GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Mechanical (I.C.Engine & Automobile Engineering)

Subject Code : ME02080041

Course / Subject Name : I.C.Engine Modelling and Simulation

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Fundamentals of IC Engine, Automobile Systems & Aerodynamics
Rationale:	To know about modeling, different types of modeling and its application in Automobile engineering, to gain the knowledge in simulation of various systems and components of IC Engines with various new engine concepts.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Understanding Basic Concepts	Remembering, Understanding
2	Developing Modeling Techniques	Applying, Analyzing
3	Analyzing Laminar Flow and Turbulence in IC Engines	Analyzing, Evaluating
4	Simulating IC Engines and their New Concepts	Applying, Evaluating, Creating
5	Creating Computer Models for Heat Transfer and Engine Cycle Simulations	Applying, Creating
6	Evaluating and Presenting Research Papers on Engine Modeling and Simulation	Evaluating, Creating

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Unit 1: Introduction to modeling;** importance of modeling; Spray equation model; Thin and thick spray model; Droplet turbulence interactions; Droplet impingement on walls.	6	13
2.	**Unit 2: Modeling of IC Engines:** Classifications, zero-dimensional and quasi-dimensional modeling, comparison of combustion systems, combustion efficiency. Heat of reaction, adiabatic combustion, thermal efficiency at full throttle, part throttle, and supercharged conditions.	16	35
3.	**Unit 3: Laminar Flow Modeling:** K-e model, probability density functions, effective viscosity, vortex structures, compression-generated turbulence.	8	17
4.	**Unit 4: Simulation of IC Engines:** SI and CI engine simulation, air standard cycle, fuel-air cycle, progressive combustion cycle, and actual cycle simulation under various conditions.	9	22
5	**Unit 5: Simulation of New Engine Concepts:** Dual fuel engine, low heat rejection engine, lean burn engine, variable compression ratio engine, HCCI, controlled auto ignition engine.	6	13
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	**25**	**25**	**20**	**10**	**5**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. J.I Ramos – Internal Combustion Engine Modeling – Hemisphere Publishing Corporation, 1989.
2. James N. Mattavi and Charles A. Amann – Combustion Modeling in Reciprocating Engines – Plenum Press, 1980.

3. G.C. Koltsakis and A.M. Stamatelos – Mathematical Modeling of Precious Metals Catalytic Converters for Diesel Nox Reduction – Proc. Institution of Mechanical Engineers.
4. V. Ganesan – Computer Simulation of Spark Ignition Engine Process – Universities Press (I) Ltd, Hyderabad, 2001.
5. J.B. Heywood – Internal Combustion Engine Fundamentals – McGraw Hill Book Co., USA, 2001.
6. A.L. Ramoss – Modeling of Internal Combustion Engines Processes – McGraw Hill Publishing Co., 1992.
7. Ashley Campbell – Thermodynamic Analysis of Combustion Engines – John Wiley & Sons, New York, 1986.
8. R.S. Benson, N.D. Whitehouse – Internal Combustion Engines – Paragon Press, Oxford, 1979.

(b) Open-source software and website:
OpenFOAM, Simulink (MATLAB), GEM(Gasoline Engine Management) Simulations, PyFOAM, CFDTool and FreeCAD etc.

Website: https://www.sae.org/
Website: https://www.researchgate.net/
Website: https://www.cfd-online.com/

Suggested Course Practical List: If any

1. Study of Weibe's combustion model.
2. Study of single-zone and multi-zone combustion models for SI engines.
3. Study of premixed-diffusive models for CI engines.
4. Characterization of spray using thin and thick spray combustion models.
5. Study of different turbulence combustion models.
6. Study of droplet breakup, collision, and wall interaction models.
7. Design-based Problem (DP): Prepare a computer code to simulate any stroke of the auto cycle using software like MATLAB or Scilab.

Online Learning Platforms

- NPTEL Courses: Comprehensive fluid mechanics modules., https://nptel.ac.in, etc.

Suggested Project List:

1. Development and Simulation of Weibe's Combustion Model for SI Engines
2. Study of Single Zone and Multi-zone Combustion Models for SI Engines
3. Development of Premixed-Diffusive Combustion Model for CI Engines

4. Study of Spray Characterization Using Thin and Thick Spray Combustion Models
5. Simulation of Air-Fuel Cycle and Actual Cycle for an SI Engine
6. Modeling and Simulation of Part Throttle and Full Throttle Conditions for IC Engines
7. Simulation of Heat Transfer in Engine Components (e.g., Piston or Valve)
8. Simulation of Combustion Efficiency in an IC Engine
9. Simulation of Dual-Fuel Engine Operation
10. Modeling of Low Heat Rejection (LHR) Engine for Fuel Efficiency
11. Simulation of Lean-Burn Engine and Emissions Reduction
12. Modeling of Variable Compression Ratio (VCR) Engine
13. Simulation of Homogeneously Charged Compression Ignition (HCCI) Engine
14. Simulation of Compression Generated Turbulence in IC Engines
15. Simulation of a Controlled Auto-Ignition (CAI) Engine
16. Development of Zero-Dimensional and Quasi-Dimensional Modeling of IC Engines
17. Simulation of Turbocharged IC Engines for Performance Analysis
18. Exhaust Gas Recirculation (EGR) Simulation in IC Engines
19. Optimization of Engine Components for Enhanced Performance
20. Optimization of Engine Cooling System for Improved Efficiency

Suggested Activities for Students:

1. Group Discussions on Combustion Models
2. Hands-on Simulation Exercises
3. Modeling Workshops on Engine Performance
4. Comparative Study of Combustion Models
5. CFD Simulation Projects
6. Group Research Presentations on Advanced Engine Concepts
7. Modeling Heat Transfer in Engine Components
8. Practical Demonstrations of Engine Components
9. Peer Review of Simulation Models
10. Simulation of Engine Emissions and Environmental Impact
11. Guest Lectures/Industry Interaction
12. Case Studies on Engine Design Optimization

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