

**SUMMER EXAMINATIONS 2015**

**EXAMINATION:**

**UNIT 2 Packaging Materials and Containers I**

**COURSE:**

**CPD Diploma in Packaging Technology**

**DATE:**

**20th May 2015**

**2pm to 4pm**

**EXAMINERS: Colm Munnelly, David Little**

**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.

Unit 2 Page 1 of 3

**Question 1 (25 marks)**

1. Describe with the aid of a diagram how glass is made starting with the raw materials and finishing with the production of a glass gob. Give indications of the temperatures at each stage.

**(15 marks)**

1. Describe the main ingredients in a batch of glass and explain what each ingredient is used for

**(5 marks)**

1. Discuss FIVE different methods of reducing the energy requirement to manufacture a batch of glass.

**(5 marks)**

**Question 2 (25 marks)**

1. Describe using diagrams, the production of a glass beer bottle from a gob of molten glass to the production of a finished bottle in a modern high speed production facility. Explain why this method is chosen over the more traditional method

**(15 marks)**

1. Describe how stresses are induced in cooling glass containers and name the process to relieve these stresses?

**(5 marks)**

1. Describe how stress is relieved in glass containers passing through a Lehr oven. Indicate the approximate temperatures of the glass at different stages in the oven profile and why these temperature levels are set.

**(5 marks)**

**Question 3 (25 marks)**

1. Starting with felled trees, describe the fibre preparation and manufacture of a virgin coated folding boxboard (FBB), by the Fourdriner method, suitable for converting into a carton. End with the board, packed ready for delivery to the offset lithographic print converter.

**(20 marks)**

b) Name 3 other types of cartonboard.

**(5 marks)**

**Question 4 (25 marks)**

1. What is Aluminium Foil? Describe the two different appearances on the surface of a foil and how they are produced?

**(5 marks)**

1. Aluminium sheet can be hot rolled or cold rolled. Explain what happens during each method and the characteristics of the resultant product.

**(10 marks)**

1. Explain the reasons why aluminium foil is a commonly used material in flexible packaging.

**(10 marks)**

**Question 5 (25 marks)**

For each of the following, briefly describe the materials, flute construction and flute type that would be suitable, giving reasons for your selections:

1. A printed carton for a one litre gift pack of whisky **(5 Marks)**
2. A case for bags of frozen vegetables **(5 Marks)**
3. A reusable transit case for heavy engineering components **(5 Marks)**
4. A ‘carry home’ pack for a duvet **(5 Marks)**
5. A SRP (Shelf Ready Pack) for 12 stand up pouches of cat food **(5 Marks)**

Unit 2 Page 2 of 3

**Question 1 (25 marks)**

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## Glass Making Process: Raw Materials to Gob (15 marks)

**Diagram:**

+----------+ +----------+ +----------+ +----------+

| Raw | ----> | Batch | ----> | Furnace | ----> | Gob |

| Materials | (Mixing) | (1400°C) | ----> | (1500°C) | ----> | (1050°C) |

| (Sand, | | (Crushed | | (Melting) | | (Molten |

| Soda Ash, | | Mixture) | | | | Glass) |

| Limestone)| +----------+ +----------+ +----------+

**Description:**

1. **Raw Materials:**
   * Silica Sand (SiO2): Main source of glass (around 70%). Provides the structure of the glass.
   * Soda Ash (Na2CO3): Lowers melting temperature and improves workability. Acts as a flux.
   * Limestone (CaCO3): Improves chemical durability and stability. Contributes to strength and reduces thermal expansion.
2. **Batch House (Mixing):**
   * Raw materials are accurately weighed and proportioned according to the desired glass type.
   * Mixing ensures a homogenous blend for consistent glass properties.
   * Temperature: Around room temperature (20-25°C).
3. **Furnace (Melting):**
   * The batch is fed into a large furnace where it's heated to high temperatures.
   * The high temperature melts the raw materials, transforming them into molten glass.
   * Temperature: Typically around 1400°C to 1600°C depending on glass composition.
4. **Gob Formation:**
   * A gob is a small, precisely measured amount of molten glass.
   * It's typically formed by shearing or pouring techniques.
   * The gob size and temperature are crucial for shaping the final glass product.
   * Temperature: Around 1050°C to 1200°C depending on shaping method.

## Main Ingredients in a Glass Batch (5 marks)

1. **Silica Sand (SiO2):** The primary component (around 70%) that forms the glass network, providing rigidity and structure.
2. **Soda Ash (Na2CO3):** Acts as a flux, lowering the melting temperature of the silica and making the molten glass easier to work with.
3. **Limestone (CaCO3):** Improves chemical durability, reduces thermal expansion, and contributes to the overall strength of the glass.

