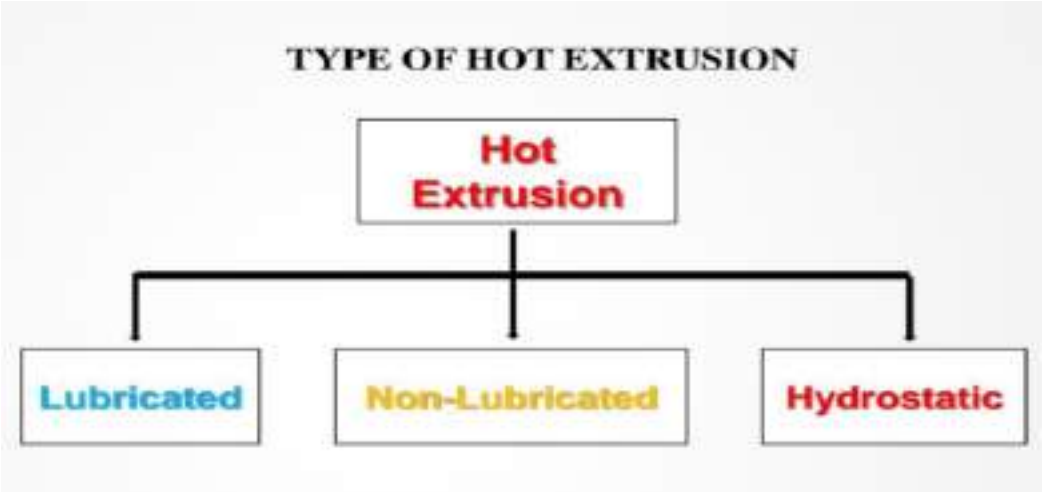
Hardening and to make it easier to push the material through the die. The

Biggest disadvantage of this process is its cost for machinery.

- Hot extrusion is done at fairly high temperatures, approximately 50 to 75% of The melting point of the metal. The pressure can range from 35-700 Mpa

-Due to the high temperature and pressure and its detrimental effect on the die Life as well as other components,

Good lubrication is necessary. Oil and Graphite work at lower temperatures, Whereas at higher temperatures glass Powder is used.



Lubricated Hot Extrusion:

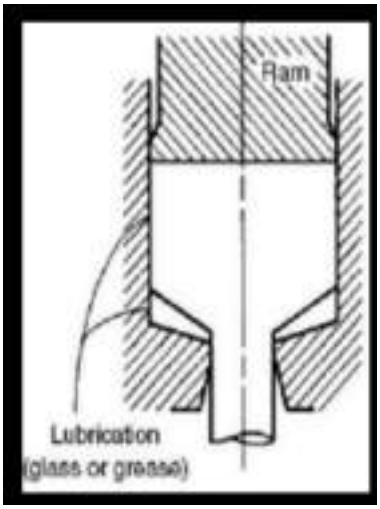
- Before the billet is inserted into the hot extrusion container, a suitable

Lubricating system is positioned immediately ahead of the die in order to

Reduce frictional stresses.

- Oil and graphite are used at lower temperature whereas at higher Temperatures, glass powder is used.

- Copper alloys, titanium alloys, alloy steels, Stainless steels, and tool steels Are extruded using lubrication.

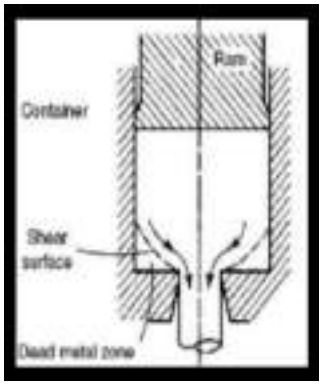


Non-Lubricated Hot Extrusion:

- No lubrication is used on the billet, container, or die for reducing frictional Stresses.

- It has the ability to produce very complex sections with excellent surface Finishes and low dimensional tolerances.

- Solid and hollow dies with flat shear faces are typically used.

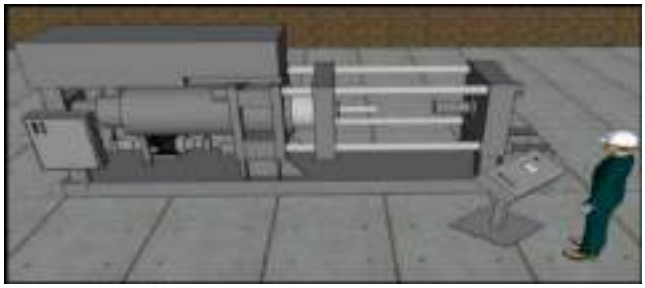


Horizontal extrusion presses

- The layout of operating machine is horizontal and movement of billet as well As of ram is horizontal in direction.

- 15-50 MN capacity.

- It is mostly used for commercial extrusion of bars and shapes.



Vertical extrusion presses

- The movement of billet and ram is vertical in orientation.

- 3-20 MN capacity.

- Mainly used in the production of thin-wall tubing.

