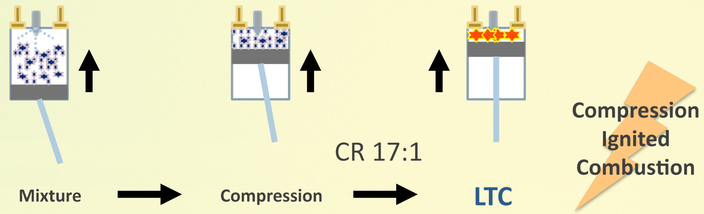
Argonne's Innovative Approach to Engine Efficiency and Emissions

Improving Low Temperature Combustion through Fundamental Science and Applied Engineering

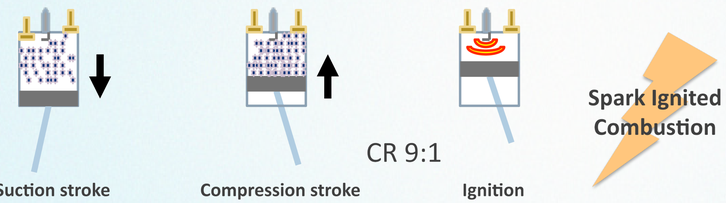
Different Combustion Processes

Low Temperature Combustion (LTC)

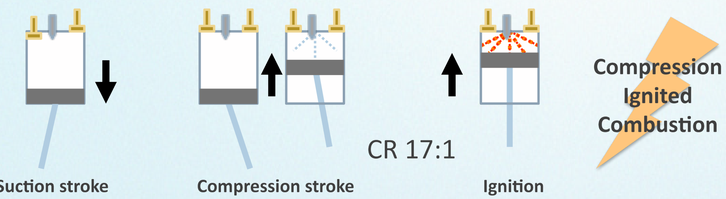


Partially premixed but not well mixed fuel-air mixture

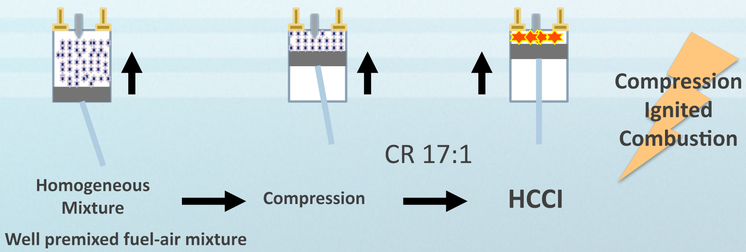
Spark Ignition (homogenous mixture; no soot; HC, CO and (NO) emissions; throttling issues)



Compression Ignition (diffusion combustion, fuel efficient, high smoke and NO_X emissions)



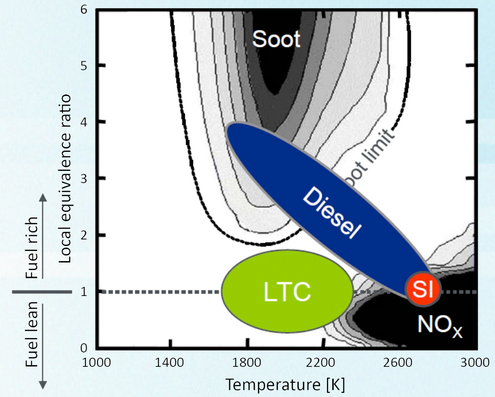
Homogeneous Charge Compression Ignition (HCCI)



Well premixed fuel-air mixture

LTC: A Promising Approach

Why is LTC an Attractive Solution to Efficiency and Emissions Challenges?



Ref. SAE 2003-01-1789, Takaaki Kitamura et.al.

This chart illustrates how LTC avoids both soot and NO_X by controlling fuel/air mixing (equivalence ratio) and by slowing down the rates of reaction (peak combustion temperature).

Key Factors for LTC

Physical Properties

Pressure and temperature (air preheating, turbo charging, EGR and compression ratio)

Auto-ignition

Chemical Properties

Octane rating, cetane rating (fuels and additives)

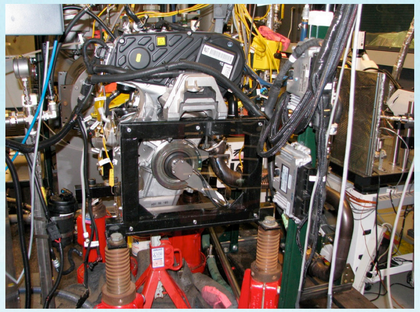
Mixture Preparation

Injection timing, pressure and number of injections

Argonne researchers are working across scientific disciplines and leveraging the lab's state-of-the-art facilities as they pursue optimal LTC operating conditions.

Project Details

Engine Specifications and Fuel Properties



Argonne's experimental setup includes a GM 1.9 L, 110 kW @ 4500 rpm (designed to run on #2 diesel), and a Bosch II generation common rail injection system.

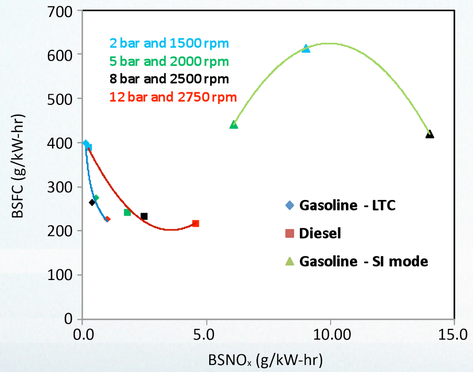
Engine Specifications

Compression ratio	17.8:1
Bore (mm)	82
Stroke (mm)	90.4
Connecting rod length (mm)	145.4
Number of valves	4
Injector	7 holes, 0.15-mm diameter

Properties of the Two Tested Fuels

Property	#2 diesel	Low-octane gasoline
Specific gravity	0.8452	0.7512
Low heating value (MJ/kg)	42.9	42.5
Initial boiling point (°C)	180	86.8
T10 (°C)	204	137.8
T50 (°C)	255	197.8
T90 (°C)	316	225.1
Cetane Index	46.2	25.0

Effect on BSFC and $BSNO_X$ Emissions



Color of the trend line reads the fuel (green – gasoline, red – diesel & blue - LTC)

Color of the marker reads the operating condition (blue – 2 bar, green – 5 bar, black – 8 bar & red – 12 bar)

This graph shows the effect of different combustion processes on BSFC and $BSNO_X$.

Argonne NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY