Innovative Combustion Technology

The Plan for the Rising Sun Engine Initiative to Save the World

Innovative Combustion Technology from Japan; the Trump Card to Save the Global Environment

Cars provide indispensable support to industry, society and our personal lives, getting us from place to place quickly and comfortably. At the same time, the impact of vehicles on the global environment calls for improvements in drivability, safety and greater environmental performance. Innovative combustion technology (The Plan for the Rising Sun Engine Initiative to Save the World) aims to dramatically improve internal combustion thermal efficiency up to a maximum of 50 percent, reducing the impact of combustion engines on the environment. This cooperative research and development project between industry, academia and government will also contribute to the development of Japan's practical engineering capacity and the nation's ability to compete.

Program Director

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* The affiliation and title of PD shall be as of the end of the 1st period (the end of FY2018).

Profile

Joined Toyota Motor Corporation in 1984. Took charge of development of V6 engines from 2002. Took charge of promotion of reform of engine development activities from 2003. Engine Project Promotion Director from 2007. Managing Director and Engine Technology Area Director from 2013. Managing Director in charge of the development of advanced technology in Power Train Company and Director of Higashi-Fuji Technical Center from 2017. Executive Advisor of Future Creation Center from 2018. The present post from 2019.

Research and Development Topics

1. Research to improve gasoline engine thermal efficiency

Work towards elemental technologies for super lean burn, high boosted combustion, as well as combustion under high EGR volume,leading to thermal efficiency of up to 50 percent in comparison to the initial maximum of 39 percent.

2. Research to improve diesel engine thermal efficiency

Develop elemental technologies such as fast and quiet combustion and clean low temperature combustion that lead to thermal efficiency of up to 50 percent in comparison to the initial maximum of 43 percent.

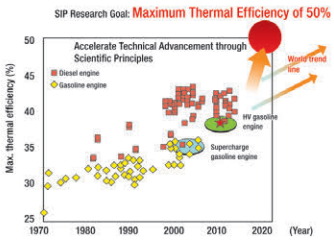
3. Shared research for gasoline and diesel engines

Develop foundational technologies shared between gasoline and diesel engines, including modeling and control technologies for combustion, research into combustion analysis tools, and research into various types of loss reduction.

•SPORT HYBRID i-MMD 2.0L DOHC i-VTEC

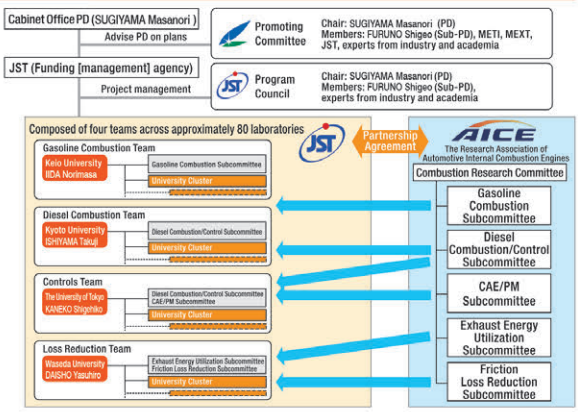
(Source: Honda R&D Co., Ltd.)

•Changes in the Thermal Efficiency of Automotive Internal Combustion Engines and SIP Goals



Implementation Structure

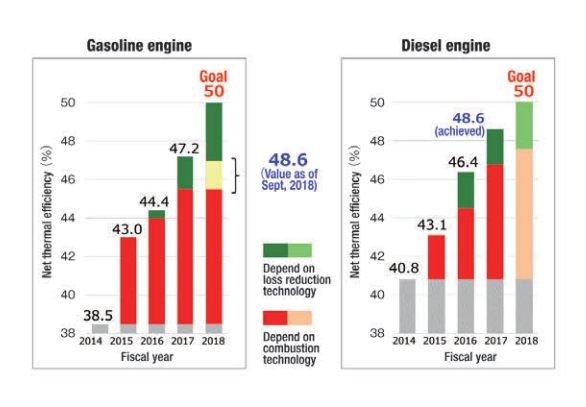
As an expert in research management, the Japan Science and Technology Agency (JST) oversees the program as a whole. Approximately 80 participating laboratories and public research institutions have been divided into four teams covering the research fields of gasoline combustion, diesel combustion, control, and loss reduction, each led by a leader university. The Research Association of Automotive Internal Combustion Engines (AICE) has entered into a partnership agreement with JST to support each research team, creating a research and development framework that brings together industry, academia and government agencies.



