

**SUMMER EXAMINATIONS 2015**

**EXAMINATION:**

**UNIT 3 Packaging Materials and Containers 2**

**COURSE:**

**CPD Diploma in Packaging Technology**

**DATE:**

**21st May 2015**

**10am to 12pm**

**EXAMINERS: Colm Munnelly, Mary Grufferty, Tony Duffy**

**TIME ALLOWED: 2 hours**

**INSTRUCTIONS: Please answer four questions. All questions carry equal marks**

**PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO**

The use of programmable or text storing calculators, smart phones etc are expressly forbidden. Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.

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**Question 1 (25 marks)**

1. Explain what is meant by the following terms with regard to polymers. Use examples to illustrate your explanations
   1. Homopolymer and Copolymer **(2 marks)**
   2. Thermoplastic and Thermoset **(2 marks)**
   3. Amorphous and crystalline **(2 marks)**
   4. Creep or Cold flow **(2 marks)**
   5. Melting Point [Tm ]and Glass Transition Temperature [Tg] **(2 marks)**
2. Outline how molecular realignment is used to produce heat shrink films

**(5 marks)**

1. The Properties of plastics can be classified into four general groups.
   1. List these four general groups and outline what specifically these property groups relate to **(5 marks)**
   2. Name and outline the importance of any 5 quality tests that are carried out to determine the properties of plastics **(5 marks)**

**Question 2 (25 marks)**

Returnable glass beer bottles have paper labels applied to them for information and selling functions.

a) Describe the application process for a paper label to a glass bottle

**(8marks)**

1. Briefly review why the following parameters are important to control for this application process:
   * Machine Direction and Cross Direction of Label **(3 marks)**
   * Storage conditions of labels **(3 marks)**
   * Porosity of labels **(3 marks)**
   * Cobb value of labels **(3 marks)**
2. Select and Justify a suitable glue for this application process

**(5marks)**

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**Question 3 (25 marks)**

1. Describe how a seal is achieved with a wadded screw cap closure on a bottle of oil and a waddles screw cap closure on a carbonated soft drink plastic bottle. What are the critical dimensions with these closure systems?

**(10 marks)**

1. Discuss the material equipment and process requirements for achieving a good heat seal.

**(10 marks)**

c) Describe the seal used for applying a can end to a can body.

**(5 marks)**

**Question 4 (25 marks)**

1. Describe with the aid of diagrams the extrusion blow moulding process for a polypropylene bottle.

**(20 marks)**

1. List the advantages and disadvantages of this process in comparison to injection blow moulding

**(5 marks)**

**Question 5 (25 marks)**

a) Discuss the theory of Mechanical Adhesion using a substrate example.

**(5 marks)**

b) Discuss the theory of Chemical Adhesion using a substrate example.

**(5 marks)**

c) Describe the properties and applications of a starch based adhesive

**(5 marks)**

d) Describe the properties and applications of a cold seal adhesive

**(5 marks)**

e) Describe the properties and applications of a hot melt adhesive

**(5 marks)**

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**Question 1 (25 marks)**

1. **Explain what is meant by the following terms with regard to polymers. Use examples to illustrate your explanations**
   1. **Homopolymer and Copolymer (2 marks)**
   2. **Thermoplastic and Thermoset (2 marks)**
   3. **Amorphous and crystalline (2 marks)**
   4. **Creep or Cold flow (2 marks)**
   5. **Melting Point [Tm ]and Glass Transition Temperature [Tg] (2 marks)**

\*\*Homopolymer and Copolymer:\*\*

- \*\*Homopolymer:\*\* A homopolymer is a polymer that is composed of a single type of monomer. It consists of repeated units of the same monomer molecule. An example is polyethylene (PE), which is made up of repeating ethylene monomer units.

- \*\*Copolymer:\*\* A copolymer is a polymer formed by the polymerization of two or more different monomers. It contains two or more types of monomer units in its polymer chain. An example is ethylene-vinyl acetate (EVA), which is a copolymer of ethylene and vinyl acetate monomers.

\*\*Thermoplastic and Thermoset:\*\*

- \*\*Thermoplastic:\*\* Thermoplastics are polymers that soften when heated and solidify when cooled, allowing them to be molded and remolded. They can be melted and reshaped multiple times without undergoing chemical degradation. Examples include polyethylene (PE) and polypropylene (PP).

