Engine Performance

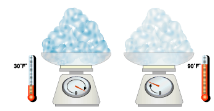
Fuel and Air Inlet Systems

Donald Jones
Brookhaven College

Engine Performance

Air Density

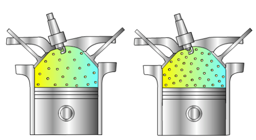
- Air/fuel ratios are stated as a measure of weight or mass
- Dense air has more mass
- High altitudes and high temperatures reduce air density
- Air mass must be measured to provide accurate air/fuel ratios



Engine Performance

Air Fuel Ratios

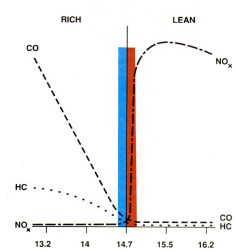
- Stoichiometric
  - 14.7:1 air/fuel ratio
- Lean
  - More oxygen than stoichiometric
  - Flame propagation is more difficult because the fuel molecules are further apart
- Rich
  - Less oxygen than stoichiometric
  - Fuel molecules are closer together and the air fuel mixture burns quickly requiring less spark advance



Engine Performance

Results of Combustion

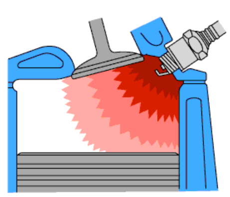
- Rich mixtures
  - Power increases
  - Increased fuel consumption
  - HC emissions increase
  - CO emissions increase
- Lean mixtures
  - Improved fuel economy
  - Increased combustion chamber temperatures
  - NO_x emissions increase
- Stoichiometric
  - Allows catalytic converter to efficiently control emissions



Engine Performance

Flame Speed and Timing

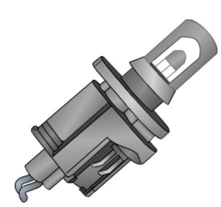
- Flame speed increases with rich mixtures
- Low octane fuels burn more rapidly than high octane fuels
- Detonation occurs after ignition when the air/fuel mixture reaches its flash point due to excessive combustion chamber pressure and temperature
- Pre-ignition occurs when the air fuel ratio is ignited prior to ignition by hot surfaces in the combustion chamber



Engine Performance

Intake Air Temperature

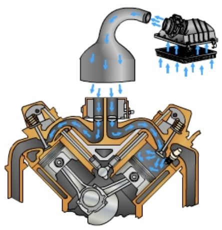
- Intake air temperature affects
  - Air density
  - Vaporization capability
- Intake air temperature control systems
  - Outside air intake
  - Heated air intake
  - Heated intake manifold
  - Charge air cooler



Engine Performance

Cylinder Charging

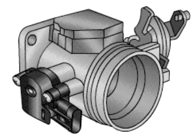
- Five cylinder charging factors
  - throttle opening
  - intake manifold pressure
  - volumetric efficiency
  - intake resonance
  - cylinder scavenging



Engine Performance

Throttle Opening

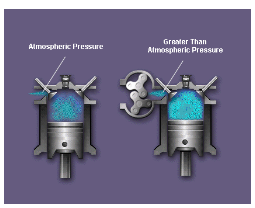
- The throttle valve regulates the amount of air entering the intake
- More air flows when the throttle is opened wider
- A larger throttle body allows more air to flow



Engine Performance

Intake Pressure

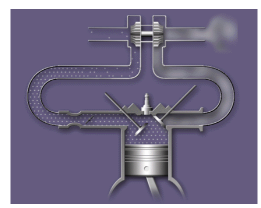
- Higher manifold pressures increase cylinder charging
- Wide throttle openings increase intake pressures
- Intake pressures may be increased with turbochargers and superchargers



Engine Performance

Turbochargers

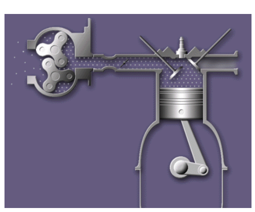
- Produces extra power while consuming minimal power
- Uses exhaust heat energy to drive turbine
- Impeller pressurizes intake charge
- Most effective at high RPM
- Low turbine speed at low RPM leads to turbo lag