Die Materials

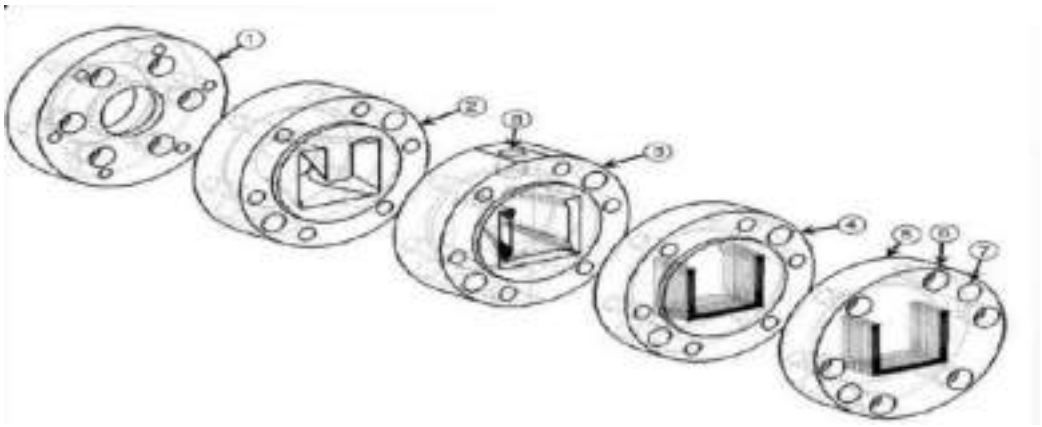
- Dies are made from highly alloy tools steels or ceramics

- Commonly used materials are Tool Steels and Carbides

- For improved wear resistance, steel dies may be chromium plated, and carbide Dies may be coated with titanium nitride

- For Hot drawing, cast-steel dies are used .

- Heat treatments such as nitriding are required (several times) to increase Hardness (1000-1100 Hvor 65-70 HRC). This improves die life.



There are two general types of extrusion dies:

- Flat-faced dies

-Dies with conical entrance angle

(1)extruder mounting plate; (2) die adapter Plate; (3) transition plate; (4) preland plate; (5) Die land plate; (6) die bolt hole; (7) alignment Dowel pin hole; (8) thermocouple well;

Among the advantages of this technology are:

1.There is no friction between the depositor and the granules, which reduces the external forces required and the heat generated from friction, and this allows for a high speed extrusion process.

2.Large cross sections can be extruded.

3.There is no fuse left in the warehouse .

As for the disadvantages of this technique:

-The presence of surface defects, so the surface of the granules must be treated to remove them.

-Difficulty containing fluid under high pressures.

Advantage of the extrusion process in general Process:

1. In the case of hot extrusion, post adjustments are easy because the product is still In heating condition.

2- Continuous operation.

3- The output quantity is high.
4- surface finish is obtained well.

5- Good mechanical properties.

Disadvantages of the extrusion process:

1- The initial preparations and steps are high in cost and the difference in the size and dimensions of the product
2- Product restriction due to only one type of cross-section obtained at a specific time.

Extrusion Process Parameters: Processing Parameters

The important quantities of the extrusion process are similar to the important quantities in the injection molding process, which are the material forming temperature and the screw speed. Other secondary variables such as pressure, material moisture, and the electric current of the screw drive are controlled and monitored to give a good homogeneity of the molten. The tolerance of common extrusion products is in the order of % 1 of the measured value and that any factor that stabilizes any amount is an important factor for the process [36,37, 39, 41]

Extruder and extrusion applications Practical variables in product development :

There are three major types of extruders being used in the Food industry; piston extruders, roller-type extruders, and Screw extruders. Screw

extruders are most common extruders Used these days and can be categorized as single and twin Screw extruders.

Single Screw Extruder :

As the name suggests, the single-screw extruder has a single Archimedian screw that rotates in a heated metal barrel. Unlike Twin-screw machines, which require material to be dosed into The screw to prevent an overload, solid material enters the barrel Through a gravity feed hopper at the feed throat. This material is Conveyed along the extruder barrel by the action of the screw. The Material is plasticated during this action and then passes through A breaker plate before exiting at the die. A breaker plate is used To take the rotation out of the melt. Without a breaker plate, the

Material would spiral out of the die in line with the movement of The screw. It also helps to build up pressure in the melt. A breaker Plate is illustrated in Figure 6.3. As the die also acts as a fl ow Restricter, pressure is required to force the melt through. This is Referred to as die head pressure and varies according to the size of The die and the speed and fl ow properties of the melt. The layout Of an extruder is given in Figure 6.4.

Figure 6.3 Breaker plate

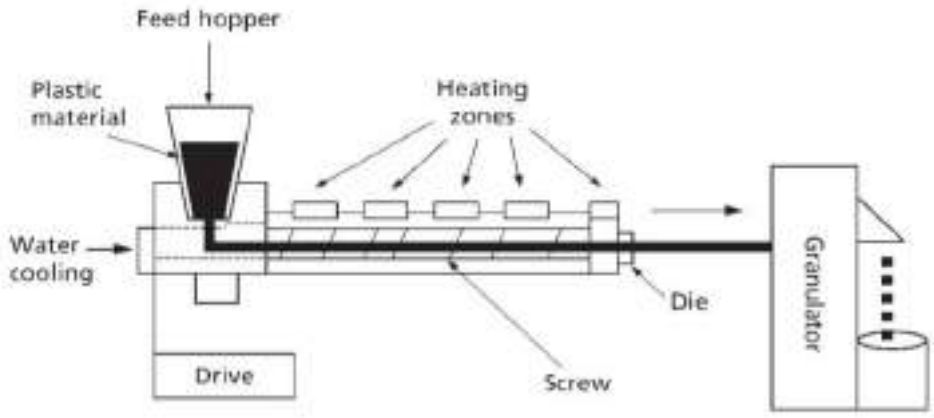


Figure 6.4 Schematic of an extruder

Twin Screw Extruder:

A twin-screw extruder can have either counter-rotating or corotating screws. Co-rotating twin-screw extruders are used mainly For compounding. Counter-rotating screws are generally used in The processing of heat sensitive materials, such as polyvinylchloride (PVC) pipes and sheets. They are especially suited to heat sensitive Materials, because they allow greater temperature control.