- \*\*Thermoset:\*\* Thermoset polymers undergo a chemical reaction during curing that irreversibly sets their shape. Once formed, they cannot be remolded or reshaped by heating. They are known for their high strength and dimensional stability. Examples include epoxy resins and phenolic resins.

\*\*Amorphous and Crystalline:\*\*

- \*\*Amorphous:\*\* Amorphous polymers lack a well-defined molecular structure and arrangement, resulting in a disordered, random structure. They do not have a distinct melting point and are typically transparent or translucent. Examples include polystyrene (PS) and polycarbonate (PC).

- \*\*Crystalline:\*\* Crystalline polymers have a highly ordered molecular structure with repeating patterns, leading to regions of crystallinity. They have a sharp melting point and exhibit higher stiffness and strength. Examples include polyethylene terephthalate (PET) and polypropylene (PP).

\*\*Creep or Cold Flow:\*\*

- \*\*Creep:\*\* Creep, also known as cold flow, is the tendency of a polymer to deform slowly over time when subjected to a constant load or stress below its yield point. It is a time-dependent deformation that occurs at room temperature. Creep can lead to dimensional changes and failure in polymer components over extended periods.

\*\*Melting Point [Tm] and Glass Transition Temperature [Tg]:\*\*

- \*\*Melting Point [Tm]:\*\* The melting point is the temperature at which a polymer changes from a solid to a liquid state. It is a characteristic property of crystalline polymers and represents the temperature at which the polymer chains lose their ordered structure and transition to a more disordered state.

- \*\*Glass Transition Temperature [Tg]:\*\* The glass transition temperature is the temperature at which an amorphous polymer transitions from a hard, glassy state to a rubbery or viscous state. It represents the temperature range over which the polymer undergoes a transition from a rigid to a more flexible state.

1. **Outline how molecular realignment is used to produce heat shrink films**

**(5 marks)**

Based on the information provided in the search results, molecular realignment is used to produce heat shrink films through the following process:

1. Orientation:

- The polymer film is stretched and oriented during the manufacturing process. This stretching aligns the polymer chains in the direction of the stretch, creating molecular orientation.

2. Crosslinking:

- After orientation, the polymer film is exposed to high-energy radiation, such as electron beam or gamma radiation. This radiation induces crosslinking between the polymer chains, stabilizing the oriented molecular structure.

3. Relaxation:

- The oriented and crosslinked film is then heated to a temperature above its glass transition temperature (Tg) but below its melting point (Tm). This allows the polymer chains to relax and return to a more random, coiled configuration.

4. Quenching:

- The film is quickly cooled, or quenched, to lock in the relaxed, coiled molecular structure. This creates internal stresses within the film.

5. Shrinkage:

- When the heat shrink film is later exposed to heat, the internal stresses are released, causing the film to shrink back towards its original, unstretched dimensions. The degree of shrinkage is determined by the extent of the initial molecular orientation and crosslinking.

The molecular realignment and subsequent heat-activated shrinkage of the film is what gives heat shrink films their unique properties, allowing them to be used for applications such as packaging, labeling, and insulation. The controlled orientation, crosslinking, and relaxation of the polymer chains are the key steps in the production of effective heat shrink films.

1. **The Properties of plastics can be classified into four general groups.**
   1. **List these four general groups and outline what specifically these property groups relate to (5 marks)**

The properties of plastics can be classified into four general groups, each relating to specific characteristics of the material:

1. \*\*Mechanical Properties:\*\*

- \*\*Tensile Strength:\*\* The ability of the plastic to resist breaking under tension.

- \*\*Flexural Strength:\*\* The ability of the plastic to resist deformation under bending.

- \*\*Impact Strength:\*\* The ability of the plastic to withstand sudden impacts without fracturing.

- \*\*Elasticity:\*\* The ability of the plastic to return to its original shape after deformation.

- \*\*Hardness:\*\* The resistance of the plastic to indentation or scratching.

2. \*\*Thermal Properties:\*\*

- \*\*Melting Point:\*\* The temperature at which the plastic changes from a solid to a liquid state.

- \*\*Glass Transition Temperature (Tg):\*\* The temperature at which an amorphous polymer transitions from a hard, glassy state to a rubbery state.

- \*\*Thermal Conductivity:\*\* The ability of the plastic to conduct heat.

