Research Center for New Fuels and Vehicle Technology

Recently, the rapid expansion of worldwide energy demand has caused increased concern about the supply of crude oil. On the other hand, there is an urgent need to reduce greenhouse gases such as CO_2 in order to combat global warming. In addition, it is essential to decrease vehicular exhaust gas pollutants as much as possible in order to preserve the atmospheric environment.

Under these circumstances, the Research Center for New Fuels and Vehicle Technology (NFV) is developing innovative automobile and fuel technologies by integrating pioneering and stand-alone technologies in cooperation with industry, aiming at the proliferation of new fuels (biomass-based fuels and fossil-sourced clean fuels), energy conservation, and super clean exhaust gas. Another important task is the standardization of new fuels and of technologies for measurement and evaluation of fuels and exhaust gases, which are crucial for expanding the use of new fuels. NFV is also working to establish an international talent promotion network by accepting researchers and doing collaborative research in this field, thus carrying out an "Innovation Hub" function (Fig. 1) towards the expansion of new fuel vehicles and related technologies.

The specific mission of the NFV consists of the following primary areas:

1. Development of innovative technologies for production of new fuels, novel engine combustion strategies, exhaust gas treatment methods, and advanced measurement technologies for new fuels and vehicles
2. Promoting the standardization of new fuels and exhaust gas measurement methods
3. Establishment of a human resource promotion network employing researchers exchange and joint research programs, in order to improve the state-of-the-art for both Japanese and foreign countries.

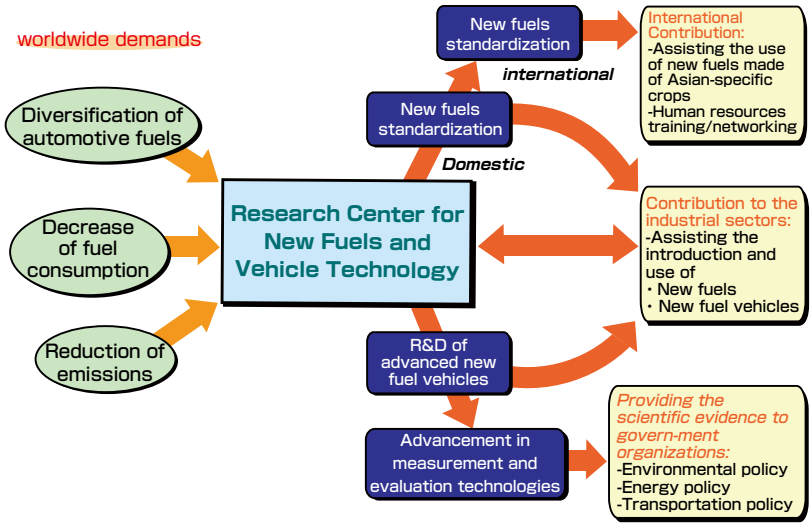

Fig. 1 Innovation hub function of NFV

New Fuels Production Technology

The demand to reduce vehicular emissions, including CO_2, requires stringent specification of conventional petroleum fuel content, and utilization of alternative fuels derived from biomass and other sources. Catalysis is a key technology for upgrading fuel quality and converting biomass resources into clean fuels. As shown in Fig. 2, the Hydrotreating Catalysis Team (HCT) is working on research and development of hydrotreating catalysts for producing cleaner transportation fuels and for standardizing and upgrading BDF (biodiesel fuels), and crude synthesized oils such as GTL (gas-to-liquids). Specific research topics are outlined below.

(1) Improving conventional transportation fuels, with subtopics of:

- Concept proofing R & D for commercializing in-house ultra-deep hydrodesulfurization catalysts (S < 10ppm)
- Innovation of hydrodesulfurization catalysts for zero-sulfur (S < 2ppm) fuels

- Sulfur-tolerant noble metal catalysts for low-aromatic fuel production
- Conditioning the fuel components for new engines and new combustion systems

(2) Production and improvement of alternative fuels

- Improvement of FAME (fatty acid methyl esters) by partial hydrogenation
- Hydrodeoxygenation of triglycerides and biomass-derived oils
- Hydrocracking and isomerization of crude GTL and BTL (biomass-to-liquids)

In addition, HTC is focusing on tailoring and characterizing heterogeneous catalysts and catalytic materials.