* It shows the structure and organization at the end of the 1st period (the end of FY2018).

❶ Achievement of the thermal efficiency of 50%

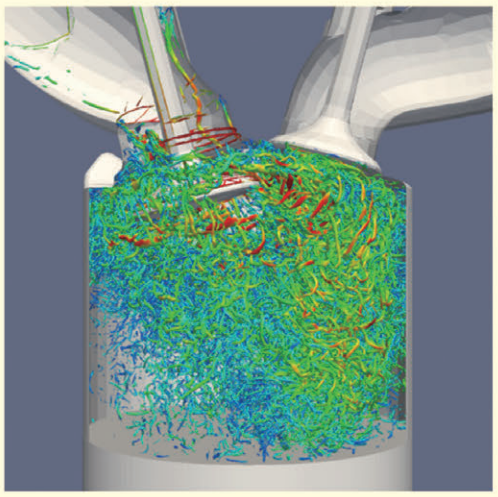
The thermal efficiency of 50%, which had been set as a target for this initiative, was achieved in a very short time (five years) both for gasoline engines (51.5%) and diesel engines (50.1%), with advancement and modeling of basic research and measurement techniques for combustion, reduction of mechanical friction loss and effective utilization of exhaust energy. Though it will take more time for engines actually installed in products (automobiles) to achieve this level of thermal efficiency, we have produced results that will contribute to future stable improvement of fuel efficiency. In addition, as for single-cylinder engines, we succeeded in realizing stable ignition and combustion in the super-lean-burn area. This research result is so academically significant that textbooks on combustion need to be rewritten, because it disproved the common knowledge that the combustion in the superlean-burn was unstable and inefficient in its entirety.



❷ Development of a wide variety of software and models

Academia's findings in SIP led to the establishment of a suite of advanced models that can be roughly classified into ten types, including the spray formation model which is indispensable to advanced combustion control, the PM (particulate matter) model "RYUCA", the model-based control system "RAICA", the tribo-simulator for predicting risks of burn-in and abrasion, and the turbo model. Apart from this, the three-dimensional combustion analysis software "HINOCA" was developed. As a result of the establishment of an advanced fluid platform and sub-models, this software is capable of examining chemical reaction mechanisms in detail to analyze combustion on the basis of phenomenology. This newly developed suite of sophisticated models that even encompass phenomenology is much sought after not only in Japan but also overseas. For example, the website introducing chemical reaction mechanisms of combustion has been accessed more than 62,000 times (including accesses from abroad) for approximately three years up to January 2019, and the chemical reaction mechanisms, etc. have been downloaded approximately 2,700 times.

•HINOCA (three-dimensional combustion analysis software)



❸ Create a sustainable multi-industry, multi-academic structure

Mutual understanding between industry and academia has been promoted, and the needs and recognized issues of industry match with insights from basic and applied studies in academia. As a result, the joint research structure based on multi-industry, multi-academic structure which can be seen only in Japan has been established. "FVV" in Germany, which is used as a reference for an multi-industry, multi-academic structure, focuses on setting engineering research themes directly connected to industry. On the other hand, the collaboration structure in Japan encompasses a wide range of efforts including both basic and applied research. An open lab (a company-owned space equipped with state-of-the-art facilities where large-scale research that could not be conducted by a single university is possible) established in the research and development center with the help of Ono Sokki Co., Ltd. and HORIBA, Ltd. served as a platform for the collaboration. In addition, for the purpose of maintaining the multi-industry, multi-academic structure established in this initiative even after completion of SIP, the Internal Combustion Engine Consortium (Secretariat: National Institute of Advanced Industrial Science and Technology) was established as an association in academia.