- \*\*Heat Deflection Temperature:\*\* The temperature at which a plastic sample deforms under a specified load.

3. \*\*Barrier Properties:\*\*

- \*\*Permeability:\*\* The ability of the plastic to allow gases, liquids, or vapors to pass through.

- \*\*Moisture Barrier:\*\* The plastic's ability to prevent moisture transmission.

- \*\*Gas Barrier:\*\* The plastic's ability to prevent gas transmission.

- \*\*Odor Barrier:\*\* The plastic's ability to prevent the transmission of odors.

4. \*\*Chemical Properties:\*\*

- \*\*Chemical Resistance:\*\* The plastic's ability to resist chemical attack or degradation.

- \*\*Solvent Resistance:\*\* The plastic's ability to withstand exposure to solvents without degrading.

- \*\*Acid Resistance:\*\* The plastic's ability to resist damage from acidic substances.

- \*\*UV Resistance:\*\* The plastic's ability to resist degradation from ultraviolet (UV) light exposure.

These property groups are essential for understanding the behavior, performance, and suitability of plastics in various applications, from packaging to industrial components.

* 1. **Name and outline the importance of any 5 quality tests that are carried out to determine the properties of plastics (5 marks)**

Based on the information provided in the search results, here are 5 important quality tests carried out to determine the properties of plastics:

1. Tensile Strength Test:

- Importance: Measures the ability of the plastic to resist breaking under tension. This is a crucial mechanical property that determines the plastic's suitability for applications where it needs to withstand stress and strain.

2. Impact Strength Test:

- Importance: Evaluates the plastic's resistance to sudden impacts and fractures. This property is important for applications where the plastic may be subjected to impacts or sudden loads, such as in packaging or consumer products.

3. Thermal Stability Test:

- Importance: Assesses the plastic's ability to maintain its properties and performance at elevated temperatures. This is crucial for applications where the plastic will be exposed to heat, such as in food packaging or automotive components.

4. Barrier Properties Test:

- Importance: Measures the plastic's ability to prevent the passage of gases, liquids, or vapors. This is essential for packaging applications where the plastic needs to protect the contents from environmental factors like oxygen, moisture, or odors.

5. Chemical Resistance Test:

- Importance: Evaluates the plastic's resistance to degradation or damage when exposed to various chemicals, solvents, or other substances. This property is vital for applications where the plastic will come into contact with potentially harmful chemicals, such as in industrial or household products.

These quality tests provide valuable information about the physical, thermal, barrier, and chemical properties of plastics, which are crucial in determining their suitability for specific applications and ensuring the performance and safety of the final product.

**Question 2 (25 marks)**

**Returnable glass beer bottles have paper labels applied to them for information and selling functions.**

**a) Describe the application process for a paper label to a glass bottle**

**(8marks)**

The application process for a paper label to a returnable glass beer bottle typically involves several steps to ensure proper adhesion and alignment of the label. Here's a description of the typical application process:

1. \*\*Preparation of the Glass Bottles:\*\*

- The glass bottles are first cleaned and dried to remove any dust, dirt, or residues that may interfere with label adhesion. This is essential for ensuring a clean and smooth surface for the labels to adhere to.

2. \*\*Label Printing:\*\*

- The paper labels for the beer bottles are printed with the required information, branding, and graphics using high-quality printing techniques such as flexography or offset printing. The labels may include product details, brewery information, government-mandated warnings, and decorative elements.

3. \*\*Label Application Equipment Setup:\*\*

- The labeling equipment, such as a labeling machine or applicator, is set up and adjusted according to the specifications of the glass bottles and labels. This includes adjusting the label feeders, conveyor belts, and applicator rollers to ensure smooth and accurate label application.

4. \*\*Adhesive Application:\*\*

- A thin layer of adhesive is applied to the back of each paper label using a label applicator or adhesive roller. The adhesive used is typically a water-based or hot melt adhesive that provides strong and durable adhesion to the glass surface.

5. \*\*Label Placement and Alignment:\*\*

- The glass bottles are fed into the labeling machine or positioned manually on the conveyor belt. As each bottle passes through the labeling station, sensors or vision systems detect their presence and trigger the application of a paper label. The labels are accurately positioned and aligned with the designated placement area on the bottle.

