Question Bank III IAE

Q1. (Analyze – 13 Marks)

Analyze how the rheological behavior of non-Newtonian foods affects the design of food processing equipment. Support your answer with examples from industry applications.

Key Answer Points:

- Non-Newtonian behavior (e.g., pseudoplastic, Bingham) affects flow, pumping, and mixing.
- E.g., tomato paste requires higher shear force in pipelines.
- Design needs variable speed pumps, positive displacement systems, etc.

Q2. (Evaluate – 13 Marks)

Evaluate the effectiveness of using dielectric properties in determining moisture content in grains during storage.

Key Answer Points:

- Dielectric constant varies with moisture.
- Accurate for non-destructive testing.
- Limitations: affected by temperature, bulk density.

Q3. (Apply – 13 Marks)

Apply viscoelastic theory to explain dough performance during extrusion and how it affects product texture.

Key Answer Points:

- Dough exhibits both viscous and elastic behavior.
- Affects expansion, shaping, and final texture.
- Viscoelastic response critical in snack and pasta manufacturing.

Q4. (Analyze – 13 Marks)

Analyze the causes and consequences of high electrical impedance in bulk food storage systems.

Key Answer Points:

- High impedance = poor conductivity.
- Caused by dry material, poor contact.
- Leads to inefficient energy transfer in sensors or heating systems.

Q5. (Evaluate – 13 Marks)

Evaluate the suitability of rheopectic behavior in industrial coatings for food packaging applications.

Key Answer Points:

- Rheopectic: viscosity increases over time under shear.
- Helps in thickening layers for durability.
- Downsides: clogging in nozzles, requires careful flow control.

Q6. (Apply – 13 Marks)

Apply flow curve analysis to determine the best processing conditions for a thixotropic fluid like ketchup.

Key Answer Points:

- Flow curve shows shear stress vs. shear rate.
- Thixotropic: viscosity decreases with time under shear.
- Helps optimize nozzle design and reduce energy.

Q7. (Analyze – 13 Marks)

Analyze the implications of low dielectric loss factor in microwave drying of leafy vegetables.

Key Answer Points:

- Low loss factor = poor microwave energy absorption.
- Leads to uneven or slow drying.
- May require pretreatment or hybrid drying techniques.

Q8. (Evaluate – 13 Marks)

Evaluate the trade-offs between using plastic and metal electrodes in dielectric property measurements of agricultural products.

Key Answer Points:

- Metal: accurate but prone to corrosion.
- Plastic: durable, less precise.
- Choice depends on accuracy, cost, product type.

Q9. (Apply – 13 Marks)

Apply rheological data to improve pump selection for handling chocolate in a confectionery line.

Key Answer Points:

- Chocolate is a Bingham plastic.
- Requires pump that handles yield stress and prevents shear-induced crystallization.
- Positive displacement pumps preferred.

Q10. (Analyze – 13 Marks)

Analyze the effect of frequency variation on dielectric heating efficiency in grains with different moisture levels.

Key Answer Points:

- Higher frequency: shallow penetration, better for moist grains.
- Lower frequency: deeper heating, less uniform.
- Match frequency with moisture profile for efficiency.

Case Study 1: Designing a Rheological Testing Setup for Chocolate Processing

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GATE Reference: GATE AG 2021 (Inspired)

Industry Example: Nestlé / Mondelez

Question:

Design a rheological testing protocol to evaluate the flow behavior of molten chocolate during processing. Include sample preparation, measurement method, expected flow type, and industrial relevance.

Answer Key:

- Use rotational viscometer or rheometer.
- Control temperature ~45°C for molten chocolate.
- Expect Bingham plastic behavior (yield stress + flow).
- Results guide pump design, cooling rates, and tempering conditions.

Case Study 2: Optimizing Microwave Heating for Moisture-Dependent Grains

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GATE Reference: GATE AG 2020 (Adapted)

Industry Example: ITC Agri / Britannia

Question:

Create a strategy to improve microwave drying of grains with varying moisture levels using dielectric property data. Include heating mechanism, equipment setup, and moisture management.

Answer Key:

- Use dielectric loss factor to segment grains.
- Pre-classify batches by moisture content.
- Adjust microwave frequency and power accordingly.
- Prevent overheating/drying gradients in processed grains.