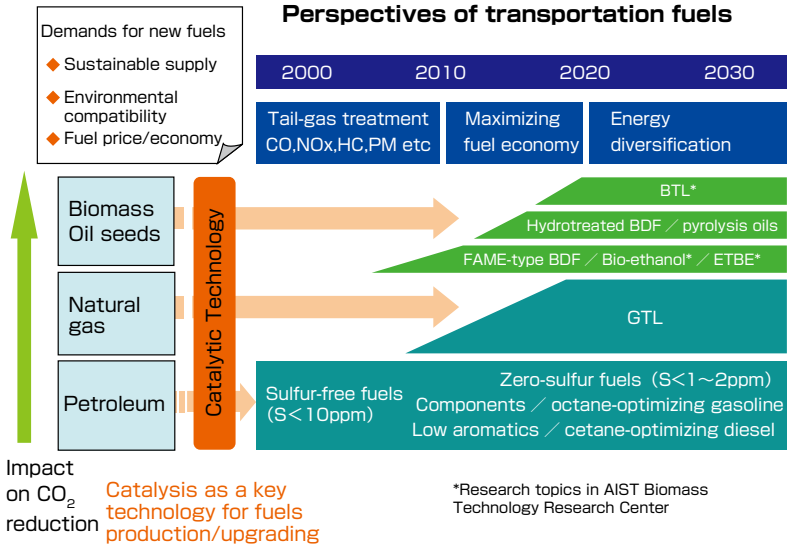

Fig. 2 Transportation fuels being studied at NFV

●Engine Combustion Technology

Physical and chemical characteristics of new fuels depend on their initial source, such as biomass, natural gas, or coal. Therefore, it is necessary to develop the appropriate combustion technologies for improved fuel economy and cleaner exhaust gas. The Combustion and Engine Research Team (CERT) is not only cultivating conventional combustion technologies but also developing new combustion technologies that can address various combustion characteristics of new fuels. CERT is conducting development of an innovative, next-generation, low-pollution engine, and fundamental studies of advanced technologies related to ignition, measurements, and numerical simulation. CERT aims to prove the feasibility of these technologies in real life applications (Fig. 3).

(1) Next-Generation Engine System Research

PCI (Premixed Compression Ignition) is an advanced combustion concept, in which fuel and in-cylinder gases are well-mixed in order to achieve a considerable simultaneous reduction of NOx and soot. Ultra-high pressure fuel injection and hydraulic valve actuation systems are also key technologies for a next-generation engine system. In this research, an optimal design of fuel properties is being conducted to match an innovative, next-generation, low-pollution engine, which can simultaneously decrease exhaust emissions and fuel consumption.

(2) Research on New Ignition Technologies

Fundamental research on advanced ignition technology using a laser is being conducted in an effort to stabilize ignition of new fuels and fuel sprays. The aim of this research is to use this ignition technology for a gas fueled engine, an engine with PCI concept, among others.

(3) Fundamental Study of Measurement and Numerical Analysis of Fuel Sprays and Combustion

The physical and chemical phenomena occurring in an engine are known to be complex. Although over 100 years have passed since the first engine was invented, there are still numerous phenomena that are not well understood. Moreover, there has been little research on complex phenomena of new fuels. CERT aims to acquire quantitative data and to understand the essence of the phenomena by means of advanced techniques such as laser diagnostic and numerical simulation.

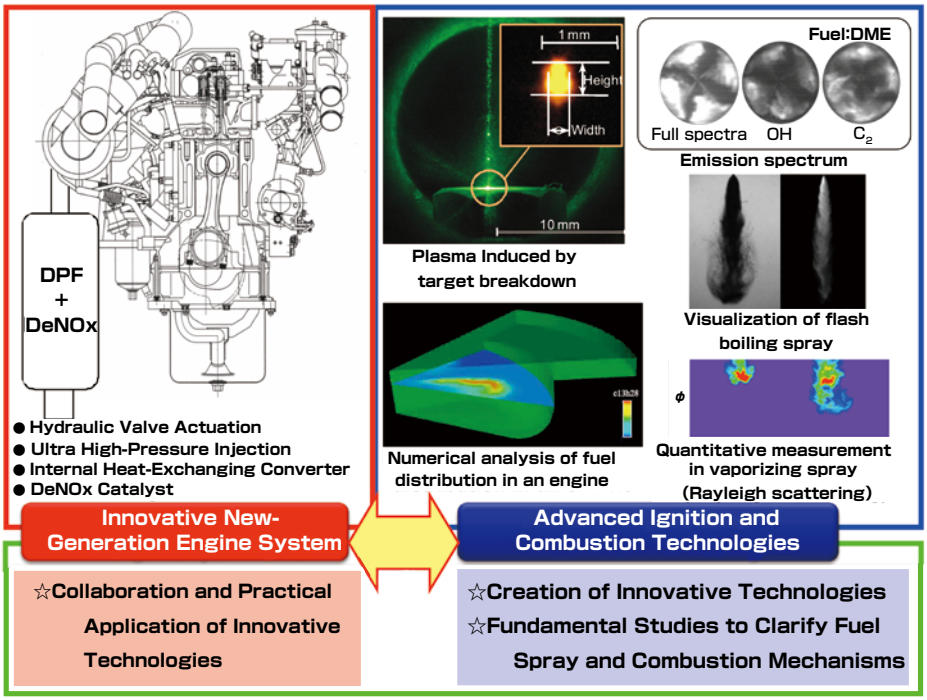

Fig. 3 Research and development of innovative next-generation engine systems

●Exhaust Gas Treatment and Measurement Technologies

Future vehicles must be fuel-efficient and emit increasingly clean exhaust-gases, as new regulations concerning exhaust gas quality and fuel economy will be put into force in 2009 and 2015, respectively, in Japan. In order to meet this social demand, the Emission Control and Catalysis Team (EMCTRL-CAT), the Energy-saving System Team (ESST), and the Measurement and Evaluation Team (MET) are working on research and development of exhaust gas treatment and measurement technologies. The following section gives more detail on this area.