The aim of both types of screw is plastication, that is, to produce an Easily formable melt stream. The temperature of extrusion will fall

Between the melting point of the polymer as a minimum, otherwise The polymer simply will not fl ow, but below the onset of thermal degradation to prevent excessive damage to the compound. The Heating of the material is carried out by means of external heating Zones, which are incorporated into the body of the machine. The Number of zones will depend on the size of the extruder, generally They are positioned at the point of input, the centre region of the Screw and the point of output. These correspond to the conveying Section, the transition (melting) region and metering section, and fi nally the exit die region. This allows the temperature to be varied Across the length of the screw. Generally, the temperatures will be Profi led, to be coolest at the point of input to aid with material Feed, and hottest at the point of exit. The latter is to compensate For the extra heat that will be lost from the material in this region. The twin-screw is a very effective

mixer and also ensures both An evenly dispersed mixture and an even temperature across the Exiting material. Because of the combination of feeding and screw action, twin-screw Extruders can produce compounds with very low levels of polymers, In some cases less than 20%. The single-screw extruder cannot Cope with such high levels of non-polymeric materials. However, For melt blending of virgin and recyclates or adding relatively low Levels of additives the single-screw extruder is an effective method For mixing and compounding a plastic mixture.

Both single- and twin-screw extruders can be confi gured for Particular polymeric materials. This can include the design of the Screw to control levels of mixing, the use of vents to aid in removing Volatiles or, in the case of twin-screws, additional feeding units Can be incorporated downstream of the polymer feed. Extruders Can also be used to make fi nished or semi-fi nished goods such As solid profi les (bars), hollow profi les (window frames), pipes, Films, sheets and fi laments, as discussed earlier. If the product is a Granular material, it will fi nd use as feedstock for other processes, For example, injection moulding or blow moulding.

Co-Extrusion :

For some applications, two different materials with differing Properties are used together. Co-extrusion may be carried out to Produce the component. Each material requires an individual extruder Which feeds into a special co-extrusion die where the melts can be combined as required. Multi-layer pipes and sheets can be produced, Which enables recyclate materials to be sandwiched between virgin Material outer layers if required. Multi-layer technologies are not Limited to extrusion, it is also possible to create multi-layers using Injection moulding, blow moulding and fi lm blowing.

Extrusion Defects

1) Inhomogeneous deformation -

- In direct extrusion, a dead zone along the outer surface of the billet due to the Movement of metal in the center being higher than the periphery.

- After 2/3 of the billet is extruded, the outer surface of the billet (normally with Oxidized skin) moves toward the center and extrudes to the through the die,Resulting in internal oxide stringers. – transverse section can be seen as an Annular ring of oxide.

2) Surface cracking

- It is the ranging from a badly roughened surface to repetitive transverse

Cracking called fir-tree cracking.

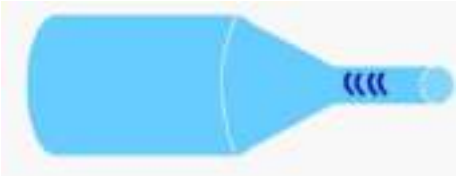
- It is due to longitudinal tensile stresses generated as the extrusion passes Through the die.

- In hot extrusion, this form of cracking usually is intergranular and is

Associated with hot shortness.

- The most common case is too high ram speed for the extrusion

Temperature.

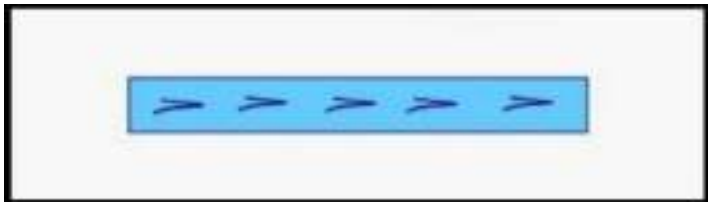


3) Centre burst or chevron cracking

- It can occur at low extrusion ratio due to low frictional conditions on the Zone of deformation at the extrusion die.

- High friction(at a the tool-billet interface).

- Low friction center burst.

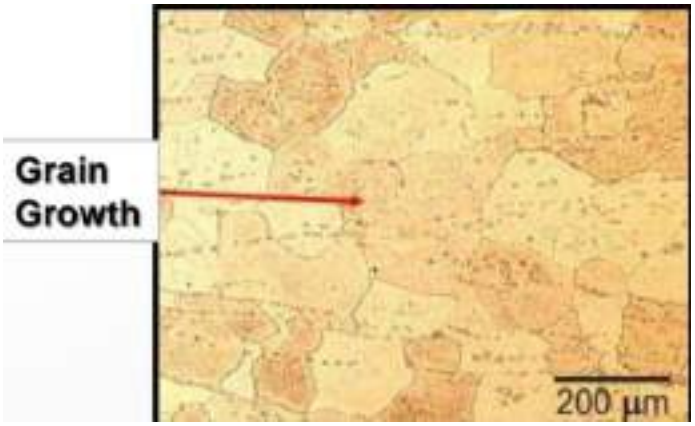


4) Variations in structure and properties

- Structure & properties are varied within the extrusions due to nonuniform deformation for example at the front and the back of the

Extrusion in both longitudinal and transverse directions.