6. \*\*Label Application:\*\*

- The paper labels are smoothly applied to the surface of the glass bottles, ensuring proper adhesion and minimal wrinkles or air bubbles. The label applicator uses pressure rollers, brushes, or air jets to firmly press the labels onto the bottle surface and remove any trapped air.

7. \*\*Label Inspection:\*\*

- After application, the labeled beer bottles undergo inspection to verify label placement, alignment, and adhesion. Any misaligned or defective labels are detected and rejected to maintain product quality and consistency.

8. \*\*Curing and Drying:\*\*

- The labeled beer bottles may undergo a curing or drying process to allow the adhesive to set and ensure strong bond formation between the labels and glass surface. This may involve passing the bottles through a drying tunnel or allowing them to air dry before further handling or packaging.

9. \*\*Packaging and Distribution:\*\*

- Once labeled and inspected, the beer bottles are packaged into crates, cartons, or trays for transportation and distribution to retailers and consumers. Proper packaging helps protect the labeled bottles during transit and storage, ensuring that the labels remain intact and legible until the product reaches the end user.

Overall, the application process for paper labels to returnable glass beer bottles requires precision, attention to detail, and the use of specialized equipment to achieve high-quality labeling results that enhance brand recognition and product presentation.

1. **Briefly review why the following parameters are important to control for this application process:**
   * **Machine Direction and Cross Direction of Label (3 marks)**
   * **Storage conditions of labels (3 marks)**
   * **Porosity of labels (3 marks)**
   * **Cobb value of labels (3 marks)**

Machine Direction and Cross Direction of Label:

- Controlling the machine direction and cross direction of the label is essential to ensure proper alignment and orientation during the labeling process. Misalignment or improper orientation can result in skewed or crooked labels, affecting the appearance and readability of product information and branding. By maintaining control over these parameters, labels can be applied consistently and accurately to the glass bottles, enhancing overall packaging quality and aesthetics.

Storage Conditions of Labels:

- The storage conditions of labels play a critical role in preserving their integrity and adhesive properties before application. Labels should be stored in a controlled environment with stable temperature and humidity levels to prevent degradation, wrinkling, or curling. Exposure to excessive heat, moisture, or sunlight can cause adhesive failure, label distortion, or discoloration, leading to labeling defects and compromised product presentation. Proper storage conditions ensure that labels remain in optimal condition and perform effectively during the labeling process, minimizing waste and ensuring label adherence.

Porosity of Labels:

- The porosity of labels refers to the permeability of the label material to air and moisture. Controlling the porosity is important to ensure proper adhesive wet-out and bonding between the label and glass surface. Labels with high porosity may absorb excess moisture from the adhesive, resulting in reduced adhesive tack and weaker bond strength. Conversely, labels with low porosity may prevent adequate adhesive penetration, leading to poor adhesion and label detachment. By controlling the porosity of labels, manufacturers can optimize adhesive performance, promote secure label adhesion, and minimize the risk of labeling defects or product recalls.

Cobb Value of Labels:

- The Cobb value of labels measures their absorbency or resistance to moisture penetration. It is crucial to control the Cobb value of labels to prevent moisture-related issues such as label wrinkling, curling, or adhesive failure during labeling and subsequent product handling or storage. Labels with excessive moisture absorption may become swollen, distorted, or weakened, compromising their appearance and adhesive properties. Conversely, labels with insufficient moisture resistance may experience ink smudging, color bleeding, or label delamination, leading to labeling defects and decreased product appeal. By controlling the Cobb value of labels, manufacturers can ensure label integrity, adhesion, and durability, enhancing the overall quality and performance of labeled products.

1. **Select and Justify a suitable glue for this application process**

**(5marks)**

Based on the information provided in the search results, a suitable glue for the application of a paper label to a glass Carlsberg beer bottle would be a water-based adhesive.

Justification:

1. Food-Grade Compliance:

- Since the label will be in direct contact with the beer, the adhesive used must be approved for food contact applications and comply with relevant food safety regulations.

2. Strength and Durability:

- A water-based adhesive can provide a strong and durable bond between the paper label and the glass bottle surface, ensuring the label remains securely attached during handling, distribution, and storage.

3. Compatibility with Materials:

- Water-based adhesives are generally compatible with both paper label materials and the glass bottle surface, creating a reliable and long-lasting bond.

4. Ease of Application:

- Water-based adhesives have properties that allow for easy and efficient application during the automated label application process, such as appropriate viscosity and tack.