Case Study 3: Designing a Flow System for Tomato Puree in Pouch Filling Lines

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GATE Reference: GATE AG 2019 (Conceptual Basis)

Industry Example: PepsiCo / HUL (Kissan)

Question:

Design a hygienic flow system for filling tomato puree (a pseudoplastic fluid) into pouches. Include pipe layout, pump type, and shear sensitivity considerations.

Answer Key:

- Tomato puree is shear-thinning (pseudoplastic).
- Use short, wide pipes to reduce shear.
- Select positive displacement pump (e.g., lobe pump).
- Ensure CIP (clean-in-place) for hygiene compliance.

Case Study 4: Electrode Selection for Online Moisture Monitoring in Cereal Mills

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GATE Reference: GATE AG 2022 (Adapted)

Industry Example: General Mills / Cargill

Question:

Develop a sensor system for continuous online monitoring of moisture in cereal grains using dielectric properties. Justify electrode choice, signal interpretation, and placement.

Answer Key:

- Use capacitive sensors with stainless steel electrodes.
- Non-contact or embedded in flow channel.
- Dielectric constant correlates with moisture.
- Must account for temperature compensation.

Case Study 5: Improving Dough Texture Using Viscoelasticity Analysis

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GATE Reference: GATE AG 2018 (Inspired)

Industry Example: Parle / ITC Foods

Question:

Create an experimental protocol using viscoelasticity testing to enhance cookie dough texture and machinability. Define parameters, methods, and link to product quality.

Answer Key:

- Use stress-relaxation or creep test.
- Measure elastic modulus and yield stress.
- Balance elasticity and plasticity for machinability.
- Fine-tune water and fat content.

Case Study 6: Designing an Energy-Efficient Heating System Using Loss Tangent

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GATE Reference: GATE AG 2023 (Modeled)

Industry Example: Amul / Patanjali

Question:

Design a heating system for milk-based ready-to-eat product using dielectric properties (loss tangent). Choose frequency, geometry, and efficiency parameters.

Answer Key:

- Loss tangent = dielectric loss / dielectric constant.
- Higher loss tangent = better microwave absorption.
- Use 915 MHz for deeper penetration.
- Optimize cavity size and product uniformity.

Question 1: Viscoelastic Behavior and Dough Machinability

Bloom's Taxonomy Level: Evaluate

GATE Reference Year: GATE AG 2021

Question:

Evaluate the impact of viscoelastic behavior on the machinability of dough in automated food processing lines.

Key Answer Points:

- Discuss elastic vs. viscous response of dough
- Relation to stress relaxation and modulus
- Effect on extrusion, cutting, shaping
- Balancing elasticity and plasticity for optimal performance

Question 2: Pump Selection for Bingham Plastic Foods

Bloom's Taxonomy Level: Analyze

GATE Reference Year: GATE AG 2020

Question:

Analyze the flow behavior of Bingham Plastic foods and explain how it influences the pump selection in a chocolate processing plant.

Key Answer Points:

- Define Bingham plastic (yield stress)
- Analyze flow curve and shear requirements
- Need for positive displacement pumps
- Industry application in chocolate systems

Question 3: Designing Microwave Drying Using Loss Tangent

Bloom's Taxonomy Level: Evaluate

GATE Reference Year: GATE AG 2022

Question:

Evaluate the use of dielectric loss tangent for designing microwave drying protocols for high-moisture agricultural produce.

Key Answer Points:

- Loss tangent = loss factor / dielectric constant
- Indicates energy absorption capacity
- Impacts uniformity and efficiency in drying
- Applicability to fruits, grains, leafy crops

Question 4: Limitations of Impedance-Based Moisture Sensing

Bloom's Taxonomy Level: Analyze

GATE Reference Year: GATE AG 2019

Question:

Analyze the limitations of using impedance-based sensors for moisture estimation in bulk grain storage.

Key Answer Points:

- Based on electrical resistance and reactance
- Affected by packing, temperature, signal interference
- Calibration errors and sensor drift
- Recommendations for improved accuracy

Question 5: Thixotropic Behavior in Industrial Sauce Filling

Bloom's Taxonomy Level: Evaluate

GATE Reference Year: GATE AG 2020

Question:

Evaluate the implications of thixotropic behavior in sauces for designing industrial filling lines.

Key Answer Points:

- Thixotropy = viscosity decreases over time under shear
- Impact on flow rate and valve timing
- Flow restart challenges after pause
- Use in ketchup, sauces, and dressing lines