- Regions of exaggerated Grain growth, due to high Hot working temperature.



5) Hot shortness (in aluminum extrusion)

- High temperatures generated cause incipient melting, which causes Cracking.

Types of Extrusion defects:

- Surface Cracking
- Internal Cracking
- Piping Defect

Surface Cracking

Surface cracks are developed due to

• High extrusion temperature

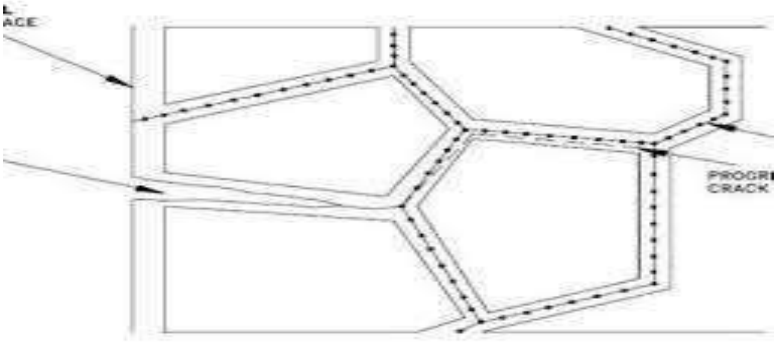
•High screw speed

• High Friction

It occurs at High temperature such as Hot hardness

• Can also occur at low temperature

• These cracks are intergranular



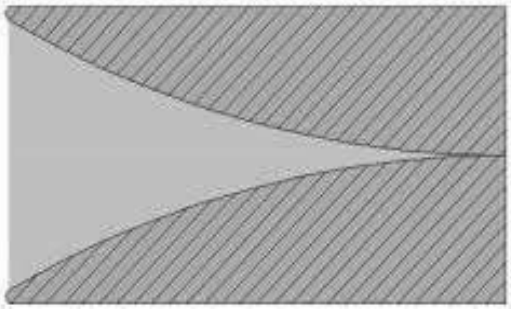
Internal cracking

- Cracks are developed in the center of extruded material
- This is also named as
- Center Cracking
- Center Burst
- Chevron Cracking
- Arrow head Cracking
- These are hard to detect in the material
- It occurs due to difference in velocity and tensile stresses in center of the material
- These can be prevented by using appropriate
- Die angle
- Friction
- Extrusion Ratio

Piping Defect

- It occurs during hot extrusion due to presence of impurities and oxides.
- Propagates as Funnel Shaped Void.

PIPING DEFECT



Chapter Two

Practical part:

Work plan:

Mixing two polypropylene materials with methyl methacrylate, then extruding them in the extrusion machine according to different temperatures and speed ratios And then the samples are tested in tensile test, hardness test and impact test Then study and discuss properties improvement.

The method of work:

1. Collect water cans made from PET and then clean it with hot water and iron soda.
2. They were placed in a cutting machine and turned into granules for the purpose of forming.
3. 50 grams of polypropylene + 50 g from PET were mixed after weight with balance.
4. The mixture is placed in the extrusion machine at 200 temperature and at a different speed of 25-50 rpm.
5. Then both materials were extruded together at the same temperature and different speed.
6. Samples were made for testing: a tensile test, a hardness test, and a impact test.
7. The three tests were carried out on the samples .

Tests:

Tensile test:

In the tensile test, samples were cut with standard dimensions according to ASTM (D1708-02a). This test is done at University of Babylon/ College of Materials Engineering/ Polymer Engineering Department using the model (WDW-5E, China) as Shown in figure. The two ends of the sample were connected to the jaws of the device To start a tensile test at room temperature by computer control, where a tensile force Was applied to the sample by (5kN) and quickly (10mm/ min) until the failure occurred In the sample

Fig. 2. 2. The tensile test device

The concept of tensile testing Tensile testing is one of the most important and simple Physical tests that are carried out on a different set of materials, in order to determine Their suitability for use in various engineering and construction applications to ensure The safety and quality of those applications. This is done by holding its opposite ends With special equipment and pulling it out, and it is worth noting that the process of Applying force in an axial (longitudinal) way continues in this way until the sample is Broken, then a number of its characteristics can be determined, including the amount Of stress, pressure, deformation and many other characteristics that Distinguish the Sample from others. The steps of conducting a tensile test. The process of conducting A tensile test on a sample includes a set of steps, and the following will be mentioned In detail: [9, 10] Preparation of equipment and tools for conducting a tensile test, which Includes the following: A tensile testing machine that fits the nature and type of the Sample to be tested . Dilation meter monitors the expansion phases of the sample while The test is being performed. Special electronic devices or software to operate the tensile Testing machine and record measurements and results while the test is being carried Out. Tension handles suit the nature and type of the sample, as the handles differ According to their working principle and the nature of the face they have. Types of handles, according to their working principle, are wedge handles, self-tightening or Scissors, while the handles are usually serrated in order to hold the two ends of the Sample tightly. Preparation of the test sample by pouring the sample material into Special molds whose shape suits the requirements of the tensile test device to be used, Which is usually in the form of a dog bone. Putting the upper (fixed) and lower (moving) handles designated for conducting the tensile test in the device, as their type And location are compatible with the nature and length of the sample. Placing the Specimen in its correct position between the handles to avoid the application of lateral Tension forces that would cause the specimen to bend during the test, which would Ultimately adversely affect the validity and accuracy of the results. Delivery of the Dilation gauge along the sample to monitor and quantify the change in its length during The test. Start the test by separating the tension knobs at a constant speed depending on The size and shape of the sample. During the test, the sample will expand and then begin To deform until it is broken. Once the sample is broken, the tension test ends. Abstract The tensile test is used to verify the strength and durability of many materials used in Engineering applications such as buildings, and it works on the principle of exposing These materials to a strong force to make sure that they break, and then several Measurements

can be taken, and used in equations, then arriving at the strength of the Material and its conformity with specifications and standards Security required

Hardness test:

The (shore D) device was used to determine the hardness of samples cut into Different sizes (different shapes) for recycled polyethylene. Where the samples were Cut with standard dimensions according to ASTM (D2240). This test is carried in the University of Babylon, College of Materials Engineering, Department of Polymers and Petrochemical Industries with the model (TH 210 FJ, Germany). The (shore D) device Contains a needle like indenter at the end of the measuring tool to determine the Hardness of the samples, and the needle is directed in a direction perpendicular to the Sample and the device is controlled by the lever and when performing the hardness test For samples at room temperature, from the start of the test and an average of four Readings of each sample in different locations of the samples calculated to obtain the Required accuracy.

Fig. 2. 3. The hardness test device using (shore D)

A Shore-D device (Shore Duro-meter) was used to measure the hardness of thermally Hardened polymeric materials, which is a compass-like device and contains a needle in The middle. Measure its hardness so that it is in contact with the surface of the sample Whose hardness is to be measured in order for the needle to be inserted into the surface Of the

material and for a waiting period of about three seconds, after which the value of the hardness is taken from the device. Regarding the Shore D hardness, no less than Six readings were taken in different places on the surface of the sample، The sample Used for this test has a diameter of (40 mm) and a height of (5 mm)

Impact test:

A Charpy method was used to determine the impact strength of samples cut into Different sizes (different shapes) for recycled polyethylene. In this way, impact load is Suddenly applied to samples. Where the samples were cut with standard dimensions According to ASTM (D-22885). This device is available at the University of Babylon/ College of Materials Engineering/ Department of Polymers Engineering and Petrochemical Industries, specifically the with the model (pendelschlagwerk, gunt, Hamburg/ Germany), calculates the energy needed for the fracture through the energy Indicator, as the impact strength (I. S.) is calculated for each sample through the Following equation

$$I*S= UC /A$$

Where:

UC: Is the fracture energy (joule) measured by the Charpy impact test instrument.

A: Is the cross-sectional area for the sample.

Impact test determines the amount of energy absorbed by a material during Fracture. Impact test determines the amount of energy absorbed by a material during

Fracture. This absorbed energy is a measure of a given material's toughness and acts as A tool to study temperature-dependent brittle-ductile transition. This absorbed energy is a measure of a given material's toughness and acts as

A tool to study temperature-dependent brittle-ductile transition. It is to determine Whether the material is brittle or ductile in natureIn the project we used Charpy V-notch Test. It is to determine

Whether the material is brittle or ductile in natureIn the project we used Charpy V-notch

Test. The Charpy impact test, also known as the Charpy V-notch test, is a high strainrate test that involves striking a standard notched specimen with a controlled weight Pendulum swung from a set height. The Charpy impact test, also known as the Charpy V-notch test, is a high strainrate test that involves striking a standard notched specimen with a controlled weight

Pendulum swung from a set height. The impact test helps measure the amount of energy Absorbed by the specimen during fracture The impact test helps measure the amount of energy Absorbed by the specimen during fracture.

Fig. 2. 4. The impact test device by a charpy method

Fig. 2. 5. The twin-screw extruder device

Test result:

Tensile test result

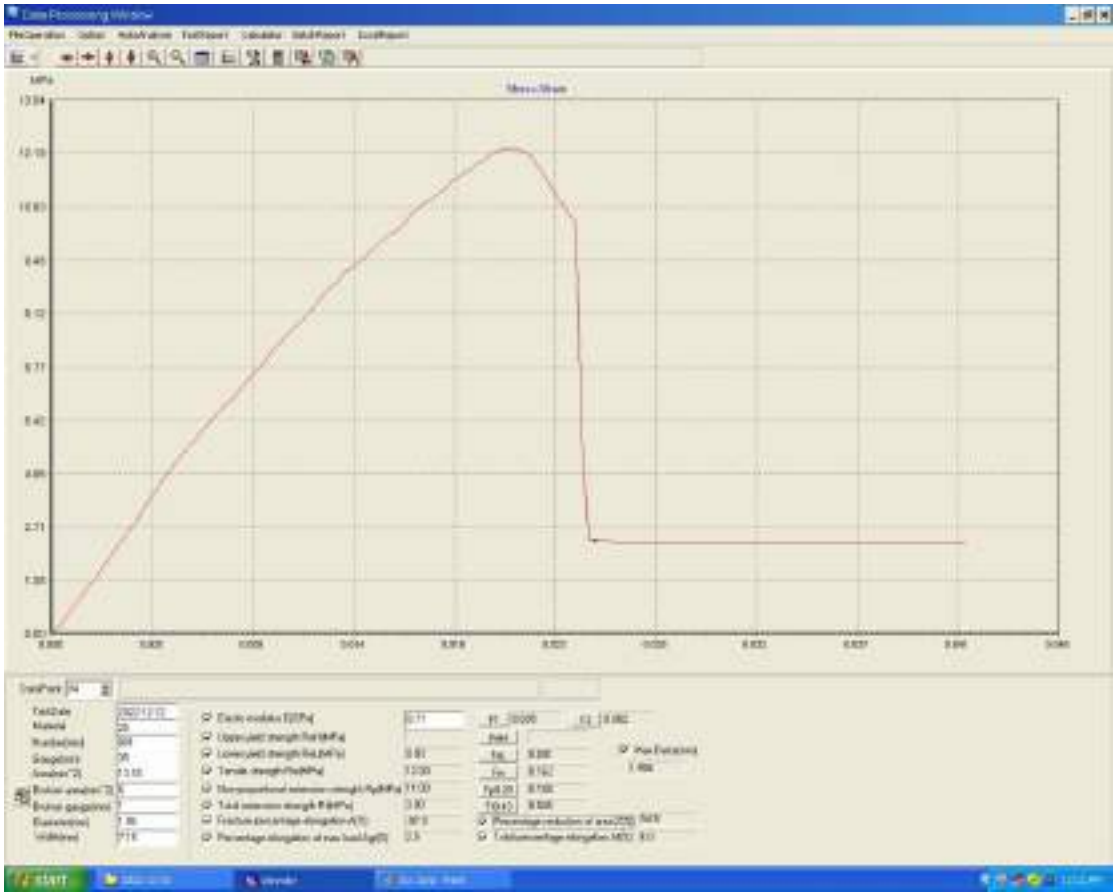


Fig 2. 6. The tensile test inspection of PET+PP speed 25

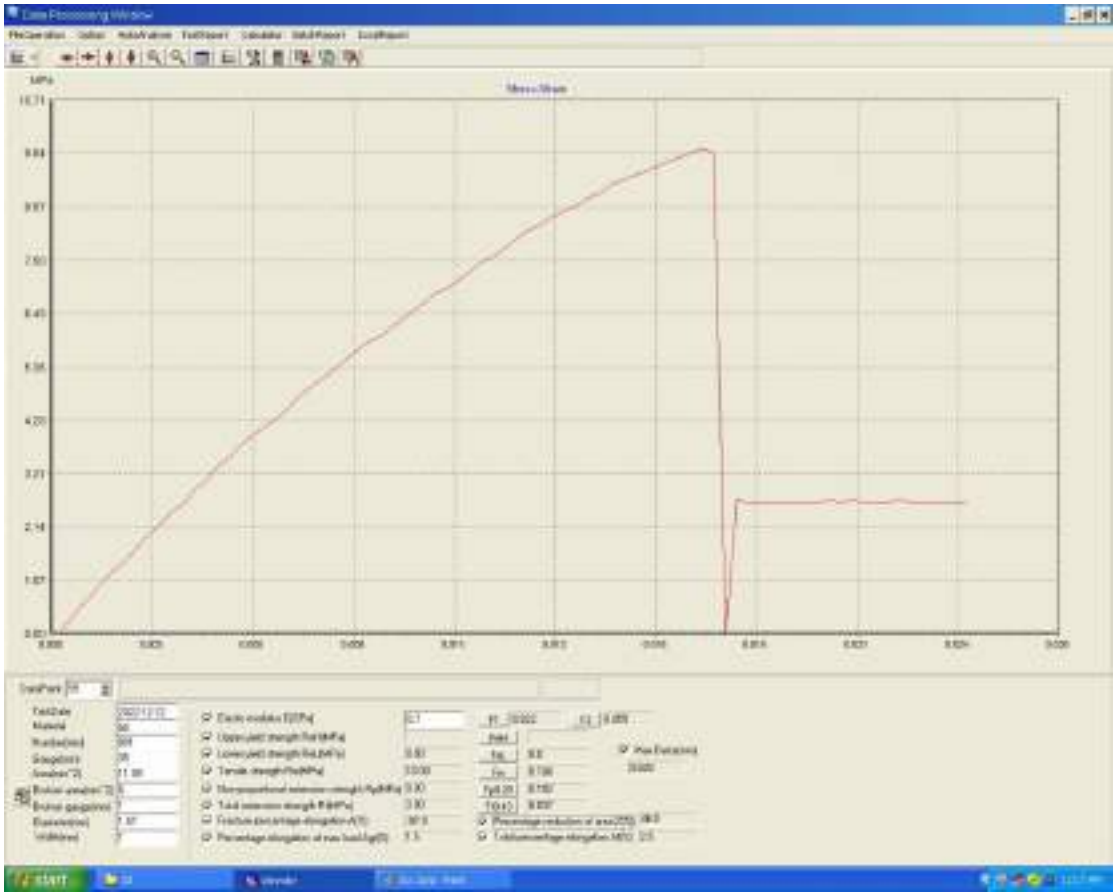


Fig. 2. 7. The tensile test inspection of PET+PP speed 50

Tensile test result:

Table 2. 1. It shows the value of the elastic modulus of the samples resulting from

The tensile test

Name of sample +Speed	Elastic modulus E(Gpa)	Tensile strength (Mpa)
PET+PP 25	0.71	12
PET+PP 50	0.7	10

Fig. 2.8.Tensile test sample befor and after mearsurd.