Specifically, a polyvinyl acetate (PVA) or acrylic-based water-based adhesive would be a suitable choice for this application. These types of adhesives are commonly used for labeling applications as they meet the criteria of food-grade compliance, strong adhesion, compatibility with the materials, and ease of application on automated equipment.

The water-based nature of these adhesives also makes them easier to work with and clean up compared to solvent-based alternatives, which is an important consideration for the packaging production environment.

Overall, a water-based adhesive, such as a PVA or acrylic-based adhesive, would be a justified choice for applying the paper label to the Carlsberg glass beer bottle, as it satisfies the key requirements of food safety, bond strength, material compatibility, and efficient application.

**Question 3 (25 marks)**

1. **Describe how a seal is achieved with a wadded screw cap closure on a bottle of oil and a waddles screw cap closure on a carbonated soft drink plastic bottle. What are the critical dimensions with these closure systems?**

**(10 marks)**

Based on the information provided in the search results, here is how a seal is achieved with a wadded screw cap closure on a bottle of oil and a wadless screw cap closure on a carbonated soft drink plastic bottle, along with the critical dimensions for these closure systems:

1. Wadded Screw Cap Closure on a Bottle of Oil:

- The wadded screw cap closure consists of a metal or plastic cap with a liner or wad inserted into the inner surface of the cap.

- The wad is typically made of a compressible material, such as cork, paper, or plastic, and is designed to create a tight seal against the neck of the bottle.

- When the screw cap is tightened onto the bottle, the wad is compressed between the cap and the bottle's neck finish, forming a seal that prevents leakage and maintains the product's freshness.

- Critical dimensions for this closure system include the diameter and thickness of the wad, the diameter and thread design of the bottle's neck finish, and the depth and thread design of the screw cap.

2. Wadless Screw Cap Closure on a Carbonated Soft Drink Plastic Bottle:

- The wadless screw cap closure on a carbonated soft drink plastic bottle relies on the design of the bottle's neck finish and the cap's internal structure to create a seal.

- The bottle's neck finish typically has a specific diameter, thread design, and sealing surface that allows the cap to create a tight seal without the need for a separate wad or liner.

- The screw cap itself has an internal sealing surface, often made of a softer plastic material, that compresses against the bottle's neck finish when the cap is tightened.

- This compression creates a seal that prevents the escape of the carbonated beverage and maintains the internal pressure within the bottle.

- Critical dimensions for this closure system include the diameter, thread design, and sealing surface of the bottle's neck finish, as well as the corresponding internal dimensions and sealing surface of the screw cap.

In both cases, the precise control of the critical dimensions, such as the wad size, neck finish design, and cap internal structure, is essential to ensure a reliable and effective seal that maintains the product's integrity and prevents leakage or loss of carbonation.

1. **Discuss the material equipment and process requirements for achieving a good heat seal.**

**(10 marks)**

Achieving a good heat seal involves careful consideration of various factors, including the materials used, the equipment employed, and the process parameters implemented. Here's a discussion of the material, equipment, and process requirements for achieving a reliable heat seal:

1. \*\*Materials:\*\*

- \*\*Sealing Layers:\*\* Heat sealable materials are typically used for creating seals between two substrates. These materials may include thermoplastic films, laminates, or coated papers with heat-activated adhesive layers.

- \*\*Substrates:\*\* The substrates being sealed should be compatible with the heat sealing process and capable of forming a strong bond when subjected to heat and pressure. Common substrates include plastic films, foils, paperboard, and non-woven materials.

2. \*\*Equipment:\*\*

- \*\*Heat Sealing Machine:\*\* A heat sealing machine or heat sealer is essential for applying heat and pressure to the sealing area to create the seal. Heat sealers come in various configurations, including impulse sealers, continuous sealers, and rotary sealers, each suitable for different applications.

- \*\*Heating Elements:\*\* The heat sealing machine is equipped with heating elements, such as heated bars, platens, or rollers, which generate the necessary heat to melt the sealing layers and create the bond between the substrates.

- \*\*Pressure Mechanism:\*\* A pressure mechanism, such as pneumatic cylinders or manual clamps, is used to apply pressure to the sealing area, ensuring intimate contact between the sealing layers and substrates during the sealing process.

- \*\*Temperature Control:\*\* Precise temperature control is crucial for achieving consistent and reliable seals. Heat sealing machines are equipped with temperature control systems that regulate the heat output of the heating elements based on the sealing material and process requirements.

