Gasoline and Alternative Fuels

Objectives

- Understand Octane Rating Methods
- Be able to name alternative fuels
- Know the 5 things necessary for combustion

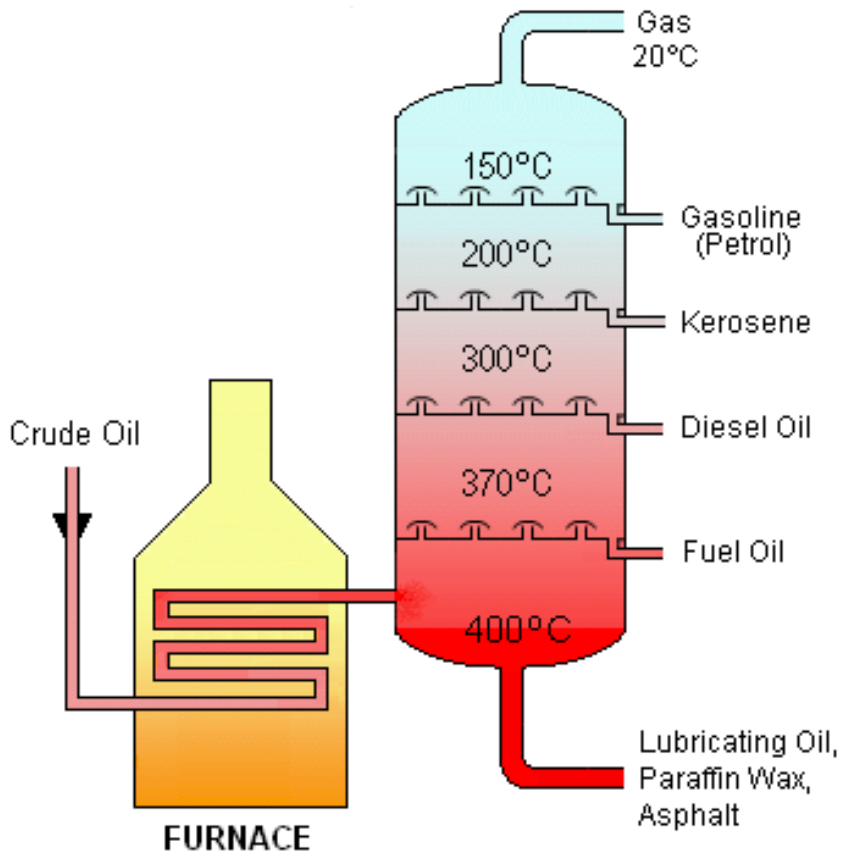
Fossil Fuel

- Formed from the decomposition of organic materials (crude oil)
- Millions of years of pressure transform it into a dark and waxy substance known as Kerogen
- Heat in the earth's crust causes the Kerogen molecules release carbon and hydrogen atoms known as hydrocarbons
- Depending on the temperature the hydrocarbons form either crude oil or natural gas

Refining

- Crude oil hydrocarbons (HC) have different boiling points
- Distillation is a boiling process that separates these HCs
- Vapors of the HCs the lowest boiling points rises to the top of the distillation column
- Different products are tapped off as the vapors rise

Fractional Distillation



Gasoline

- Complex mixture of various hydrocarbons
- If combustion were perfect, all the fuel and air would be consumed
- Carbon dioxide and water would be the buy product

Hydrocarbon Refining

- Unrefined hydrocarbons are large hydrogen and carbon atoms chains
- Cracking is a process that breaks these long HC chains into smaller chains of various different lengths
- Different length chains are then blended to form different types and octanes of fuels

Normal Combustion

- Under ideal conditions the common internal combustion engine burns the fuel/air mixture in the cylinder in an orderly and controlled fashion
- Combustion is started by the spark plug before TDC
- This ignition advance allows time for the combustion process to develop peak pressure at the ideal time for maximum power from the expanding gases

Normal Combustion

- The air and fuel mixture is compressed by piston
- When the piston reaches a predetermined point BTDC the plug fires and starts the combustion process, originating at the plug tip
- The burn should be steady and even as it spreads out from the plug and moves across the chamber
- Pressure rises smoothly to a peak, as nearly all the available fuel is consumed, then pressure falls as the piston descends
- At the end of the combustion process, all of the air fuel mixture has been burned and the piston is traveling back down the cylinder.
- There is no “explosion” – just an even and controlled ignition