Hardness test results:

Table 2. 2. It shows the results of the hardness test of the samples

Sequence	PET+PP 25	PET+PP 50
1	68.3	69.8
2	64.7	64.4
3	65.5	69.8
Average	66.2	68.0

We notice an increase in the curve in its strength at speed 50 more heightAs for the speed of 25.

Figure (2.9): it Shaow the sheets of pure PET+PP for hardness test.

Impact test:

Table 2. 3. Hardness test chart

Name of sample +speed	Width	Thickness	Impact strength(J)
PET+PP 25	13.41	1.70	0.125
PET+PP 50	13	1.46	0.08

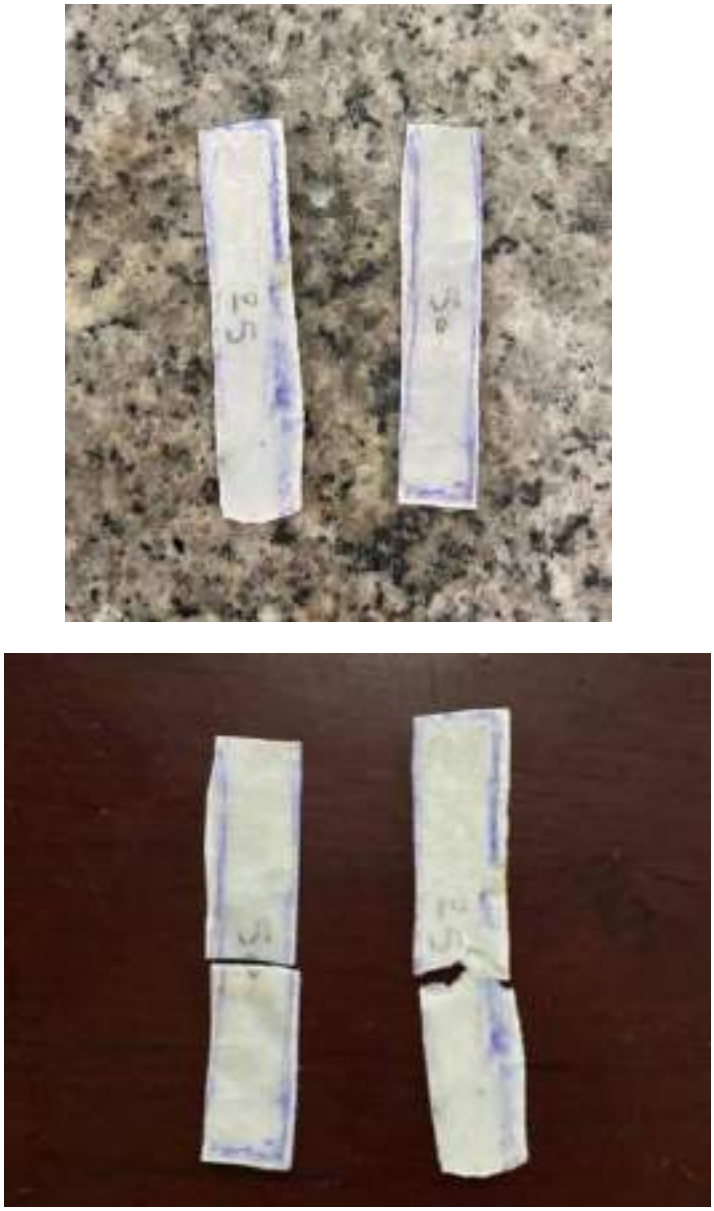


Figure (2.10): Impact test sample befor and after mearsurd.

Discussing test results:

1. In the tensile test, we notice an increase in the value of the modulus of elasticity and tensile strength in the 25-speed sample by a small percentage over the 50-speed sample.
2. In the hardness test, we notice an increase in the average hardness of the 50-speed sample by a small percentage over the 25-speed sample
3. In the impact test, we notice an increase in the rate of impactstrength for the 25-speed sample by the 50-speed sample.
4. We notice that at speed 25 there is a slight increase from speed 50.

Recommendations:

We recommend in the future extrusion PET + PP material at 25 speed because they give better results and mechanical properties better.

Conclusion:

Take two materials, PET and PP, and extrude them at a temperature of 200 at a Different speed of 25,50., then The three tests were conducted: tensile, hardness and impact test and the results are Shown above for all tests with a discussion of the reasons for which the results appeared .

