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COIMBATORE-641 035, TAMIL NADU

23FTT202 FLUID MECHANICS FOR FOOD TECHNOLOGY

UNITIII: Viscous flow and turbulent flow

The continuity equation in fluid mechanics expresses the principle of conservation of mass. In the context of food technology, it is essential for analyzing the flow of fluids—whether it's liquids like sauces, juices, or slurries—and ensuring efficient processing in various operations.

Continuity Equation in Cartesian Coordinates

In Cartesian coordinates, the continuity equation for a three-dimensional, incompressible fluid can be expressed as:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

For an incompressible fluid, the density (ρ) remains constant, allowing us to simplify the equation:

$$\nabla \cdot \mathbf{v} = 0$$

Where:

- $\mathbf{v}$ is the velocity vector of the fluid.
- $\nabla \cdot$ represents the divergence operator.
- t is time.

In Cartesian Coordinates

In three-dimensional Cartesian coordinates (x, y, z), the continuity equation can be written as:

$$\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z} = 0$$

Where:

- v_x, v_y, and v_z are the velocity components in the x, y, and z directions, respectively.

Applications in Food Technology

1. **Pumping Systems:**

    - When designing pumps for transferring liquid food products, ensuring that the continuity equation is satisfied helps to avoid issues such as cavitation and inefficiencies in flow rates.
2. **Mixing Processes:**
    - In processes like emulsification or mixing of sauces, applying the continuity equation can help understand how different ingredients interact and ensure uniform distribution throughout the mixture.
3. **Fluid Flow in Pipelines:**
    - The continuity equation is used to analyze flow rates in pipelines transporting liquid foods. It ensures that the mass flow rate remains constant along the pipe, which is crucial for maintaining product consistency.
4. **Heat Exchangers:**
    - In heat transfer processes, such as pasteurization, the continuity equation helps to model the flow of fluids through heat exchangers, ensuring efficient heat transfer and product safety.
5. **Food Processing Equipment:**
    - The design and analysis of equipment such as homogenizers, blenders, and extruders often rely on the principles expressed in the continuity equation to optimize flow and processing conditions.

Summary

The continuity equation in Cartesian coordinates is a fundamental principle that helps food technologists analyze and optimize fluid flows in various food processing applications. By ensuring that mass is conserved throughout different operations, manufacturers can improve efficiency, maintain product quality, and enhance overall process safety.

i) Objective methods: You can also measure colour, flavour, texture and nutritive quality with help of instrument. However, sensory method is the best method for judging the quality.

Specifications for cereals

There are at least 330 specifications for cereals and cereal products at national and international level (over 50 countries or regions) of which at least 12 are applicable globally. The criteria assigned to grains are the intrinsic varietal qualities and those which are environment- or process induced.

Intrinsic Qualities

Colour: Cereal grains are pigmented and range through the colour spectrum from very light tan or almost white, to black. Where extractive milling is required, highly-pigmented varieties may give low yields of white flour.

Composition: Composition, e.g. protein, carbohydrate, lipids and their breakdown products, qualitatively influences product acceptability, by affecting texture and taste. Quality changes evolve slowly in stored grain and more rapidly in milled or processed intermediary products.Some grain components, for example husk, are inedible and quantitatively influence product yield and gross nutrients available to the consumer.

Bulk Density: Each type or variety of grain when in optimum health, fully mature, etc. has a characteristicbulk density.

Odour, aroma: Most grain types, when fresh, have a distinctive natural odour or aroma. This is generally accepted as an indicator of good quality, although some people prefer grain which smells 'old' or even fermented.

Size, shape: Rice, as a whole-grain food, is classified by size (length) and shape (length:breadth ratio). Other grains also have its size considered in their specification. In general a small range in size assists with processing and handling.

Induced Qualities

Age: During the post-harvest phase, grain undergoes complex biochemical changes termed 'aging'. Changes to carbohydrate, lipids and protein fractions result in, for example, firming of texture in rice on cooking, and increased gas-retention

capability in wheat flour. For most consumers, the effects of these changes are considered to be desirable. When plotting consumer acceptability of a grain product against its age since harvesting, generally it is considered to be maturing during the upward curve of the graph, and deteriorates only when the curve changes direction downwards.

Broken grains: Grain is marketed normally in whole grain form and is considered to be of inferior quality if broken. Breakage may occur from fissures as a result of excessive drying/weathering conditions in the field or during handling. Breakage reduces quality by reducing acceptability and by increasing susceptibility to infestation during storage. This affects milling yield.

Chalky or immature grain: Empty grains result from sterility and pre-harvest infections and insect attack. Immature grain content is affected by time of harvest. In rice, immature grains are greenish in colour. Thin white (usually opaque) grains are caused by incomplete grain filling and may result from pests or disease. Chalkiness is caused by incompletely filled starchy endosperm which disrupts light transmission, causing opaque regions. In most cereals, chalky areas have lower mechanical strength on crush tests and may break during handling. The broken portion is more easily invaded by certain storage pests.

Foreign matter: Dilution of the prime product by foreign matter reduces the value, and also may affect handling and processing. Foreign matter may be animal origin - vegetable origin - mineral origin.

Infested, infected grain: Grain mass, and therefore yield, is reduced by infestation. Contamination not only has direct food hygiene implications but also indirect ones, as invading micro-organisms may produce toxins under certain conditions which may lead to acute or chronic illness.

Mixed varieties: A mixture is an indication of poor pre- and post-harvest management and supervision, e.g. seed selection, lot segregation and treatment, contamination, etc. Grains differing in size and other characteristics affect processing potential. Whilst preference for a particular variety may be influential nationally or regionally, internationally-traded grain is recognised usually by grain type rather than by variety e.g. yellow or white maize. Exceptions do occur, e.g. basmati rice, (due to its aroma).

Moisture content: Moisture content of grain plays a crucial role in post-harvest processing and is associated with most of the induced characteristics. Water vapour will diffuse throughout a bulk of grain and the moisture content will tend to equalise. 'Hot spots' may occur at a site of increased respiration (caused by sprouting, infestation or microbial activity), and condensation may occur on cold grain or containers