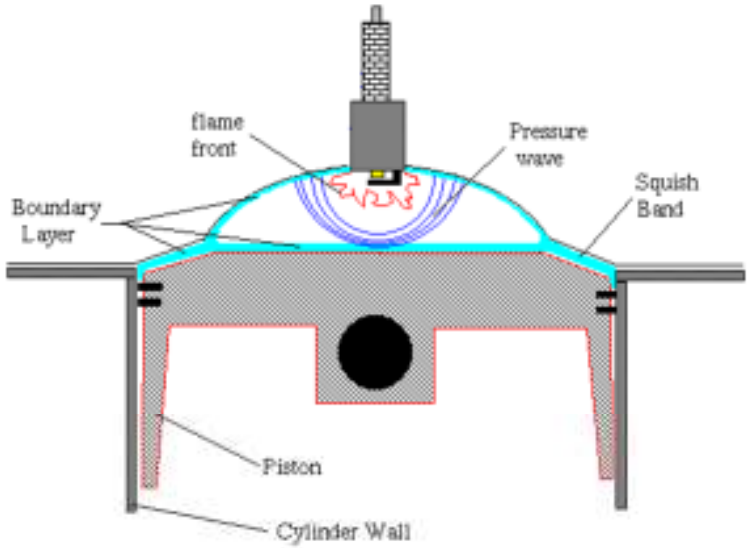


Fig. 2 – Combustion Chamber Side View

Abnormal Combustion

- Unburned fuel/air mixture beyond the boundary of the flame front spontaneously ignites
- Detonation
- Instantaneous, explosive ignition of at least one pocket of fuel/air mixture outside of the flame front

Abnormal Combustion

- Unburned fuel/air mixture beyond the boundary of the flame front spontaneously ignites
- Detonation:
  - Instantaneous ignition of at least one pocket of fuel/air mixture outside of the flame front
- Pre-ignition: Fuel is ignited before the spark plug fires

Detonation / Spark-Knock

- Occurs after the spark plug fires
- Due to heat and pressure
- Results in two or more competing flame fronts
- Rattling noise
- Cause rod bearing wear

Cause of Detonation

- Plug fires, combustion causes an increase in heat and temperature
- Heat and pressure become too high and light off the remaining AFR mix before the flame front reaches it
- Result is multiple flame fronts inside the combustion chamber
- Sharp spike in cylinder pressure results
- The knocking sound is the rotating assembly of the engine absorbing the shock

Detonation
Begins a few degrees before a top dead center. Pressure builds and heat spreads out from the point of ignition.

Combustion continues
The end gasses overheat and spontaneously combust.

Detonation creates violent shock waves that produce an audible knock and cause damage to the engine. Cylinder pressure is elevated.

Causes of Detonation

- Incorrect octane rating
- Incorrect ignition spark timing

Pre Ignition

- Air/fuel mixture ignites before the spark plug fires
- Initiated by an ignition source other than the spark
- Also referred to as run-on or dieseling
- Worst possible thing that can happen during the combustion process

Causes of Pre-ignition

- Carbon deposits form a heat barrier and can be a contributing factor to pre-ignition.
- Overheated spark plug (too hot a heat range for the application).
- Glowing carbon deposits on a hot exhaust valve
- A sharp edge in the combustion chamber or on top of a piston
- Sharp edges on valves that were reground improperly
- A lean fuel mixture
- An engine that is running hotter than normal due to a cooling system problem
- Insufficient oil in the engine

Pre-ignition Damage

Detonation induced pre-ignition

- Detonation breaks components in the cylinder, such as the spark plug electrode
- Components can start to get very hot over sustained periods of detonation and glow.
- Glowing hot parts can cause pre-Ignition
- An engine can run for thousands of miles with mild detonation
- Pre-ignition can destroy an engine in just a few strokes of the piston

Controlling Spark Knock

- Ignition timing determined by fuel octane
- Timing must be advanced (spark plug fires sooner) when premium gas is used because it takes longer for premium to burn
- Computer controlled vehicles
  - Knock sensor: senses pre-ignition and adjust ignition timing to eliminate the knock

