

**SUMMER EXAMINATIONS 2020**

**EXAMINATION:**

**UNIT 2 Packaging Materials and Containers I**

**COURSE:**

**CPD Diploma in Packaging Technology**

**DATE:**

**13th May 2020**

**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 using a diagram, how glass is made from raw materials to the production of a glass gob. Give indications of the temperatures at each stage.

**(14 marks)**

b) Outline SIX properties of glass

**(6 marks)**

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

**(5 marks)**

**Question 2 (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 products.

**(10 marks)**

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

**(10 marks)**

**Question 3 (25 marks)**

1. With the aid of a diagram describe the typical production process for wide mouth glass jars from gob formation to the presentation of containers for annealing

**(13 marks)**

1. Why are surface coatings used on glass? Name where they are applied, their function and an example of each type

**(7 marks)**

1. Packaging designers focus on specific areas when designing glass bottles. Briefly discuss the five regions of a glass wine bottle and why they merit special consideration for designers.

**(5 marks)**

Unit 2 Page 2 of 3

**Question 4 (25 marks)**

1. What are the different types of pulp used in the manufacture of carton board and what are the basic differences / benefits of each type?

**(15 marks)**

1. In the finishing of paperboard jumbo reels, what are the main two processes involved and what other options are available to customers?

**(10 marks)**

**Question 5 (25 marks)**

1. Corrugated Board is used for various type of packaging. List 5 of these types and for 3 of them, suggest a grade and evaluate the properties of the material that makes it suitable for this use.

**(13 marks)**

1. Evaluate the following board grade fluting types, using the terms Very Good, Good, Fair, Poor, as you see appropriate, to show the grade strengths for: Flat Crush strength, Stacking strength and Printability.

| Board | Flat Crush | Stacking | Surface print |  |
| --- | --- | --- | --- | --- |
|  |  | strength | quality |  |
| B Flute |  |  |  |  |
| C Flute |  |  |  |  |
| B/C Double Wall |  |  |  |  |
| E Flute |  |  |  |  |
|  |  |  | **(12 marks)** | |



Unit 2 Page 3 of 3

**Question 1 (25 marks)**

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**(14 marks)**

**b) Outline SIX properties of glass**

**(6 marks)**

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

**(5 marks)**

Answer:

a) Diagram of Glass Manufacturing Process from Raw Materials to Glass Gob Production:

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Raw Materials

(Silica, Soda Ash, Limestone)

|

Batching

|

Melting

(1500-1600°C)

|

Refining/Fining

(1550-1650°C)

|

Homogenization

(1550-1650°C)

|

Conditioning

(1200-1400°C)

|

Glass Gob Formation

(1100-1200°C)

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The glass manufacturing process begins with the preparation of raw materials, typically consisting of silica (sand), soda ash, and limestone. These raw materials are accurately weighed and mixed in the batching process.

The batch is then fed into a furnace, where it is heated to extremely high temperatures, typically between 1500-1600°C, to melt the raw materials and form a homogeneous molten glass.

The molten glass then undergoes a refining or fining process, where it is heated to 1550-1650°C to remove any bubbles or impurities. This is followed by a homogenization stage, where the glass is further heated to 1550-1650°C to ensure a consistent composition throughout.

The molten glass is then conditioned, where it is cooled to a temperature range of 1200-1400°C, making it suitable for the final stage of glass gob formation. The glass gob, a controlled amount of molten glass, is then formed and prepared for the container or product manufacturing process.

b) Six Properties of Glass:

1. Transparency: Glass is a transparent material, allowing light to pass through it.

2. Durability: Glass is a hard and durable material, resistant to scratches and breakage.

3. Chemical Inertness: Glass is chemically inert, making it suitable for storing a wide range of products.

4. Impermeable: Glass is impermeable to gases and liquids, providing an excellent barrier for packaging.

5. Thermal Resistance: Glass can withstand high temperatures without deforming or melting.

6. Recyclability: Glass can be recycled repeatedly without losing its quality or properties.

c) Five Methods of Reducing Energy Requirements in Glass Manufacturing:

1. Cullet Utilization: Incorporating recycled glass (cullet) into the batch can reduce the energy required for melting, as cullet has a lower melting point than raw materials.

2. Batch Preheating: Preheating the batch before it enters the furnace can reduce the energy needed for melting.

3. Furnace Design Optimization: Improving the design and insulation of the furnace can minimize heat loss and improve energy efficiency.

