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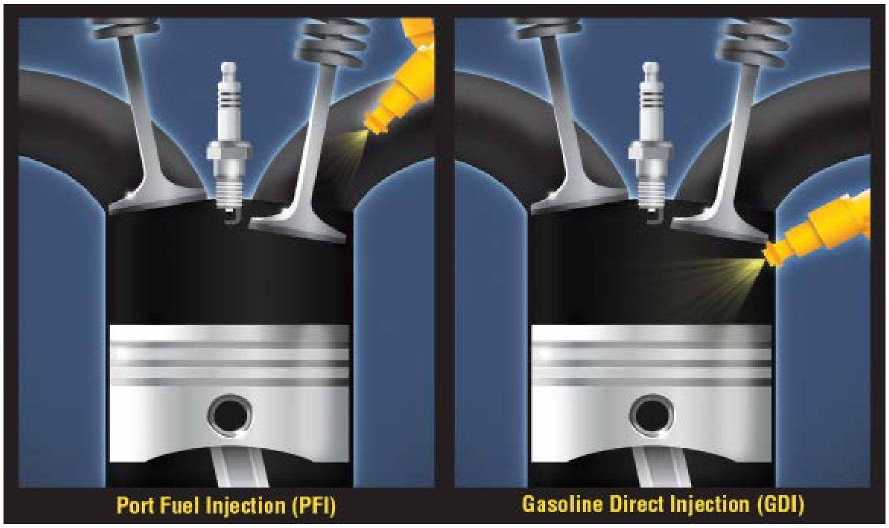
(1)Gasoline Engine の Port injection と Direct Injection の違いを調査して図解せよ.



[Fig1.1 Structure of PFI and GDI]

(A) The GDI engine boasts more power with increased fuel economy. GDI engine is sprayed directly in combustion chamber while PFI engine injecting in the air intake), so it allows for a more thorough burn. Ideally, this more complete combustion translates to better mileage and greater power. GDI engines burn leaner than port fuel injection engines. A leaner mixture allows fuel to be burned much more conservatively. GDIs have accurately controlled emissions levels, more aggressive ignition timing curves, and more precise control over fuel and injection timing.

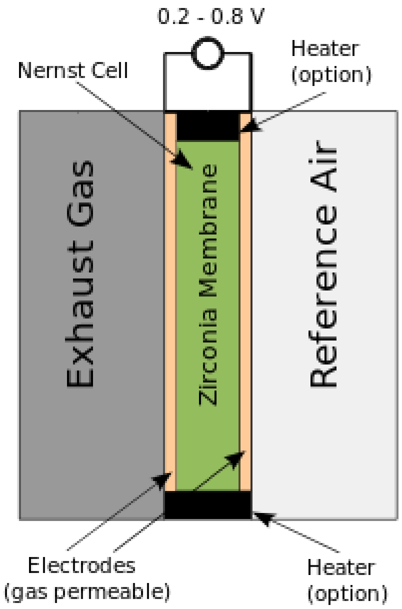
(B) The GDI technology is less develop than the PFI. Which means GDI engine is less stable than the PFI engine. GDI need the fuel inject port exposed in the combustion chamber, where is extremely hot and high pressure than the air intake. The high operating temperatures in combustion chamber can lead to engine oil evaporation. Oil vapors create deposits and pooling in intake boots, valves, piston crown, head squish area and catalytic system. Carbon buildup on the backsides of valves can result in reduced airflow. A combination of sticky deposits and oil evaporation can lead to carbon buildup in several places in the engine. These sticky deposits can be cooked to diamond hard deposits and can dislodge and cause damage to turbochargers, catalytic converters, etc. These hard deposits can also cause irreversible cylinder scoring. In a PFI engine, these droplets are “washed off” the intake valves by a constant stream of gasoline. However, a GDI engine does not have that advantage because the injectors spray inside the cylinders.

(2)2000rpm で作動している 4 cycle port injection gasoline engine において, 1 cycle に要する時間は何秒か?