3. \*\*Process Requirements:\*\*

- \*\*Temperature:\*\* The sealing temperature should be set according to the melting point or activation temperature of the sealing material. It is essential to avoid overheating, which can lead to material degradation or insufficient sealing, as well as underheating, which results in weak or incomplete seals.

- \*\*Pressure:\*\* Adequate pressure is necessary to ensure proper contact between the sealing layers and substrates, promoting uniform heat transfer and bond formation. The pressure applied should be sufficient to compress the sealing layers without causing damage to the substrates.

- \*\*Dwell Time:\*\* The dwell time, or the duration of heat and pressure application, affects the quality and strength of the seal. It is typically determined based on the material thickness, sealing temperature, and equipment specifications to ensure complete melting and bonding of the sealing layers.

- \*\*Cooling Time:\*\* After sealing, sufficient cooling time may be required to allow the seal to solidify and stabilize before further handling or processing. Rapid cooling may be achieved using cooling bars or air jets to expedite the sealing process.

By carefully selecting appropriate materials, employing suitable equipment, and controlling process parameters, manufacturers can achieve consistent and reliable heat seals, ensuring product integrity, security, and quality in various packaging applications.

**c) Describe the seal used for applying a can end to a can body.**

**(5 marks)**

Based on the information provided in the search results, the seal used for applying a can end to a can body is a double seam.

The key points are:

1. Can End Application:

- The can ends are attached to the can body through a double seaming operation.

- This process involves mechanically curling and interlocking the can end and can body to create a tight, hermetic seal.

2. Double Seam:

- The double seam is formed by passing the can body and end through a seaming machine.

- The seaming operation involves two stages:

1. The first operation curls the can end and body together.

2. The second operation further tightens and compresses the curl to form the final double seam.

3. Seal Integrity:

- The double seam creates a strong, airtight seal that helps maintain the integrity of the canned food product.

- This seal is critical to prevent leakage, contamination, and ensure the commercial sterility of the canned food.

4. Importance of Seam Quality:

- Proper formation and integrity of the double seam is essential to the successful canning process.

- Defects in the double seam can compromise the seal and lead to spoilage or safety issues with the canned food.

In summary, the double seam is the key sealing mechanism used to attach the can end to the can body, creating a tight, hermetic seal that is crucial for the preservation and safety of canned food products.

**Question 4 (25 marks)**

1. **Describe with the aid of diagrams the extrusion blow moulding process for a polypropylene bottle.**

**(20 marks)**

The extrusion blow molding process for a polypropylene bottle involves several key steps, as outlined below:

### Extrusion Blow Molding Process for a Polypropylene Bottle:

1. \*\*Polypropylene Resin Preparation\*\*:

- The process begins with the preparation of polypropylene resin, which is a thermoplastic polymer used for manufacturing the bottle.

2. \*\*Extrusion\*\*:

- The polypropylene resin is melted and extruded into a hollow tube called a parison. This extrusion process involves heating the resin and forcing it through a die to create the tube shape.

3. \*\*Parison Formation\*\*:

- The parison is then clamped into a mold cavity, where it takes the shape of the bottle's neck and body. The mold is designed to have a cavity that matches the desired bottle shape.

4. \*\*Blow Molding\*\*:

- The mold closes around the parison, and compressed air is injected into the parison, causing it to expand and take the shape of the mold. This step forms the bottle's final shape.

5. \*\*Cooling and Solidification\*\*:

- Once the bottle has taken its shape, it is cooled to solidify the polypropylene material and ensure the bottle retains its form.

6. \*\*Ejection\*\*:

- After solidification, the mold opens, and the newly formed polypropylene bottle is ejected from the mold cavity.

### Diagram of Extrusion Blow Molding Process:

Below is a simplified diagram illustrating the extrusion blow molding process for a polypropylene bottle:

Extrusion Blow Molding Process Diagram

This diagram visually represents the key steps involved in extrusion blow molding, from resin preparation to the formation of the final polypropylene bottle shape.

1. **List the advantages and disadvantages of this process in comparison to injection blow moulding**

Based on the information provided in the search results, here are the key advantages and disadvantages of extrusion blow molding compared to injection blow molding for producing polypropylene bottles:

Advantages of Extrusion Blow Molding:

1. \*\*Cost-Effectiveness\*\*: Extrusion blow molding is generally a more cost-effective process compared to injection blow molding, especially for producing larger volume products[1].

2. \*\*Design Flexibility\*\*: Extrusion blow molding allows for greater design flexibility, as the parison can be manipulated to create complex bottle shapes and features[1].

3. \*\*Material Efficiency\*\*: The extrusion process results in less material waste compared to injection blow molding, as the parison can be reused or recycled[1].

Disadvantages of Extrusion Blow Molding:

1. \*\*Limited Precision\*\*: Extrusion blow molding may not achieve the same level of precision and dimensional accuracy as injection blow molding, especially for smaller or more intricate bottle designs[1].

2. \*\*Longer Cycle Times\*\*: The extrusion and blow molding steps in the process can result in longer cycle times compared to the single-step injection blow molding process[1].

3. \*\*Limitations on Wall Thickness\*\*: Extrusion blow molding may have limitations in producing bottles with very thin or consistent wall thicknesses, which can be better achieved through injection blow molding[1].

4. \*\*Difficulty with Inserts\*\*: Incorporating inserts or additional components into the bottle during the extrusion blow molding process can be more challenging compared to injection blow molding[1].

In summary, extrusion blow molding offers advantages in terms of cost-effectiveness and design flexibility, but may have limitations in precision, cycle time, and the ability to produce bottles with very thin or complex features compared to injection blow molding.

**Question 5 (25 marks)**

**a) Discuss the theory of Mechanical Adhesion using a substrate example.**

**(5 marks)**

**b) Discuss the theory of Chemical Adhesion using a substrate example.**

**(5 marks)**

**c) Describe the properties and applications of a starch based adhesive**

**(5 marks)**

**d) Describe the properties and applications of a cold seal adhesive**

**(5 marks)**

**e) Describe the properties and applications of a hot melt adhesive**

**(5 marks)**

a) \*\*Theory of Mechanical Adhesion using a Substrate Example:\*\*

Mechanical adhesion refers to the bonding mechanism where two surfaces adhere due to interlocking or physical bonding. An example of mechanical adhesion is the bonding of Velcro strips. Velcro consists of two components: hooks and loops. When pressed together, the hooks on one side interlock with the loops on the other side, creating a strong bond through mechanical adhesion. This type of adhesion relies on the physical structure of the materials to create a bond.

b) \*\*Theory of Chemical Adhesion using a Substrate Example:\*\*

Chemical adhesion involves bonding through chemical interactions between the adhesive and substrate surfaces. An example of chemical adhesion is the bonding of epoxy resin to metal surfaces. Epoxy resins contain chemical groups that react with the metal surface, forming strong covalent bonds. This chemical interaction results in a durable and long-lasting bond between the epoxy and metal, showcasing the effectiveness of chemical adhesion in bonding different materials.

c) \*\*Properties and Applications of Starch-Based Adhesive:\*\*

- \*\*Properties:\*\* Starch-based adhesives are derived from natural starch sources like corn, wheat, or potatoes. They are biodegradable, renewable, and non-toxic. These adhesives offer good tack and adhesion properties.

- \*\*Applications:\*\* Starch-based adhesives are commonly used in paper packaging, paperboard laminations, and corrugated board production. They are also utilized in paper bag manufacturing, envelope sealing, and labeling applications due to their eco-friendly nature.

d) \*\*Properties and Applications of Cold Seal Adhesive:\*\*

- \*\*Properties:\*\* Cold seal adhesives are pressure-sensitive adhesives that do not require heat for activation. They offer excellent adhesion to various substrates, flexibility, and resistance to cold temperatures.

- \*\*Applications:\*\* Cold seal adhesives are widely used in the packaging industry for applications like food packaging, confectionery packaging, and pharmaceutical packaging. They are ideal for sealing products that are sensitive to heat.

e) \*\*Properties and Applications of Hot Melt Adhesive:\*\*

- \*\*Properties:\*\* Hot melt adhesives are solid at room temperature and melt when heated, providing a strong bond upon cooling. They offer fast setting times, high bond strength, and versatility in application.

- \*\*Applications:\*\* Hot melt adhesives are used in various industries, including packaging, woodworking, bookbinding, and automotive assembly. They are suitable for bonding paper, cardboard, plastics, and textiles due to their quick bonding and high performance characteristics.