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AN AUTONOMOUS INSTITUTION

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DEPARTMENT OF AGRICULTURE ENGINEERING

COURSE CODE & NAME: 16AGT301 & HEAT POWER ENGINEERING

III YEAR / V SEMESTER

UNIT : 1 FUELS AND COMBUSTION
TOPIC 9 : Stoichiometric Air Requirement

INTRODUCTION

- In theory, a stoichiometric mixture has just enough air to completely burn the available fuel. In practice, this is never quite achieved, due primarily to the very short time available in an internal combustion engine for each combustion cycle. Most of the combustion process is completed in approximately 2 milliseconds at an engine speed of 6,000 revolutions per minute.
- This is the time that elapses from the spark plug firing until 90% of the fuel–air mix is combusted, typically some 80 degrees of crankshaft rotation later.
- Catalytic converters are designed to work best when the exhaust gases passing through them are the result of nearly perfect combustion.

INTRODUCTION

- A perfectly stoichiometric mixture burns very hot and can damage engine components if the engine is placed under high load at this fuel–air mixture.
- Due to the high temperatures at this mixture, the detonation of the fuel-air mix while approaching or shortly after maximum cylinder pressure is possible under high load (referred to as knocking or pinging), specifically a "pre-detonation" event in the context of a spark-ignition engine model.
- Such detonation can cause serious engine damage as the uncontrolled burning of the fuel-air mix can create very high pressures in the cylinder.
- As a consequence, stoichiometric mixtures are only used under light to low-moderate load conditions. For acceleration and high-load conditions, a richer mixture (lower air–fuel ratio) is used to produce cooler combustion

STOICHIOMETRIC RATIOS

- The stoichiometric mixture for a gasoline engine is the ideal ratio of air to fuel that burns all fuel with no excess air. For gasoline fuel, the stoichiometric air–fuel mixture is about 14.7:1 i.e. for every one gram of fuel, 14.7 grams of air are required. For pure octane fuel, the oxidation reaction is:
- $25\ O_2 + 2\ C_8H_{18} \rightarrow 16\ CO_2 + 18\ H_2O$ + energy
- Any mixture greater than 14.7:1 is considered a lean mixture; any less than 14.7:1 is a rich mixture – given perfect (ideal) "test" fuel (gasoline consisting of solely *n*-heptane and iso-octane).
- In reality, most fuels consist of a combination of heptane, octane, a handful of other alkanes, plus additives including detergents, and possibly oxygenators such as MTBE (methyl *tert*-butyl ether) or ethanol/methanol.

MIXTURE

- **Mixture** is the predominant word that appears in training texts, operation manuals, and maintenance manuals in the aviation world.
- Air–fuel ratio is the ratio between the *mass* of air and the mass of fuel in the fuel–air mix at any given moment. The mass is the mass of all constituents that compose the fuel and air, whether combustible or not. For example, a calculation of the mass of natural gas—which often contains carbon dioxide (CO), nitrogen (N), and various alkanes—includes the mass of the carbon dioxide, nitrogen and all alkanes in determining the value of m_{fuel}.
- For pure octane the stoichiometric mixture is approximately 15.1:1, or λ of 1.00 exactly.
- In naturally aspirated engines powered by octane, maximum power is frequently reached at AFRs ranging from 12.5 to 13.3:1 or λ of 0.850 to 0.901.
- The air-fuel ratio of 12:1 is considered as the maximum output ratio, whereas the air-fuel ratio of 16:1 is considered as the maximum fuel economy ratio
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FUEL– AIR RATIO (FAR)

- **Fuel–air ratio** is commonly used in the gas turbine industry as well as in government studies of internal combustion engine, and refers to the ratio of fuel to the air.
- **Air–fuel equivalence ratio (*λ*)**
- Air–fuel equivalence ratio, λ (lambda), is the ratio of actual AFR to stoichiometry for a given mixture. $\lambda = 1.0$ is at stoichiometry, rich mixtures $\lambda < 1.0$, and lean mixtures $\lambda > 1.0$.

- There is a direct relationship between λ and AFR. To calculate AFR from a given λ, multiply the measured λ by the stoichiometric AFR for that fuel. Alternatively, to recover λ from an AFR, divide AFR by the stoichiometric AFR for that fuel.

- Because the composition of common fuels varies seasonally, and because many modern vehicles can handle different fuels when tuning, it makes more sense to talk about λ values rather than AFR.

- Most practical AFR devices actually measure the amount of residual oxygen (for lean mixes) or unburnt hydrocarbons (for rich mixtures) in the exhaust gas.

THANK YOU…