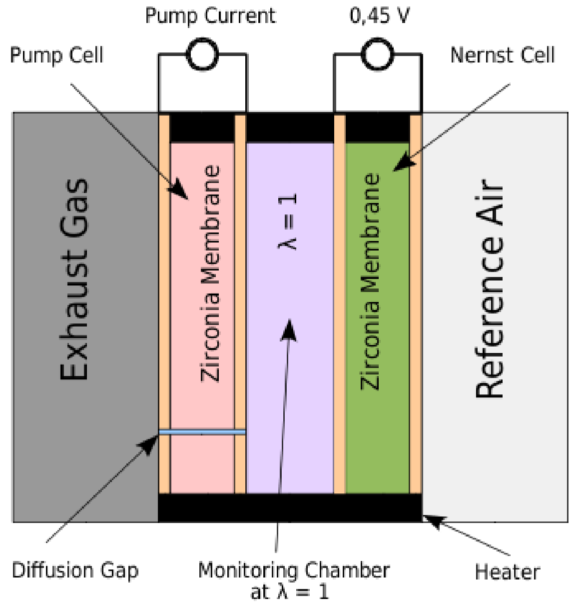
2000rpm means the angular velocity of engine crankshaft is 2000 rounds per minute (60 second). As for 4 cycle port injection gasoline engine, per cycle means half round of engine crankshaft, so per circle need 60÷2000÷2 = 0.015s

(3)O_2 センサーの仕組みを図解せよ.

Zirconia a typical kind of probe in oxygen sensor. The zirconium dioxide, or zirconia, lambda sensor is based on a solid-state electrochemical fuel cell called the Nernst cell. Its two electrodes provide an output voltage corresponding to the quantity of oxygen in the exhaust relative to that in the atmosphere. The ECU is a control system that uses feedback from the sensor to adjust the fuel/air mixture.

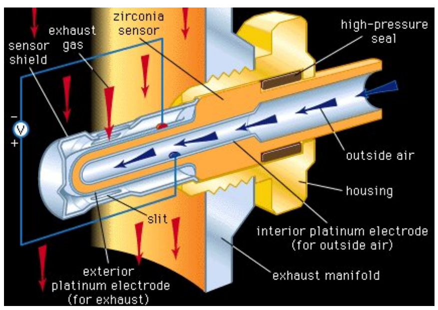


[Fig 3.1 Structure of Zirconia Probe]



[Fig 3.2 Structure of Wideband Zirconia Probe]

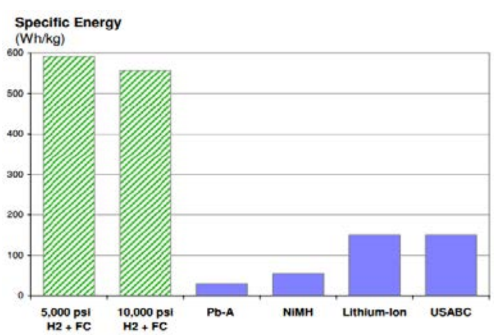
It is based on a planar zirconia element, but also incorporates an electrochemical gas pump. An electronic circuit containing a feedback loop controls the gas pump current to keep the output of the electrochemical cell constant, so that the pump current directly indicates the oxygen content of the exhaust gas. This sensor eliminates the lean-rich cycling inherent in narrow-band sensors, allowing the control unit to adjust the fuel delivery and ignition timing of the engine much more rapidly.



[Fig 3.3 Structure of Oxygen Sensor]

(4)火花点火エンジンに適する燃料の例を挙げ、化学的・物理的観点からその理由を述べよ.

There are many kinds of fuel suit for spark ignition engines besides petrol/gasoline, such as autogas (LPG), methanol, ethanol, bioethanol, compressed natural gas (CNG), hydrogen, and (in drag racing) nitromethane. I'd like to choose Hydrogen as the sample to present.



[Fig-3] Compare PFCV with BEV in Specific Energy

There are a number of unique features associated with hydrogen that make it remarkably well suited in principle, to engine applications. Some of these most notable features are the following:

(A) According to many different research, Hydrogen's energy density ranges from 120MJ/kg~140MJ/kg. [Fig-3] compared energy density of hydrogen tanks and fuel cell systems compared to the energy density of batteries, thus PFCVs much light and small than same power BEVs, which is also means high Will-to-Wheel Efficiency.

(B) Hydrogen, over wide temperature and pressure ranges, has very high flame propagation rates within the engine cylinder in comparison to other fuels.

(C) The lean operational limit mixture in a spark ignition engine when fuelled with hydrogen is very much lower than other common fuels. This permits stable lean mixture operation and control in hydrogen fueled engines.

(D) The operation on lean mixtures, in combination with the fast combustion energy release rates around top dead center associated with the very rapid burning of hydrogen–air mixtures results in high-output efficiency values.

(E) One of the most important features of hydrogen engine operation is that it is associated with less undesirable exhaust emissions than for operation on other fuels.

(F) The fast burning characteristics of hydrogen permit much more satisfactory high-speed engine operation.

(G) Varying the spark timing in hydrogen engine operation represents an unusually effective means for improving engine performance and avoidance of the incidence of knock.

(H) The sensitivity of the oxidation reactions of hydrogen to catalytic action with proper control can be made to serve positively towards enhancing engine performance.

Reference

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