Thermal Efficiency of Engines

(1) Aims

The roadmap of the engine system department covers gasoline engines used for passenger cars, diesel engines for passenger cars, trucks and buses, and ships. Research on fuel cells also started recently. Improvement in thermal efficiency is important in the mechanical engineering field. From this point of view, this roadmap predicts the future of fuel efficiency improvement. Refer to the roadmap of the fuel consumption in passenger car..

(2) Social and technical needs

Engines used in automobiles are closely related to our daily lives and used for inner- and inter-city transportation. It was necessary to clean exhaust gas emissions from engines, so gasoline engine emission regulation started in 1966, and emission regulation was applied to diesel engine in 1974. Emission regulation is also applied to ship engines and off-road vehicle engines. Stringent exhaust emission regulation will be required in the future. Improvement in the thermal efficiency capable of CO_2 reduction is needed and is an important factor. Improvement of the engine thermal efficiency is indispensable for preventing global warming in the future.

(3) Future drections for determining key mechanisms and parameters

Taking an example of large diesel engines for vehicles, development of the direct injection (DI) systems, turbo inter-coolers (TI), 4-valve/cylinder engines, and steel pistons enhanced thermal efficiency improvement. Electronic-controlled and high-pressure fuel injection (common rail type), variable nozzle superchargers (VGT), and variable swirl systems are produced by vehicle needs. Downsizing of vehicle engine was achieved by TI engine in 1980 by utilizing output increase due to turbochargers, resulting in remarkable fuel efficiency improvement.

The following may be promising breakthrough technologies for improving the thermal efficiencies of reciprocating engines:

(1) New combustion systems for reducing NOx and PM simultaneously like pre-mixed compression ignition combustion.
(2) Friction-reduced by lubricant oil
(3) Synthetic fuel featuring improved thermal efficiency
(4) Mechanical, electrical and chemical technology of generating and recovering thermal and kinetic energies
(5) Transfer from fossil fuel to biomass fuel

The fuel cell is an important breakthrough technology currently under examination. It is expected to be put into practical use from 2015 to 2020.

(4) Contributions to society

As global warming shows rapid progress at present, improvement of the engine thermal efficiency directly related to CO_2 reduction will possibly be accelerated by stronger external impacts. Thus, researchers and engineers in this field should be ready to take proper means of improving thermal efficiency at any time as society requires.