4. Waste Heat Recovery: Capturing and reusing the waste heat generated during the manufacturing process can significantly reduce the overall energy consumption.

5. Alternate Fuel Sources: Exploring the use of alternative fuel sources, such as natural gas or renewable energy, can help reduce the reliance on traditional energy-intensive fuels.

**Question 2 (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 products.**

**(10 marks)**

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

**(10 marks)**

## Aluminium Foil (5 marks)

**Aluminium foil** is a thin sheet of aluminium, typically ranging from 0.006 to 0.2 millimeters in thickness. It's a versatile material used in various applications due to its unique properties.

**Surface Appearances:**

1. **Shiny side:** This surface has a bright, reflective finish. It's produced when the aluminium sheet comes into contact with a polished steel roller during the rolling process.
2. **Dull side:** This side has a matte or non-reflective appearance. It typically forms on the opposite side of the sheet that doesn't directly contact the polished roller.

## Hot Rolling vs. Cold Rolling (10 marks)

**Hot Rolling:**

* **Process:** Aluminium ingots are heated to high temperatures (typically around 450-500°C) to become more malleable.
* **Action:** The heated metal is passed between powerful rollers, progressively reducing its thickness and increasing its length.
* **Characteristics:** Hot rolled aluminium has a coarse grain structure, making it less strong but easier to shape further. It's often used as an intermediate step before cold rolling for thicker sheet products.

**Cold Rolling:**

* **Process:** Pre-rolled aluminium (often from hot rolling) is further reduced in thickness and improved in surface finish at room temperature.
* **Action:** The metal is passed through a series of highly polished rollers under high pressure.
* **Characteristics:** Cold rolling strengthens the aluminium by refining its grain structure and creating a smoother, more even surface finish. It also increases the material's hardness and tensile strength.

**Comparison Table:**

| Feature | Hot Rolling | Cold Rolling |
| --- | --- | --- |
| Temperature | High (450-500°C) | Room Temperature |
| Deformation | Significant thickness reduction | Further reduction and improved surface finish |
| Grain Structure | Coarse | Finer and more uniform |
| Strength | Lower | Higher |
| Hardness | Lower | Higher |
| Surface Finish | Rougher | Smoother and more even |

## Advantages of Aluminium Foil for Flexible Packaging (10 marks)

Aluminium foil offers several key advantages that make it a popular choice for flexible packaging:

1. **Barrier Properties:** Aluminium acts as an excellent barrier against moisture, light, oxygen, and other gases. This helps protect food and other products from spoilage, degradation, and contamination.
2. **Formability:** Aluminium foil is highly malleable and can be easily shaped to conform to different packaging needs. This allows for versatile packaging designs and applications.
3. **Lightweight:** Aluminium is a lightweight material, contributing to reduced transportation costs and environmental impact.
4. **Heat Conductivity:** Aluminium conducts heat well, making it suitable for packaging products requiring heat transfer for cooking or preservation.
5. **Recyclability:** Aluminium is highly recyclable, making it an environmentally friendly packaging option. Recycled aluminium can be used to create new foil with minimal energy consumption compared to virgin aluminium production.
6. **Odor and Taste Barrier:** Aluminium foil effectively blocks odors and tastes, preventing them from transferring between the product and the packaging, ensuring product quality.

These combined properties make aluminium foil a versatile and valuable material for protecting and preserving a wide range of products in flexible packaging applications.

**Question 3 (25 marks)**

1. **With the aid of a diagram describe the typical production process for wide mouth glass jars from gob formation to the presentation of containers for annealing**

**(13 marks)**

1. **Why are surface coatings used on glass? Name where they are applied, their function and an example of each type**

**(7 marks)**

1. **Packaging designers focus on specific areas when designing glass bottles. Briefly discuss the five regions of a glass wine bottle and why they merit special consideration for designers.**

**(5 marks)**

## Wide Mouth Glass Jar Production (13 marks)

**Diagram:**

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

| Molten | ----> | Forming | ----> | Annealing | ----> | Inspected | ----> | Ready for |

| Glass Gob | (Press & Blow) | Machine | ----> | Lehrs | ----> | Containers|

| (1050°C) | +----------+ | (Cooling) | +----------+ +----------+

| | | (400°C) | |

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

| |

(Mold Shaping) (Stress Relief)