Engine Performance

Superchargers

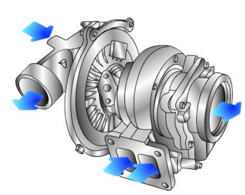
- A supercharger is a positive displacement pump
- Its purpose is to increase air pressure and density in the intake manifold
- It does this by pumping more air than the engine would use without a supercharger
- The supercharger is matched to the engine by its displacement and belt ratio, and can provide excess airflow at any engine speed



Engine Performance

Volumetric Efficiency

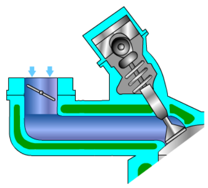
- Volumetric efficiency refers to the actual cylinder filling as applied to theoretical cylinder filling
- Generally decreases as RPM increases



Engine Performance

Resonance

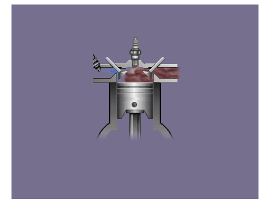
- Resonance refers to the way air bounces back when the intake valve closes
- Resonance is used to ram air into the cylinders
  - Long runners increase low speed engine performance
  - Short runners improve high speed engine performance



Engine Performance

Cylinder Scavenging

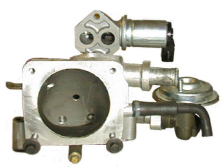
- Cylinder scavenging is the process by which spent exhaust gasses are removed from the cylinder
- If the exhaust flows to slowly fresh charge will be prevented from entering the cylinder and engine performance will be reduced
- If the exhaust gas flows too quickly, fresh charge will be drawn into the exhaust
- Watch video



Engine Performance

Intake Air Metering

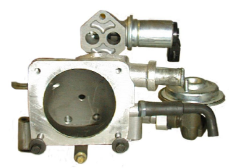
- Throttle valve
  - Controls engine operation above idle
- Idle air control valve - IAC
  - Control engine speed during closed throttle valve operation



Engine Performance

Idle Air Control Valve

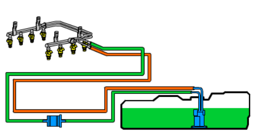
- The IAC allows air to by pass the closed throttle plates.
- The PCM uses the IAC valve assembly to control:
  - No touch start
  - Cold engine fast idle for rapid warm-up
  - Idle - corrects for engine load
  - Stumble or stalling on deceleration
  - Over-temperature idle boost



Engine Performance

Fuel System Components

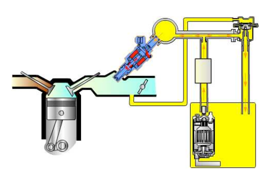
- Fuel filler cap
- Fuel tank
- Fuel pump assembly
- Fuel filters
- Supply hoses and lines
- Fuel rail
- Fuel injectors
- Fuel pressure regulator
- Fuel pressure relief valve
- Return hoses and lines



Engine Performance

Electric Fuel Pump

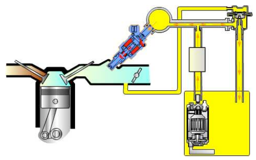
- Capable of producing one pint per ten seconds at 39 PSI
- Fuel pump relay grounded by PCM
- Activated for one second when ignition is turned on
- PCM then turns off fuel pump if PIP signal is not present



Engine Performance

Inertia Fuel Shut-off Switch

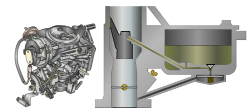
- The fuel pump circuit contains an inertia fuel shut-off (IFS) switch
- The IFS switch opens if the vehicle experiences a sharp impact
- If the IFS switch opens it must be manually reset



Engine Performance

Carburetors

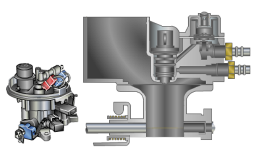
- Carburetor Circuits
  - Idle
  - Off Idle
  - Float
  - Choke
  - Main Metering
  - Power Enrichment
  - Accelerator



Engine Performance

Throttle Body Fuel injection

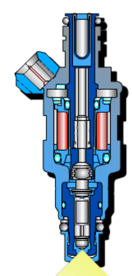
- One or two injectors located above the throttle plates
- High and low fuel pressure systems used
- The throttle body assembly commonly contains the:
  - Fuel pressure regulator
  - IAC