Taking an example of passenger cars, if the thermal efficiencies of a car at operating-area in the case of fuel economy at 15 km/L is doubled, the car will run at 30 km/L with the same quantity of fuel, and CO_2 emission is halved. In 2025, new fuel cell cars and hybrid cars will be used widely, exhaust emissions will become cleaner, and CO_2 emissions from cars will be reduced by 20 to 30 %.
As global warming shows rapid progress at present, needs for improvement of the engine thermal efficiency directly related to CO_2 reduction will become greater. Technical innovation in this field may progress earlier than prediction. We expect that more active discussions will be made based on this roadmap
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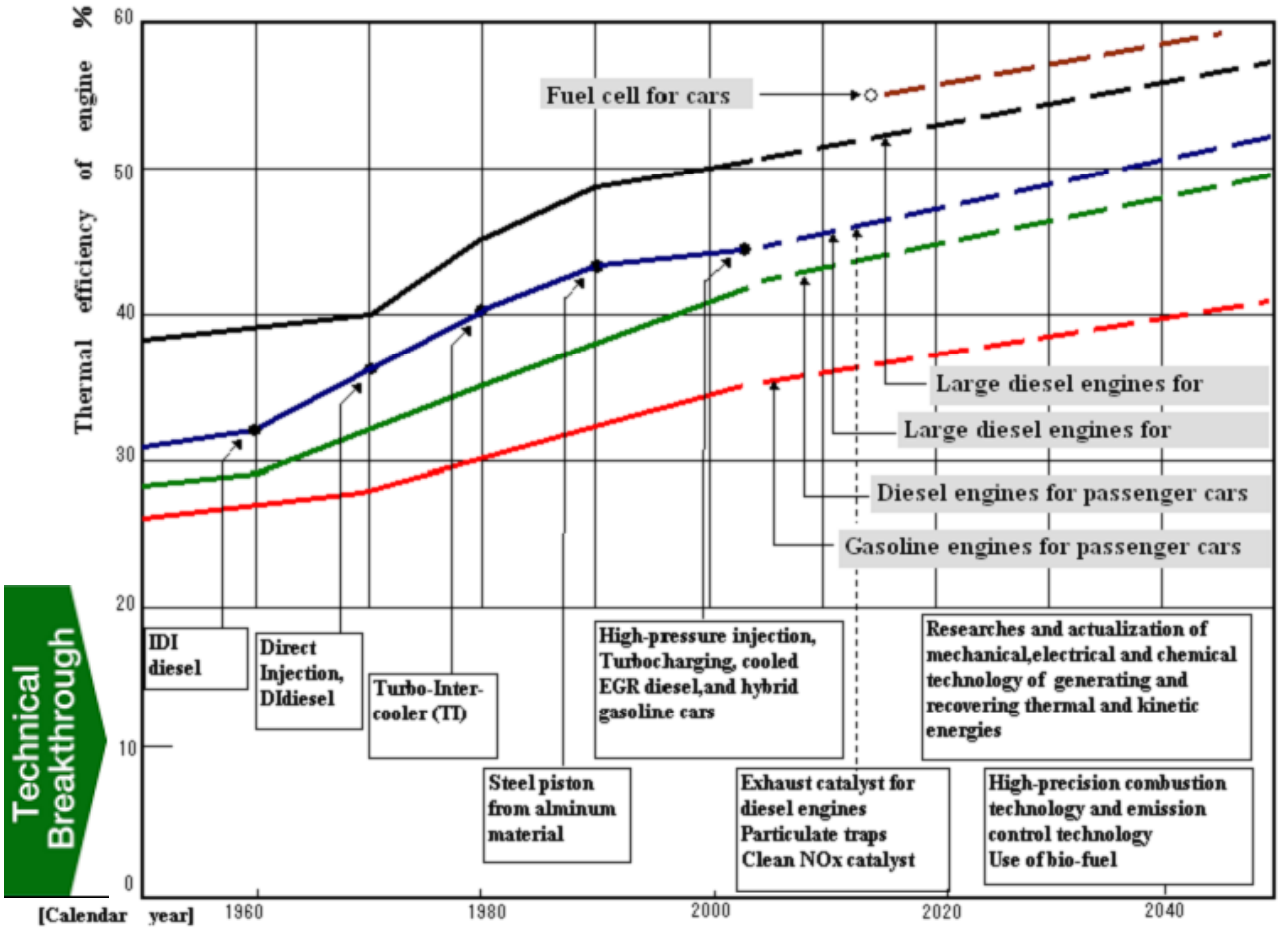
Social & Technical Needs

1950～1960	
1960～1970	・Clean exhaust emission from automobiles ・Emission regulation of gasoline engines
1970～1980	・Oil shock ・Emission regulation of diesel engines
1980～1990	
1990～2000	・Long term emission regulation of diesel engines
2000～2010	・CO2 reduction against global warming
2010～2020	・Strengthened emission regulation in EU and USA ・CO2 emission regulation ・Fuel efficiency regulation of automobiles
2020～2030	
2030～2040	
2040～2050	・Energy consumption will be reduced by 60% in 2050.



Changes in Society and Markets

1950~1970	・Age of private liter cars ・Number of owned cars in Japan exceeded 1 million. ・Transistor TV sets were released first in the world. ・Apollo 11 landed on the moon.
1970~1990	・1978 emission regulation ・Word processors and PCs were released. ・Weather and broadcast satellites were launched. ・Personal computer communication started.
1990~2010	・Japan is No.1 of passenger car production in the world. ・Final energy consumption in Japan: 2.33 million tons. (petroleum consumption: 1.58 million tons) ・BS high vision test broadcasting started. ・Internet was used widely.
2010~2030	・Hybrid gasoline engines and diesel engines will increase. ・Next-generation diesel engines will be used passenger cars. ・Final energy consumption in Japan: 3.55 million tons (petroleum consumption: 2.10 million tons)
2030~2050	・Introduction of E10 gasoline for passenger car ・Bio-diesel fuel (BDF) ・Change from fossil fuel into GTL and BTL (Gasoline consumption of 86 million kL/year will be reduced to half.)