## Reducing Energy Consumption in Glass Manufacturing (5 marks)

1. **Optimize Batch Composition:** Using recycled cullet (broken glass) reduces the need for raw materials and lowers melting temperatures.
2. **Furnace Efficiency Improvements:** Regularly maintaining furnace linings, optimizing burner systems, and utilizing waste heat recovery can significantly reduce energy consumption.
3. **Electric Melting:** Switching from traditional fossil fuel-powered furnaces to electric furnaces powered by renewable energy sources offers a more sustainable approach.
4. **Cullet Preheating:** Preheating cullet before entering the furnace reduces the energy required for melting the recycled glass.
5. **Improved Process Control:** Implementing advanced process control systems helps optimize furnace temperatures and production parameters, minimizing energy waste.

**Question 2 (25 marks)**

1. **Describe using diagrams, the production of a glass beer bottle from a gob of molten glass to the production of a finished bottle in a modern high speed production facility. Explain why this method is chosen over the more traditional method**

**(15 marks)**

1. **Describe how stresses are induced in cooling glass containers and name the process to relieve these stresses?**

**(5 marks)**

1. **Describe how stress is relieved in glass containers passing through a Lehr oven. Indicate the approximate temperatures of the glass at different stages in the oven profile and why these temperature levels are set.**

**(5 marks)**

## Glass Beer Bottle Production: Gob to Finished Bottle (15 marks)

**Modern High-Speed Production (Blow-Blow Process):**

**Diagram 1: Gob Formation**

+----------+ +----------+

| Molten | ----> | Gob |

| Glass Gob | (1050°C) |

| (1050°C) |

+----------+

**Diagram 2: Blow-Blow Process**

1. **Neck Ring Mold:** The gob is dropped into a neck ring mold, shaping the initial neck and opening. (See dashed line in Diagram 2)
2. **Blow Mold:** A compressed air blow forms the parison, a hollow glass pre-shape with a closed bottom. (See solid line in Diagram 2)
3. **Transfer and Reheating:** The parison is transferred to a final blow mold. It's reheated to soften the glass for final shaping.
4. **Final Blow:** Compressed air inflates the parison to its final bottle shape within the blow mold.
5. **Annealing Lehrs:** The formed bottle undergoes a controlled cooling process to relieve stress.

**Advantages over Traditional Method (Press & Blow):**

* **Faster production speed:** Blow-Blow allows for faster molding cycles compared to Press & Blow, increasing production output.
* **Improved bottle weight distribution:** Blow-Blow offers better control over glass distribution, resulting in lighter and more consistent bottle weights.
* **Suitable for complex shapes:** The Blow-Blow process is more adaptable to creating bottles with complex shapes, including those with narrow necks.

## Stress in Glass Containers (5 marks)

**Stress Induction:**

Rapid cooling of glass after shaping induces internal stresses within the container. These stresses can cause the glass to crack or shatter if not properly relieved.

**Annealing Process:**

This process slowly cools the glass containers to relieve the internal stresses.

## Lehr Oven and Stress Relief (5 marks)

**Lehr Oven Stages:**

**Diagram 3: Lehr Oven Profile**

Temperature ( °C )

+-------------------+

| Peak | (Around 550°C)

+-------------------+

| |

| Cooling Zone | (Slow, controlled cooling)

| |

+-------------------+

| Annealing | (Around 320°C)

+-------------------+

| |

| Holding Zone | (Maintaining temperature)

| |

+-------------------+

| |

| Packing Zone | (Gradual cooling to room temp)

| |

+-------------------+

**Temperature Levels:**

* **Peak Temperature (Around 550°C):** Maintains the glass in a softened state for stress relaxation.
* **Cooling Zone (Slow, Controlled Cooling):** Gradually reduces temperature to allow controlled stress relief.
* **Annealing Temperature (Around 320°C):** This is a critical zone where most internal stresses are relieved.
* **Holding Zone (Maintaining Temperature):** Maintains a stable temperature to ensure complete stress relief.
* **Packing Zone (Gradual Cooling to Room Temp):** Slow cooling minimizes the risk of reintroducing stress.

**Reasoning:**

The gradual cooling profile allows the glass molecules to rearrange and adjust to their final positions without creating excessive internal tension. This prevents the glass from cracking or shattering due to thermal shock.

**Question 3 (25 marks)**

1. **Starting with felled trees, describe the fibre preparation and manufacture of a virgin coated folding boxboard (FBB), by the Fourdriner method, suitable for converting into a carton. End with the board, packed ready for delivery to the offset lithographic print converter.**

**(20 marks)**

**b) Name 3 other types of cartonboard.**

**(5 marks)**

### Answer:

\*\*Fiber Preparation and Manufacture of Virgin Coated Folding Boxboard (FBB) by the Fourdriner Method:\*\*

1. \*\*Felled Trees\*\*: The process begins with the harvesting of trees, typically softwood species like spruce or fir.