References

1. *Whinfield, J.R. (May 1953). "The Development of Terylene". Textile Research Journal.* ***23*** *(5): 289–293.* 2. The name Terylene was formed by inversion of (polyeth)ylene ter(ephthalate) and dates to the 1940s. Oxford Dictionary. Terylene was first registered as a UK trademark in April 1946.
3. Pasbrig, Erwin (29 March 2007), *Cover film for blister packs*, retrieved 20 November 2016
4. Mishra, Munmaya (17 December 2018). *Encyclopedia of Polymer Applications, 3 Volume Set*. CRC Press. ISBN 978-1-351-01941-5.
5. Ashurst, P.; Hargitt, R. (26 August 2009). *Soft Drink and Fruit Juice Problems Solved*. Elsevier.
6. *"COVEME PHOTOVOLTAIC Backsheets and Frontsheets for PV modules" (PDF). Retrieved 4 March 2022.*
7. "Rynite PET Design Guide" (PDF). DuPont. Retrieved 4 March 2022
8. SIPA: Lightweight compressed gas cylinders have plastic liners / PET provides high oxygen barrier https://www.plasteurope.com, 18 November 2014, retrieved 16 May 2017.
9. *Teijin. "Teijin Develops Eco-friendly Wet-strong Printing Paper Made 100% with Recycled Polyester Derived from Used PET Bottles". Teijin Group. Archived from the original on 25 August 2013.*
10. *Margolis, James M. (28 October 2020). Engineering Thermoplastics: Properties and Applications. CRC Press.*
11. Scheirs, John; Long, Timothy E. (2003). *Modern polyesters : chemistry and technology of polyesters and copolyesters*. Hoboken, N.J.: John Wiley & Sons.
12. NPCS Board of Consultants & Engineers (2014) Chapter 6, p. 56 in *Disposable Products Manufacturing Handbook*, NIIR Project Consultancy Services, Delhi,
13. *He, Jhiyu; et al. (2 September 2022). "Diamond formation kinetics in shock-compressed C–H–O samples recorded by small-angle x-ray scattering and x-ray diffraction". Science Advances.*
14. Leah Crane (10 September 2022). "Blasting plastic with powerful lasers turns it into tiny diamonds". *New Scientist*.
15. *Ashurst, P.; Hargitt, R. (26 August 2009). Soft Drink and Fruit Juice Problems Solved. Elsevier. I*
16. *Ashurst, P.; Hargitt, R. (26 August 2009). Soft Drink and Fruit Juice Problems Solved. Elsevier. I*

17. Thiele, Ulrich K. (2007) *Polyester Bottle Resins, Production, Processing, Properties and Recycling*, Heidelberg, Germany, pp. 85 ff,
18. Edge M, Hayes M, Mohammadian M, Allen NS, Jewitt TS, Brems K, Jones K. Aspects of poly(ethylene terephthalate) degradation for archival life and environmental degradation. Polym Degrad Stab 1991;32(2):131–53
19. Pacia, Pacia National Plastics Recycling Survey 2002 Available from: http://www.pacia.org.au 2002
20. Throne JL. Effect of recycle on properties and profits, algorithms. Adv Polym Technol 1987;7(4):347–60.
21. Farahat MS, Abdel-Azim AA, Abdel-Raowf ME. Modified unsaturated polyester resins synthesized from poly(ethylene terephthalate) waste, 1. Synthesis and curing characteristics. Macromol Mater Eng 2000;283:1–6.
22. Miller C. Polyethylene terephthalate. Waste Age 2002;33(5):102–6
23. Investigating viscosity distribution inside the reactive extruder which is an important study that gives insight on the chain extender and POSTCPET reaction mechanism.
24. Scheirs J. Polymer recycling, science, technology and application. John Wiley and Sons Ltd; 1998.
25. Pawlak A, Pluta M, Morawiec J, Galeski A, Pracella M. Characterization of scrap poly(ethylene terephthalate). Eur Polym J 2000;36:1875–84.
26. Giannotta G, Po G, Cardi N. Processing effects on poly(ethylene terephthalate) from bottle scraps. Polym Eng Sci 1994;34:1219
27. Torres N, Robin JJ, Bountvin B. Study of thermal and mechanical properties of virgin and recycled poly(ethylene terephthalate) before and after injection molding. Eur Polym J 2000;36:2075–80.
28. Cardi N, Po R, Giannotta G. Chain extension of recycled poly(ethylene terephthalate) with 2,2,bis(2-oxazoline). J Appl Polym Sci 1993;50:1501–9.
29. Paci M, La Mantia FP. Competition between degradation and chain extension during processing of reclaimed poly(ethylene terephthalate). Polym Degrad Stab 1998;61:417–20.
30. Paci M, La Mantia FP. Influence of small amounts of polyvinylchloride on the recycling of polyethylene terephthalate. Polym Degrad Stab 1999;63:11–4.
31. Villain F, Coudane J, Vert M. Thermal degradation of polyethylene terephthalate, study of polymer stabilization. Polym Degrad Stab 1995;49:393–7.
32. Demertzis PG, Johansson F, Lievens C, Franz R. Studies on the development of a quick inertness test procedure for multi-use PET containers-sorption behaviour of bottle wall strips. Pack Technol Sci 1997;10:45–58.
33. Farahat MS, Abdel-Azim AA, Abdel-Raowf ME. Modified unsaturated polyester resins synthesized from poly(ethylene terephthalate) waste, 1. Synthesis and curing characteristics. Macromol Mater Eng 2000;283:1–6.

34. Fried JR. Polymer, science and technology. New Jersey: Prentice Hall PTR; 1995.
35. Goje AS, Mishra S. Chemical kinetics, simulation, and thermodynamics of glycolytic depolymerization of poly(ethylene terephthalate) waste with catalyst optimization for recycling of value added monomeric products. Macromol Mater Eng 2003;288:326–36.
36. Ibrahim Sara: Studying the effect of extrusion condition for two polymers by twinscrew device on their mechanical properties. M.S.c., Thesis, Collage of Materials Engineering, University of Babylon, 2014.
37. Manas Chanda & Salil K. Roy.: Plastics Fabrication and Recycling. CRC Press, USA, 2007.
38. Maddock, B., "A Visual Analysis of Flow and Mixing in Extruder Screws", SPE J., 15,
39. Zehev Tadmor: Principles of Polymer Processing. 2nd Edition, A John Wiley & Sons, Inc., Publication, 2006.
40. Images taken from different internet websites.
41. Tadmor, Z. and Klein, L., Engineering Principles of Plasticating -Extrusion, Reinhold, New York (1970)