SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35.

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai.

DEPARTMENT OF AUTOMOBILE ENGINEERING

23AUT202 – AUTOMOTIVE ENGINES AND EMISSION CONTROL

II YEAR / III SEMESTER

Topic – Air Fuel Ratio and Emissions

- The air-fuel ratio (AFR) is a critical factor in internal combustion engines, directly influencing the engine's performance, fuel efficiency, and emissions.
- The air-fuel ratio (AFR) is the mass ratio of air to fuel present during the combustion process in an engine.
- It is typically expressed as a ratio, such as 14.7:1, where 14.7 parts of air are mixed with 1 part of fuel by mass.

Stoichiometric Ratio

For gasoline engines, the stoichiometric AFR is 14.7:1, which is the ideal ratio where all the fuel is completely burned with the available oxygen, resulting in the most efficient combustion.

How AFR Affects Emissions

- The AFR has a significant impact on the type and amount of emissions produced by an engine.

Carbon Monoxide (CO)

Carbon monoxide is a toxic gas produced when there is incomplete combustion of fuel.

This usually occurs in rich mixtures, where there is not enough oxygen to fully oxidize the carbon in the fuel into carbon dioxide (CO2).

Rich Mixture (AFR < 14.7:1): Higher levels of CO are produced because of insufficient oxygen.

Lean Mixture (AFR > 14.7:1): CO emissions are reduced as more oxygen is available to convert CO into CO2.

Hydrocarbons (HC)

- Hydrocarbons are unburned or partially burned fuel molecules.
- HC emissions occur when the fuel does not fully combust, which can happen under various conditions, including cold starts, improper fuel-air mixing, or during rich operation.
- **Rich Mixture:** Higher HC emissions due to incomplete combustion.
- **Lean Mixture**: HC emissions can be lower, but very lean mixtures may also result in incomplete combustion due to poor flame propagation.

Nitrogen Oxides (NOx)

- NOx emissions are formed at high temperatures when nitrogen in the air reacts with oxygen.
- These reactions are more likely to occur in lean mixtures where the combustion temperature is higher.
- **Stoichiometric to Lean Mixtures**: NOx emissions typically increase as the mixture becomes leaner because of the higher combustion temperatures.
- **Rich Mixture**: Lower NOx emissions because the excess fuel tends to cool the combustion process, reducing the temperature and thus the formation of NOx.

Particulate Matter (PM)

- Particulate matter consists of tiny particles of soot formed from incomplete combustion of fuel, particularly in rich mixtures.
- **Rich Mixture:** Higher levels of PM are produced due to incomplete combustion and the formation of soot.
- **Lean Mixture**: Generally lower PM emissions, as more complete combustion occurs.

Optimizing AFR for Emission Control

Modern engines use various strategies to optimize the AFR and reduce emissions:

- **Closed-Loop Control Systems**: Oxygen sensors in the exhaust monitor the AFR, and the engine control unit (ECU) adjusts the fuel injection accordingly to maintain a near-stoichiometric ratio.
- **Three-Way Catalytic Converters**: These devices reduce CO, HC, and NOx emissions by facilitating reactions that convert these pollutants into less harmful gases. They work most efficiently at the stoichiometric AFR.

- **Variable AFR**: Some engines adjust the AFR dynamically, running lean during light load conditions to improve fuel efficiency and reduce CO and HC emissions, and switching to a richer mixture under high load to protect the engine and reduce NOx emissions.

Thank You !