Engine Performance

Port Fuel Injection

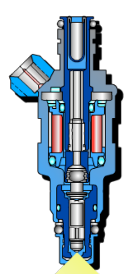
- Port Fuel Injection
  - One or two fuel injectors per cylinder near the intake valve
- MFI - multi-point fuel injection
- SFI - sequential fuel injection
  - May be bank fired under certain operating conditions



Engine Performance

Fuel Injectors

- Fuel injectors have a fixed flow rate measured in pounds per hour at a specified pressure
- Fuel flow is controlled by varying injector on-time
- On time is measured in milliseconds
- Port fuel injection system injectors may be operated sequentially or bank fired

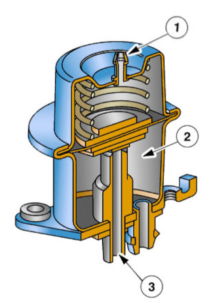


Engine Performance

Fuel Pressure Regulator

- Fuel pressure regulators maintain a constant pressure differential between the injector's internal fuel pressure and the injector nozzle's external pressure
- Most port fuel injection regulators utilize manifold vacuum to assist spring pressure in regulating the fuel system pressure
- Throttle body fuel injection systems do not need to vary fuel pressure in response to manifold vacuum since the injector is located above the throttle plate

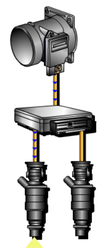
1. Manifold vacuum (PFI)
2. Fuel rail pressure
3. Fuel return



Engine Performance

Fuel Injection Systems

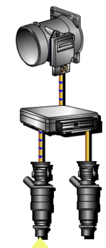
- Controls fuel delivery in response to engine:
  - Load
  - Temperature
  - Oxygen present
- Controls intake air flow during closed throttle operation
- Varies intake runner length or intake capacity on some engines



Engine Performance

Fuel Injection Strategies

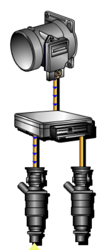
- Open loop
- Closed loop
- Idle speed control
  - Idle
  - Starting
  - Deceleration
- RPM limiter
- Vehicle speed governor
- Clear flood



Engine Performance

Monitoring Engine Load

- Driver demand
  - TP sensor
- Engine load
  - MAP sensor
  - MAF Sensor



Engine Performance

Intake Air Measurement

- Speed-Density
  - MAP
  - IAT
- Volume Air Flow
  - VAF
  - BARO
  - IAT
- Mass Air Flow
  - MAF

Engine Performance

Sensor Inputs

- Intake air density
  - BARO and/or MAF
- Intake air temperature
  - IAT
- Intake air flow rate
  - MAF or VAF
- Engine temperature
  - ECT
- Load and driver input
  - MAP and TP
- Crankshaft speed and position
  - CKP and/or CMP
  - PIP signal
- EGR flow rate
  - EVP, PFE or DPFE
- O_2 level in exhaust gas
  - EGO or HEGO
- Vehicle speed
  - VSS
- Transmission mode
  - MLP and other sensors
- Air conditioning load
  - AC switch
- Alternator load
  - battery voltage

Engine Performance

Fuel Trim Strategy

- The fuel system monitor has two means of adapting Short Term Fuel Trim and Long Term Fuel Trim .
- Short Term FT is calculated by the PCM from HO2S inputs. A negative percentage means that the HO2S is indicating RICH and the PCM is attempting to lean the mixture. Ideally, Short Term FT may remain near 0% but can adjust between -25% to +35%.
- Long Term FT is calculated by the PCM using information from the Short Term FT. The range of authority for Long Term FT is from -35% to +35%. The ideal value is near 0% but variations of ±20% are acceptable. Information gathered at different speed load points are stored in fuel trim cells in the fuel trim tables, which can be used in the fuel calculation.
- Short Term FT and Long Term FT work together. If the HO2S indicates the engine is running rich, the PCM will correct the rich condition by moving Short Term FT in the negative range (less fuel to correct for a rich combustion). If after a certain amount of time Short Term FT is still compensating for a rich condition, the PCM "learns" this and moves Long Term FT into the negative range to compensate and allows Short Term FT to return to a value near 0%.