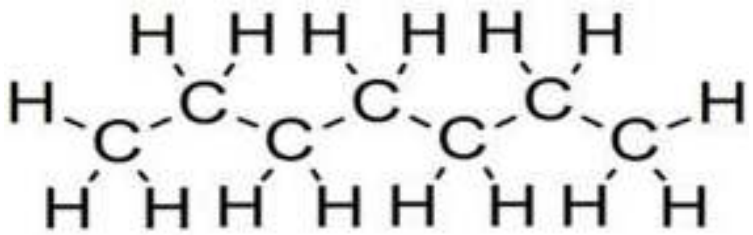
Hydrocarbon Chains

- The shortest chain is methane; 1 carbon atom surrounded by 4 hydrogen atoms
- With each successive hydrocarbon, 1 carbon atom and 2 more hydrogen atoms are added
- Resulting hydrocarbons are: ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) , pentane, hexane, heptane, and iso-octane.
- The two hydrocarbons molecules used in gasoline are heptane and iso-octane

Gasoline Reference Fuels

Heptane

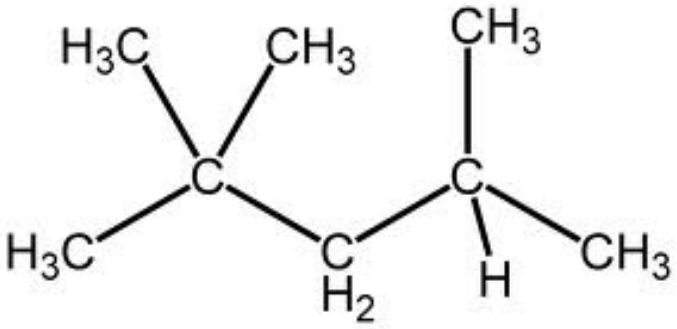
- 7 carbon & 16 hydrogen molecules
- Handles compression poorly
- Compress causes it ignite spontaneously



Octane rating of zero

Iso-octane

- 8 carbon & 18 hydrogen molecules
- Handles compression very well



Octane rating of 100

Octane Rating

- Measure of a fuel's ability to resist auto ignition
- The higher octane rating the more compression the gas can withstand before detonating
- Rating of gasoline's Anti-knock properties
- 91 octane pump gas has a higher resistance to knock then 87 octane

Octane Rating Methods

- Two methods
  - Research method (tested at 600 RPM)
  - Motor method (tested at 900 RPM)
- Anti-Knock Index (AKI) posted on pumps
  - averages of both methods : (RON+MOM)/2


MINIMUM OCTANE RATING
(R + M) /2 METHOD
87
412171

Octane Ratings

- Regular: 87 (87% isoctane: 13% heptane)
- Midgrade: 89 (89% isoctane: 11% heptane0
- Premium: 91 (91% isoctane: 9% heptane)
- Aviation Gas (AvGas 100 octane)
- Racing gas: 105-119
- The higher the octane number, the less likely the fuel is to detonate under compression

Leaded Gasoline

- Tetra ethyl lead (TEL) added to gasoline improves octane rating above the isooctane/heptane combination
- Cheaper grades of gasoline could be made usable by adding TEL

Leaded Gasoline

- Phased out in 1973
- Banned in the 1986 buy the US Clean Air Act
- It will clog a catalytic converter and render it inoperable within minutes