2. \*\*Debarking\*\*: The logs are debarked, removing the bark from the logs to expose the wood fibers.

3. \*\*Chipping\*\*: The logs are then chipped into small pieces, typically around 1-2 inches in length.

4. \*\*Pulping\*\*: The wood chips are processed into pulp through mechanical or chemical pulping methods.

5. \*\*Screening\*\*: The pulp is screened to remove impurities and achieve the desired fiber consistency.

6. \*\*Bleaching\*\*: The pulp may undergo a bleaching process to achieve the desired brightness and color.

7. \*\*Papermaking\*\*: The pulp is then fed into the Fourdriner machine, where it is formed into a continuous sheet of paper.

8. \*\*Coating\*\*: The paper sheet may be coated with a layer of clay or other materials to enhance its printability and surface properties.

9. \*\*Calendering\*\*: The paper may pass through calender rolls to improve its smoothness and finish.

10. \*\*Cutting and Packaging\*\*: The paper is then cut into sheets of the desired size, packed, and prepared for delivery to the offset lithographic print converter.

\*\*Other Types of Cartonboard:\*\*

1. \*\*Solid Bleached Board (SBB)\*\*: A high-quality, bright white board made entirely from bleached chemical pulp, known for its excellent printability and smooth surface.

2. \*\*Solid Unbleached Board (SUB)\*\*: A natural brown board made from unbleached chemical pulp, offering a more rustic appearance and good strength properties.

3. \*\*White Lined Chipboard (WLC)\*\*: A multi-layer board with a white coated surface, typically used for applications requiring a balance of strength and printability.

**Question 4 (25 marks)**

1. **What is Aluminium Foil? Describe the two different appearances on the surface of a foil and how they are produced?**

**(5 marks)**

1. **Aluminium sheet can be hot rolled or cold rolled. Explain what happens during each method and the characteristics of the resultant product.**

**(10 marks)**

1. **Explain the reasons why aluminium foil is a commonly used material in flexible packaging.**

**(10 marks)**

### Query: Question 4

\*\*What is Aluminium Foil? Describe the two different appearances on the surface of a foil and how they are produced?\*\*

Aluminium foil is a thin sheet of aluminum metal, typically less than 0.2 mm thick, that is widely used for various packaging and cooking purposes due to its excellent barrier properties and flexibility.

Aluminium foil can have two different appearances on its surface:

1. \*\*Shiny Side\*\*: The shiny side of the foil is the result of the manufacturing process where the aluminum is rolled between polished rollers, creating a smooth and reflective surface.

2. \*\*Dull Side\*\*: The dull side of the foil is the opposite side, which does not go through the same rolling process and thus appears slightly rougher and less reflective.

\*\*Aluminium sheet can be hot rolled or cold rolled. Explain what happens during each method and the characteristics of the resultant product.\*\*

1. \*\*Hot Rolling\*\*:

- \*\*Process\*\*: In hot rolling, the aluminum sheet is heated above its recrystallization temperature and passed through rollers to achieve the desired thickness.

- \*\*Characteristics\*\*: Hot rolling results in a sheet with a rough surface texture, reduced strength, and improved ductility. It is ideal for applications where formability is crucial.

2. \*\*Cold Rolling\*\*:

- \*\*Process\*\*: Cold rolling involves passing the aluminum sheet through rollers at room temperature to achieve the desired thickness.

- \*\*Characteristics\*\*: Cold rolling produces a smoother surface finish, higher strength, and less ductility compared to hot rolling. It is suitable for applications requiring a higher level of strength and surface finish.

\*\*Explain the reasons why aluminium foil is a commonly used material in flexible packaging.\*\*

1. \*\*Barrier Properties\*\*: Aluminium foil provides an excellent barrier against light, oxygen, moisture, and contaminants, preserving the freshness and quality of the packaged products.

2. \*\*Flexibility\*\*: Aluminium foil is highly flexible and can be easily shaped, folded, and wrapped around various shapes and sizes of products.

3. \*\*Heat Conductivity\*\*: Aluminium foil has good heat conductivity, allowing for effective heat sealing and protection of the packaged contents.

4. \*\*Lightweight\*\*: Aluminium foil is lightweight, reducing packaging weight and transportation costs.

5. \*\*Recyclability\*\*: Aluminium foil is recyclable, making it an environmentally friendly choice for flexible packaging solutions.

**Question 5 (25 marks)**

**For each of the following, briefly describe the materials, flute construction and flute type that would be suitable, giving reasons for your selections:**

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Unit 2 Page 3 of 3