



S.No.	Topic	No. of Lectures
12.	Recent advances in packaging, active packaging, smart packaging, antioxidant and antimicrobial packaging, edible films and biodegradable packaging, microencapsulation and nano encapsulation	2
	Total	16

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Familiarization of types of packaging material	1
2.	Determination of thickness of different types of packaging materials	1
3.	To determinewater absorption capability of flexible packaging materials	1
4.	Determination of tensile strength of packaging material	1
5.	Determination of compressive strength of packaging material	1
6.	Determination of water vapour transmission rate of packaging material	1
7.	Determination of gas transmission rate of packaging material	1
8.	Identification of different types of plastic films	1
9.	Testing of chemical and grease resistance of packaging materials	1
10.	Determination of bursting strength of packages	1
11.	Drop test for food package strength	1
12.	Vacuum packaging of various food products	1
13.	Nitrogen packaging of food products	1
14.	To study the effect of shrink wrapping onshelf life of fruits and vegetables	1
15.	To study the effect of active modified atmosphere packaging onshelf life of fruits and vegetables	1
16.	Visit to relevant industries	1
	Total	16

X. Suggested Reading

- Crosby NT. 1981. *Food Packaging Materials*. Applied Science Publisher.
- Frank A. 1992. *A Handbook of Food Packaging*. Springer.
- Mahadeviah M and Gowramma RV. 1996. *Food Packaging Materials*. Tata McGraw
- Hill.Palling SJ. 1980. *Developments in Food Packaging*. Applied Science Publisher.
- Robertson GL. 2013. *Food Packaging - Principles and Practice*. 3rd Ed Taylor & Francis.
- Sacharow S and Grittin RC. 1980. *Principles of Food Packaging*. AVI Publisher.

I. Course Title : Instrumentation and Sensors in Food Processing

II. Course Code : PFE 507

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip the students with instrumentation and use of sensors in food processing operations.

V. Theory

Unit I

Basic instrumentation systems and transducer principles. Displacement transducers, Potential meters, LDVT, Piezoelectric and capacitive transducers, Digital transducers, velocity transducers.



Unit II

Acceleration and absolute motion measurement, Force transducer, Strain gauge, Hydraulic load cell, Cantilever type and probing ring. Method of separation of force: Torque, power and energy measuring technique.

Unit III

Temperature measurement using bi-metals, thermistors, thermocouples, humidity measurement, manometers. Flow transducer, positive displacement, venturimeter, Rotameter, Drag force, hot wire anemometer.

Unit IV

Theory and classifications of chemical sensors, biosensors, fibre optic sensors, gas sensors etc. Biosensor: Concepts, types of biosensors, methods of immobilizing biosensors, application. Imaging methods: X-ray imaging, Computed tomography, MRI, Ultrasound, Hyperspectral imaging. Spectroscopy and chemometrics: UV and visual spectroscopy, NIR spectroscopy, FTIR spectroscopy.

VI. Practical

Identification of components of generalized measuring system: Calibration of instruments, experiment on LVDT, strain gauge transducer, force, torque, power and pressure, fluid flow rates, temperature, calorific value, vibration measurement. Use of data loggers and data storage devices, spectroscopy, imaging systems.

VII. Learning outcome

Student's capability to control the process operations through precise instrumentation and knowledge of sensors for precision analysis of food quality in food industries.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Basic instrumentation systems	1
2.	Transducer principles	1
3.	Displacement transducers, Potential meters, LDVT, Piezoelectric and capacitive transducers, Digital transducers, velocity transducers.	3
4.	Acceleration and absolute motion measurement, Force transducer, Strain gauge, Hydraulic load cell, Cantilever type and probing ring.	3
5.	Different methods of separation of force: Torque, power and energy measuring technique	3
6.	Temperature measurement using bi-metals, thermistors, thermocouples, humidity measurement, manometers.	3
7.	Flow transducer, positive displacement, venturi meter, Rotameter, Drag force, hot wire anemometer.	2
8.	Theory and classification of chemical sensors, biosensors, fibre optic sensors, gas sensors etc.	4
9.	Biosensor: Concepts, types of biosensors, methods of immobilizing biosensors, application.	3
10.	Imaging methods for foods, Principles, equipment, food applications- X-ray imaging, Computed tomography, MRI, Ultrasound, Hyperspectral imaging.	4
11.	Various methods of spectroscopy and chemometrics, principles, equipment, food applications- UV and visual spectroscopy, NIR spectroscopy, FTIR spectroscopy.	3
	Total	30

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Identification of components of generalized measuring system for temperature, pressure, relative humidity, moisture etc.	1
2.	Calibration of moisture measuring equipment	1
3.	Calibration of temperature control and measuring devices	1
4.	To study the working of Bourdon Pressure Gauge and to check the calibration of the gauge in a deadweight pressure gauge calibration set up.	1
5.	To study various temperature measuring instruments e.g. Mercury-in-glass thermometer, Thermocouple, Electrical resistance thermometer, laser thermometer and to estimate their response times	1
6.	To determine the calorific value of different food products using a bomb calorimeter having temperature sensing device	1
7.	To study a Linear Variable Differential Transformer (LVDT) and use it in a simple experimental set up to measure a small displacement	1
8.	To measure torque of a rotating shaft using torsion meter/strain gauge torque transducer	1
9.	To measure the speed of a motor shaft with the help of non-contact type pick-ups (magnetic or photoelectric)	1
10.	To measure static/dynamic pressure of fluid in pipe/tube using pressure transducer/pressure cell	1
11.	To determine the hardness/firmness of food samples using a texture analyzer	1
12.	To study the effect of vibrations during transportation on the quality of food (damage/ bruising/ texture etc) using a simulated vibration test	1
13.	To study and use the data logging and data storage devices	1
14.	To study and understand the working principle of UV and visual spectroscopy for measurement of food properties	1
15.	To study and understand the working principle of NIR and FTIR spectroscopy for measurement of food properties	1
16.	To study the working principle of X-ray imaging, Computed tomography, MRI, Ultrasound and Hyperspectral imaging for measurement of food quality	1
	Total	16

X. Suggested Reading

- Doebelin EO. 1990. *Measurement Systems Applications and Design*. Tata McGraw Hill.
- Erika KR and Brimelow JB. 2001. *Instrumentation and Sensors for the Food Industry*. CRC Woodhead.
- Nakra BC and Chaudhary KK. 2004. *Instrumentation Measurement and Analysis*. Tata McGraw Hill.
- Mukhopadhyay. 2014. *Novel Sensors for Food Inspection: Modelling, Fabrication and Experimentation*. Springer.
- Mukhopadhyay SC. 2017. *Sensors for Everyday Life*. Springer.
- Paré JRJ and Bélanger JMR. 1997. *Instrumental Methods in Food Analysis*. Elsevier Academic Press.