Regular vs. Premium

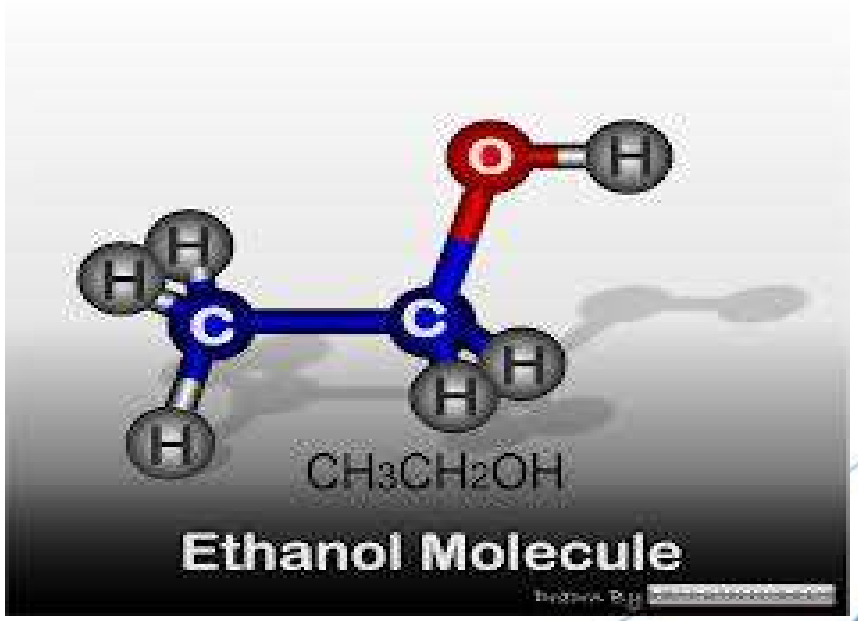
- Which produces a more power premium or regular gas?
- Which burns faster?
- Can you use 87 octane in a vehicle requires 91 octane?

Ethanol

- Alcohol molecule from fermentation of grain
- Added to fuel it increases the octane rating
- Up to 10% ethanol can be blended with gasoline
- Ethanol is very corrosive more ethanol than 10% increases risk of damaging fuel system components

Reduced Emissions

- Ethanol is an oxygenate
  - has an oxygen atom
- Provides extra oxygen at combustion which reduces CO in the exhaust



Alternative Fuels

- E15 Ethanol
- E85 Ethanol
- M85
- Diesel


E15
15% Ethanol

E15 Ethanol

- EPA approved the use of E15 -- a 15% ethanol-gasoline blend
- EPA says E15 is safe for use in virtually all vehicles 2001 and newer
- BMW, Chrysler, Nissan, Toyota and VW warranties will not cover fuel-related claims caused by E15.
- Ford, Honda, Kia, Mercedes-Benz and Volvo said E15 use will void warranties


E85
85% Ethanol

E-85

- 15% gasoline and 85% ethanol (ethyl alcohol) (octane rating 87)
- Reduced fuel economy (approx 20%)
- Reduced pollution and reduced Carbon Dioxide (CO_2)
- Less dependence on imported oil
- Use in Flex Fuel Vehicles (FFV)

M85

- 85% Methanol (methyl alcohol) and 15% gasoline
- Very corrosive requires stainless tank and lines
- 60% as efficient as gasoline

Diesel Fuel

- Diesel - contains 12% more heat energy than gasoline
- Cetane Number principal measure of diesel fuel quality
  - A measure of the delay of ignition of a diesel fuel
  - The higher cetane number the more readily the fuel ignites when sprayed into the cylinder
- 2007 vehicles and newer require Ultra Low Sulfur Diesel (ULSD)
  - Cleaner-burning diesel fuel that contains 97% less sulfur
  - Allows for the application of advanced emissions control technologies that substantially lower particulate matter
- Biodiesel – domestically produced from vegetable oils and animal fats

2007 or later model year diesel vehicles should only fuel them with ultra-low sulfur diesel (ULSD)


LOW SULFUR
HIGHWAY DIESEL FUEL
(500 ppm Sulfur Maximum)
WARNING
Federal law prohibits use in model year 2007 and later highway vehicles and engines.
Its use may damage these vehicles and engines.

Diesel Exhaust Fluid (DEF)

- Aqueous urea solution made with 32.5% urea and 67.5% deionized water
- DEF is injected into the diesel vehicle's exhaust stream, breaking down NOx (nitrogen oxide) emissions into nitrogen and water
- The emission control system that inject the DEF into the exhaust stream is called "Selective Catalytic Reduction" or "SCR"
- SCRS are used on all diesel vehicle model years 2010 and later

5 things necessary for combustion

- Air and fuel in the correct ratio
  - Too much or too little fuel will cause stalling
- Compression
- Ignition
  - Spark
  - Heat of compression
- Timing: the spark or diesel injection must occur at the correct time