(1) Catalytic Emission Control Technology

To solve the problem of air pollution caused by NOx emissions from diesel engines, EMCTRL-CAT is working to develop innovative catalysts for the selective reduction of NOx with fuel-sourced reductants such as CO, H_2 and hydrocarbons (Fig. 4). EMCTRL-CAT is also developing emission control catalysts with less platinum group metals (PGMs) as well as those with alternative metals to the PGMs, in order to cope with the possible scarcity of PGMs in the future, caused by the drastic increase in the demand of the metals. This study is made by utilizing the novel catalyst design techniques based on fundamental principle of catalytic reaction.

(2) Internal Heat Exchanging Converter Technology

The increased engine efficiencies lower the exhaust gas temperature, which normally leads to reduced catalytic performance. In this context, ESST is working towards the development of an innovative technology called “Internal Heat Exchanging Converter” (Fig. 5). This technology will raise the temperature of the catalyst inside the converter and promote chemical reactions for gas purification, by hybridizing internal heat exchange functionality with the catalytic process. For example, incoming exhaust gases as low as 150°C is expected to be heated to 300 °C with little energy cost, where total oxidation of hydrocarbons and reduction of NOx will easily proceed. ESST is also exploring the possibility to combine this technology with a diesel particulate filter (DPF), in order to make the DPF regeneration process much more energy-efficient.

(3) Exhaust Emission Measurement Technology

MET is working towards development of new measurement and evaluation technologies for application to the new Japanese regulations. Inspection of the adaptability of existing evaluation technologies for new fuels is the most important task in order to distribute new fuels into the general market. MET is researching and developing new measurement and evaluation techniques to meet these needs. The primary missions are development of measurement and evaluation technologies for PM (particulate matter), uncontrolled harmful materials and fuel efficiency.

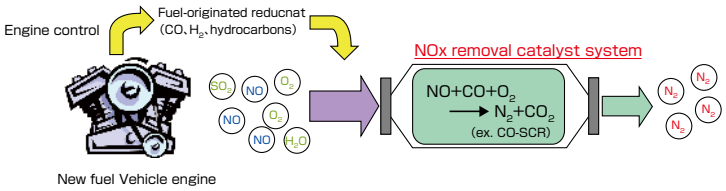

Fig. 4 Research and development of novel catalytic NOx reduction technology

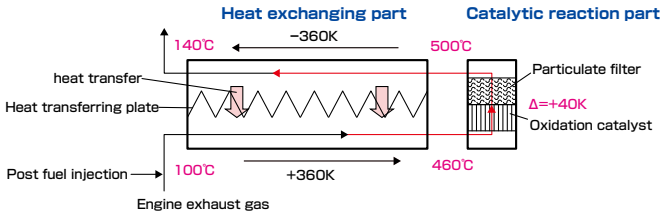

Fig. 5 Concept of internal heat exchanging converter

●Standardization of New Fuels

NFV promotes establishment of international standards and national standardization of Asian countries by promulgating technical knowledge, based on the fundamental research results of fuel production, combustion, fuel consumption and exhaust gas treatment technologies. The standardization activities are carried out taking input of an advisory board, and in cooperation with affiliated organizations.

(1) Ethanol Fuels

Ethanol is attracting much interest as a biofuel for gasoline vehicles. Using bio-ethanol as an automotive fuel involves a maximum regulated blend ratio of 3%(vol) by the Japan quality control laws. The specification of ethanol fuel, which is applied to undenatured ethanol, has been established as JASO (Japan Automotive Standard Organization) Standard JASO M361. Furthermore, establishment of standard specifications for denatured ethanol is desired. NFV is actively engaged in the assistance of standardization activities by working with affiliated organizations.

(2) Biodiesel Fuels

Biodiesel fuels, whose major component is FAME made from vegetable oil, is used as a biofuel for diesel vehicles. In Japan, the quality control law for diesel oil was amended to involve FAME 5% blended diesel oil in March, 2007. Moreover, the JASO standard of FAME as a blend stock was established in October, 2006. Recently, Asian countries have worked to introduce biofuels, so NFV is performing activities for sharing the recognition of the importance of quality control and supporting the standardization of biodiesel fuels for each country.

(3) Dimethyl Ether (DME)

DME does not emit soot in combustion, and it can be used as a fuel for heavy-duty diesel engines. Therefore, significant R&D on the utilization technologies was carried out for countermeasure of air pollution and reduction of petroleum dependence. Recently, the Japanese Ministry of Land, Infrastructure and Transport has started to make engineering standards for DME vehicle, and there are significant activities being carried out for practical use in China. If we put DME on the market, standardization is needed, such as international measurement methods, sampling methods, specifications, and specifications for various related utility vehicles. NFV supports the expansion of DME utilization as fuels not only for vehicles but also for diesel engine powered devices, through involvement with ISO's meeting such as ISO/TC28/SC5 (TC: Technical Committee, SC: Sub Committee, SC5: Sub Committee for measurement of refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels).

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