

ENGINE COMBUSTION AND POLLUTION CONTROL

ENAM 414

Lecture : 3
Tutorial : 1
Practical : 3/2

Year : IV

Part : I

Course Objectives:

The objective of this course is to enable students to calculate the thermodynamic parameters, efficiency and performance characteristics of internal combustion engines. Students will analyze four primary pollutants and select alternative fuels or after-treatment systems to reduce emissions by specific regulatory targets.

1 Chemical Reaction in Combustion (5 hours)

- 1.1 Fuel structure and composition
- 1.2 Properties of fuel
- 1.3 Chemical reactions in fuel combustion
- 1.4 Combustible mixture and products of combustion
- 1.5 Heating value of fuel and mixture
- 1.6 Heat capacity of charge and combustion products

2 Intake and Compression in Engines (4 hours)

- 2.1 Differences in theoretical and actual cycles
- 2.2 Intake admission parameters, intake coefficient and factors affecting intake
- 2.3 Compression: Pressure and temperature at the end of compression; Effect of various parameters on combustion

3 Combustion in SI Engines (5 hours)

- 3.1 Mixture formation and Ignition limits
- 3.2 Combustion: Chemistry, types, stages and flame propagation
- 3.3 Rate of pressure rise and phases of combustion
- 3.4 Effect of operating variables on: Process of combustion, flame propagation, ignition lag
- 3.5 Auto ignition and chemical reaction
- 3.6 Detonation: Phenomenon, knocking, measurements, intensity, effect of engine variables and engine design
- 3.7 Factors governing combustion
- 3.8 Combustion chamber and its types

- 4 Combustion in CI Engines (4 hours)**
- 4.1 Direct and indirect combustion chamber
 - 4.2 Importance of air motion swirl, squish and turbulence-swirl ratio
 - 4.3 Fuel air mixing
 - 4.4 Stages of combustion
 - 4.5 Delay period and operating variables affecting delay period
 - 4.6 Detonation: Phenomenon, knocking, measurements, intensity, effect of engine variables and engine design
 - 4.7 Factors governing combustion
 - 4.8 Combustion chamber design
- 5 Expansion and Exhaust (2 hours)**
- 5.1 Expansion stage and working stroke
 - 5.2 Effect of various parameters on polytropic expansion
 - 5.3 Exhaust phenomenon
- 6 Characteristics of Motor Vehicle Engine (6 hours)**
- 6.1 Indicated characteristics
 - 6.2 Brake characteristics
 - 6.3 Effect of various operating variables on indicated and brake characteristics
 - 6.4 Speed characteristics
 - 6.5 Load characteristics
 - 6.6 Adjustment characteristics
 - 6.7 Special characteristics
- 7 Vehicular Emission (6 hours)**
- 7.1 Sources of pollutants: Exhaust gases, crankcase gas and fuel vapour
 - 7.2 Composition of exhaust gases
 - 7.3 Pollutant formation in CI and SI engines
 - 7.4 Effect of composition and structure of fuels on emission
 - 7.5 Effect of air-fuel mixture, operating variables, combustion chamber design, driving conditions and drivability, traffic management on emission
 - 7.6 Effect of fuels and exhaust gases on human health and environment
 - 7.7 Batteries types, application and emissions and Control
- 8 Methods of Exhaust Gas Analysis (5 hours)**
- 8.1 Principles of optical gas analysis: Colourimeter
 - 8.2 Gas chromatograph
 - 8.3 Smoke meter
 - 8.4 Particulate measurement
 - 8.5 Odor and aldehyde emission
 - 8.6 Exhaust gas analyzer

- 8.7 Flame ionization detectors
- 8.8 Chemiluminescence NO_x analyzer
- 8.9 Non dispersive infrared (NDIR) analyzer

9 Emission Control and Alternative Fuels (6 hours)

- 9.1 Emission standard and emission control norms, euro emission standards
- 9.2 Improving fuel system and ignition system of engines
- 9.3 Use of neutralizer (Flame, liquid and catalytic) in the exhaust system
- 9.4 Emission control system: Exhaust gas recirculation (EGR), evaporative emission control (EVAP), positive crankcase ventilation (PCV), air injection system (AIS)
- 9.5 Closed loop control
- 9.6 Change in air fuel ratio and ignition timing
- 9.7 Catalytic converters
- 9.8 Use of alternative fuels (Natural gas, LPG, Biodiesel and Hydrogen)
- 9.9 Performance of alternative fuels

10 Vehicular Fluid and Noise Pollution and its Control (2 hours)

- 10.1 Management of automotive fluid waste
- 10.2 Vehicle bio-acoustics and sound pressure
- 10.3 Noise source identification and mitigation
- 10.4 Technical norms and standards

Tutorial (15 hours)

- 1. Analysis of fuel properties, air–fuel ratio, and combustion chemistry
- 2. Calculation of heating values and comparative analysis of engine cycles
- 3. Evaluation of intake processes, volumetric efficiency and compression parameters
- 4. Analysis of combustion stages and performance parameters in SI and CI engines
- 5. Analysis of vehicular emissions and exhaust gas composition
- 6. Implementation of emission control technologies including EGR and catalytic converters

Practical (22.5 hours)

- 1. Experimental evaluation and plotting of indicated and brake performance characteristics of SI/CI engines
- 2. Analysis and verification of engine speed and load characteristics using an engine dynamometer
- 3. Quantitative measurement and frequency analysis of vehicle noise levels and acoustic pressure using sound level meters
- 4. Diagnostic measurement and chemical analysis of tailpipe emissions using NDIR and smoke opacity meters

5. Characterization and performance comparison of alternative fuels (Biodiesel/Ethanol blends) vs. conventional fuels in a test engine.
6. Assignments on calculation related to performance and efficiencies of actual cycle of SI and CI engines

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1, 2	9	12
3, 4	9	12
5, 6	8	10
7, 8	11	16
9, 10	8	10
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Ganesan, V. (2012). Internal combustion engines (4th ed.). Tata McGraw-Hill Education.
2. Giri, N. K. (2015). Automobile mechanics (10th ed.). Khanna Publishers.
3. Heywood, J. B. (2018). Internal combustion engine fundamentals (2nd ed.). McGraw-Hill Education.
4. Mathur, M. L. & Sharma, R. P. (2016). A course in internal combustion engines. Dhanpat Rai Publications.
5. Pulkrabek, W. W. (2014). Engineering fundamentals of the internal combustion engine (2nd ed.). Pearson India Education Services.
6. Pundir, B. P. (2017). Engine emissions: Pollutant formation and advances in control technology (2nd ed.). Narosa Publishing House.
7. Srivastava, P. K. (2020). Automobile engineering (2nd ed.). S. Chand & Company.