# IC Engines: Combusion and Emissions - Web course

## COURSE OUTLINE

Introduction to air pollutants and pollution; Thermo-chemistry and thermodynamics of combustion; In-cylinder air motion; Laminar and turbulent premixed flames, Premixed engine combustion; Spray formation and atomization, Direct injection and CI engine combustion; Combustion systems and management; Genesis and formation of engine emissions, NO kinetics, Soot formation and oxidation.

Emission standards and measurement; Control of emissions in SI and CI engines, engine design parameters, exhaust after treatment, lean de-NOx catalysts, DISC and HCCI engines; Alternative propulsion systems e.g., HEV, FCV etc.; Engine fuel impacts on emissions, alternative fuels e.g., CNG, alcohols, biodiesel, hydrogen, GTL.

## COURSE DETAIL

| Sl. No | Topics |
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| 1. | Introduction to air pollution from IC engines, photochemical smog, primary and secondary pollutants. |
| 2. | Thermodynamics of combustion : Stoichiometry of combustion, heats of reaction and formation, adiabatic flame temperature. |
| 3,4. | Chemical equilibrium, properties of equilibrium combustion products of air-fuel mixtures, application to IC engines. |
| 5. | Introduction to chemical kinetics, order of reaction, reaction rates, engine application. |
| 6,7. | Premixed combustion, Flammability limits, SIT, flame structure, laminar and turbulent flames, flame speeds, effect of EGR. |
| 8. | Conceptual SI engine combustion models, features of SI engine combustion processes, combustion process characterization. |
| 9. | Thermodynamic analysis of burned and unburned mixture states, mixed and unmixed combustion models. |
| 10. | Combustion variations, factors affecting it and their effect on performance and emissions, effect of EGR. |
| 11. | Features of CI engine combustion process, conceptual CI engine combustion models, combustion process characterization. |

NP-TEL

NPTEL

**http://nptel.iitm.ac.in**

Mechanical Engineering

**Pre-requisites:**

- Basic Engineering Thermodynamics
- A first course on IC engines

**Additional Reading:**

1. Internal Combustion Engine Handbook, Ed. Richard Van Basshuysen and Fred Schafer, SAE International, 2004.
2. C.R. Ferguson, A. T. Kirkpatrick, Internal. Combustion Engines, 2nd Edition, John Wiley & Sons, 2001.

**Coordinators:**

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| 12,13. | Fuel injection, spray structure, atomization, penetration, drop size distribution, spray evaporation. |
| 14. | Ignition delay, factors affecting delay. |
| 15. | Mixing controlled combustion, heat release rates , effect of engine design variables, swirl, injection rates. |
| 16. | Thermodynamic analysis of CI engine combustion. |
| 17,18. | Formation of NO and NO2 in SI Engines, Prompt and thermal NO, kinetics of NO formation. |
| 19. | Formation of NO and NO2 in CI engines, NO formation in premixed and diffusion combustion periods. |
| 20. | Formation of CO, kinetic effects, effect of engine variables. |
| 21. | Flame quenching in SI engines. |
| 22. | Unburned HC formation in SI engines, crevice HC, oil film HC and other sources. |
| 23. | HC oxidation in the cylinder and exhaust, exodus of HC , contribution of different sources. |
| 24. | Formation of HC in CI engines, undermining and overmixing, effect of nozzle design and other variables. |
| 25,26. | Composition of particulates, soot structure, soot formation-stoichiometric considerations, nucleation, growth and oxidation, effect of engine variables. |
| 27,28. | Trends in vehicle emission standards, emission limits, test procedures, driving cycles. |
| 29. | Measurement of emissions, instrumentation for CO HC, NOx, PM. |
| 30. | Strategies for control of emissions in SI engines; Add on systems to control emissions inside the engine: EGR, crankcase and evaporative emission control. |
| 31. | Exhaust gas after treatment, Thermal and catalytic reactors, Elements of catalytic reactors, catalysts and substrates. |
| 32,33. | Oxidation, reduction and 3-waycatalytic reactors, closed loop feedback control, catalyst deactivation mechanism, cold start HC control. |

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| 34. | Lean de-NOx catalysts, NOx traps and SCR. |
| 35. | Diesel particulate filters (DPF), DPF regeneration, CRT. |
| 36. | Advanced Engines and Systems: VVT, VTEC, Ultra high pressure injection in diesel. |
| 37. | Advanced Engines and Systems: GDI and DISC Engines. |
| 38. | HCCI engine concepts, CAI-SI engines, HCCI-Diesel Engines. |
| 39. | HEV and FCV propulsion systems. |
| 40. | Petroleum fuels : impact of fuel characteristics including oxygenates on emissions. |
| 41,42. | Alternative fuels to reduce emissions: Alcohols, natural gas, biodiesel, hydrogen, DME. |

**References:**


1. J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill International Editions, 1989.
2. B. P. Pundir, Engine Emissions: Pollutant Formation and Advances in Control Technology, Narosa Publishing House, New Delhi, 2007.
3. Handbook of Air Pollution from Internal Combustion Engines: Pollutant Formation and Control, Ed. Eran Sher, Academic Press, 1998.