**Description:**

1. **Gob Formation (1050°C):** A precisely measured amount of molten glass is formed into a gob using a shearing or pouring technique.
2. **Press & Blow Forming:** The gob is dropped into a mold. A plunger presses the gob to create a preliminary shape (parison). Then, air is blown into the parison to expand it and form the final jar shape. This method is ideal for wide-mouth jars due to the initial pressing step.
3. **Annealing Lehrs (400°C):** The formed jars are conveyed through a long, heated tunnel called a lehr. The temperature is gradually reduced, allowing the glass to cool slowly and evenly. This process relieves internal stresses in the glass, preventing cracking or shattering.
4. **Inspection:** After cooling, the jars are inspected for any defects like cracks, bubbles, or imperfections.
5. **Ready for Annealing:** Inspected and approved jars are ready for further processing like labeling, decoration, or palletizing for shipment.

## Surface Coatings for Glass (7 marks)

Surface coatings are thin layers applied to the glass surface to enhance its properties or aesthetics. Here are some types and their applications:

* **Anti-reflective Coatings:** Applied to lenses or optical instruments to reduce light reflection and improve clarity.
* **Low-emissivity (Low-E) Coatings:** Applied to architectural glass to reflect infrared radiation, improving insulation and energy efficiency.
* **Hardcoats:** Applied to glass surfaces for increased scratch and abrasion resistance, often used for touchscreens or display panels.
* **Conductive Coatings:** Applied to create electrically conductive surfaces used in touchscreens, solar cells, or anti-static applications.

## Regions of a Glass Wine Bottle (5 marks)

Packaging designers pay close attention to five key regions of a glass wine bottle:

1. **Finish (Top):** This includes the bottle neck, lip, and closure. It's crucial for ensuring a good seal and comfortable handling.
2. **Shoulder:** The transition between the neck and body. Its shape can influence pouring and label placement.
3. **Body:** The main body of the bottle. Its size and shape contribute to aesthetics, brand identity, and product volume.
4. **Base (Punt):** The bottom of the bottle. It provides stability, adds visual interest, and can influence bottle stacking.
5. **Label Panel:** A designated area for the wine label. Its size and shape should accommodate label information effectively.

By considering these regions and their functionalities, designers can create wine bottles that are not only aesthetically pleasing but also practical for pouring, labeling, and overall brand presentation.

**Question 4 (25 marks)**

1. **What are the different types of pulp used in the manufacture of carton board and what are the basic differences / benefits of each type?**

**(15 marks)**

1. **In the finishing of paperboard jumbo reels, what are the main two processes involved and what other options are available to customers?**

**(10 marks)**

### Answer:

\*\*Types of Pulp Used in the Manufacture of Carton Board:\*\*

1. \*\*Bleached Chemical Pulp\*\*:

- \*\*Description\*\*: Bleached chemical pulp is processed using chemicals to remove lignin and other impurities, resulting in a bright, high-quality pulp.

- \*\*Benefits\*\*: Provides excellent brightness, strength, and printability, making it ideal for premium carton board applications.

2. \*\*Unbleached Mechanical Pulp\*\*:

- \*\*Description\*\*: Unbleached mechanical pulp is produced by mechanically grinding wood fibers, retaining more lignin and impurities compared to chemical pulp.

- \*\*Benefits\*\*: Offers good bulk, opacity, and cost-effectiveness, suitable for applications where brightness is not a primary concern.

3. \*\*Semi-Chemical Pulp\*\*:

- \*\*Description\*\*: Semi-chemical pulp is produced using a combination of mechanical and chemical processes, offering properties between chemical and mechanical pulps.

- \*\*Benefits\*\*: Provides a balance of strength, brightness, and cost, making it suitable for a range of carton board grades.

\*\*Differences and Benefits of Each Type of Pulp:\*\*

- \*\*Bleached Chemical Pulp\*\*: Offers high brightness, excellent printability, and superior strength, making it ideal for high-end packaging requiring vibrant graphics.

- \*\*Unbleached Mechanical Pulp\*\*: Provides good bulk, opacity, and cost-effectiveness, suitable for applications where brightness is not critical, such as industrial packaging.

- \*\*Semi-Chemical Pulp\*\*: Balances strength, brightness, and cost, offering versatility for various carton board grades, from premium to standard packaging.

\*\*Finishing Processes for Paperboard Jumbo Reels:\*\*

1. \*\*Calendering\*\*:

- \*\*Description\*\*: Calendering involves passing the paperboard through rollers to improve smoothness, gloss, and surface uniformity.

- \*\*Benefits\*\*: Enhances the appearance and printability of the paperboard, making it suitable for high-quality packaging applications.

2. \*\*Coating\*\*:

- \*\*Description\*\*: Coating applies a layer of coating material to the paperboard surface to improve print quality, brightness, and ink holdout.

- \*\*Benefits\*\*: Enhances the paperboard's surface properties, allowing for sharper graphics, better color reproduction, and improved surface finish.

\*\*Other Options Available to Customers\*\*:

- \*\*Embossing\*\*: Adds texture and visual interest to the paperboard surface.

- \*\*Laminating\*\*: Bonds multiple layers together for added strength and protection.

- \*\*Varnishing\*\*: Applies a clear coating for gloss, protection, and enhanced aesthetics.

- \*\*Die-Cutting\*\*: Shapes the paperboard into specific designs for unique packaging solutions.

**Question 5 (25 marks)**

1. **Corrugated Board is used for various type of packaging. List 5 of these types and for 3 of them, suggest a grade and evaluate the properties of the material that makes it suitable for this use.**

**(13 marks)**

1. **Evaluate the following board grade fluting types, using the terms Very Good, Good, Fair, Poor, as you see appropriate, to show the grade strengths for: Flat Crush strength, Stacking strength and Printability.**

| **Board** | **Flat Crush** | **Stacking** | **Surface print** |  |
| --- | --- | --- | --- | --- |
|  |  | **strength** | **quality** |  |
| **B Flute** |  |  |  |  |
| **C Flute** |  |  |  |  |
| **B/C Double Wall** |  |  |  |  |
| **E Flute** |  |  |  |  |
|  |  |  | **(12 marks)** | |

Answer:

5 Types of Packaging Using Corrugated Board:

1. Corrugated Boxes: Used for shipping and transporting a wide range of products, from food and beverages to electronics and industrial goods.

2. Corrugated Trays: Utilized for retail-ready packaging, product displays, and secondary packaging.

3. Corrugated Dividers: Employed for internal partitioning and protection of products within larger containers.

4. Corrugated Pallets: Provide a lightweight, cost-effective alternative to traditional wooden pallets for material handling.

5. Corrugated Inserts: Used as cushioning and protective elements within larger packaging systems.

Evaluation of 3 Corrugated Board Grades:

1. Corrugated B-Flute:

- Grade: B-Flute

- Properties:

- Flat Crush Strength: Good

- Stacking Strength: Fair

- Printability: Good

- Suitability: Suitable for general-purpose packaging, retail-ready displays, and secondary packaging where moderate strength and good printability are required.

2. Corrugated C-Flute:

- Grade: C-Flute

- Properties:

- Flat Crush Strength: Very Good

- Stacking Strength: Good

- Printability: Good

- Suitability: Suitable for heavier-duty shipping containers, industrial packaging, and applications requiring high stacking and crush resistance.

3. Corrugated B/C Double Wall:

- Grade: B/C Double Wall

- Properties:

- Flat Crush Strength: Excellent

- Stacking Strength: Very Good

- Printability: Fair

- Suitability: Suitable for the most demanding packaging applications, such as heavy-duty shipping, industrial packaging, and applications requiring exceptional stacking and crush resistance. The reduced printability may be a trade-off for the enhanced structural properties.

Evaluation of Fluting Types:

| Board | Flat Crush Strength | Stacking Strength | Surface Printability |

| --- | --- | --- | --- |

| B Flute | Good | Fair | Good |

| C Flute | Very Good | Good | Good |

| B/C Double Wall | Excellent | Very Good | Fair |

| E Flute | Fair | Poor | Good |

The evaluation of the fluting types shows that:

- B Flute has good flat crush strength and printability, but fair stacking strength.

- C Flute has very good flat crush strength and good stacking strength and printability.

- B/C Double Wall has excellent flat crush strength and very good stacking strength, but fair printability.

- E Flute has fair flat crush strength and poor stacking strength, but good printability.

The choice of the appropriate fluting type will depend on the specific packaging requirements, balancing the needs for strength, stacking, and printability.