Development of an ultra-high-compression-ratio gasoline engine (1.3L)
Realization of 30km/L over the Japanese 10-15 mode

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1. Overview

Recently, hybrid and battery electric vehicles are actively developed and fuel economy improvement technologies by electric devices are adopted increasingly. However, many vehicles are thought to be still installed with internal combustion engines (ICEs) even in 2030. Although electric devices such as idle stop (i-stop) and regenerative braking will become more popular due to cost reduction through volume effect, in order to maximize their effects, the thermal efficiency of base ICEs is essential. Therefore, we are promoting research and development of an ideal ICE from the current ICEs which utilize only 30% of combustion energy as driving force. As the first step towards the ideal ICE, we challenged the development of a gasoline engine with a high compression ratio (CR), which resulted in the power-train that contributes to vehicle fuel economy improvement of 26% (including i-stop's fuel reduction at start and matching with CVT), and achieves fuel economy of 30km/L in the 10-15 mode, equivalent with that of hybrid vehicles, without special electric devices.

2. Technology Details

The most difficult technological challenge for a high-CR gasoline engine is that, on the contrary, its thermal efficiency deteriorates due to constraints of knocking that is abnormal combustion by fuel's self ignition. Because of this, even in recent years, the progress did not go further than commercialization of an engine with CR of 11 with direct injection technology of fuel. With our combustion technology for a high CR gasoline engine, our new focus was on fuel's low-temperature oxidation reaction which occurs right before ignition due to high CR, and active utilization of its merit of enhancing combustion speed through flame propagation. As shown in Fig.1, when CR is increased from 11.2 to 13, power decreases, but at around CR of 14 where low-temperature oxidation reaction occurs, power drop is curbed. In addition to this, with various measures such as improving direct injection technology and devising a better combustion chamber design, as shown in Fig.2, while suppressing power drop due to high CR, we were able to realize power output equivalent with conventional engines.

Also, in order to reduce mechanical friction, almost all components were revisited to minimize contact area/contact load,/friction coefficient of sliding/rotating components and fluid work such as pumps. The major technologies we have adopted are weight reduction of piston and conrod, drivetrain mechanism of roller-follower, a thin-axis crankshaft, new type of a water pump, a variable hydraulic pump and so on. Fig.3 shows the shape of piston and conrod. As a result, the total mechanical friction has been improved by 30%.

Furthermore, i-stop technology has evolved. With electric VVT reducing intake air volume at engine stop and restart, not only smooth but also highly efficient starting was made possible. With this higher efficiency, restart loss has been reduced by more than 60% compared with conventional engines, and thus, fuel can be saved with only a 2-second i-stop. Also, enhancement of charging capability of the i-stop battery shown in Fig.4 has almost doubled the utilization of deceleration energy for electricity generation, and by providing this electricity to starter drive at re-start, fuel used for re-start has been reduced by about 30%.

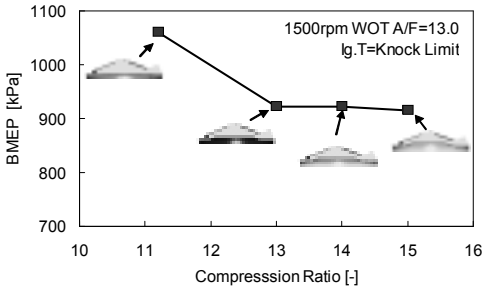

Fig.1 Compression Ratio and Power Output

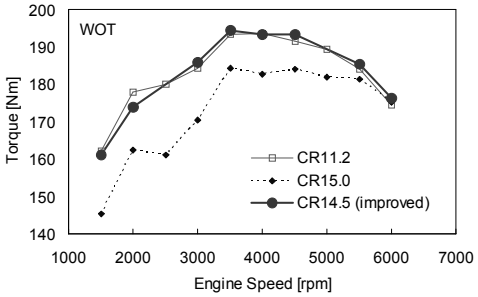

Fig.2 Comparison on Power Output

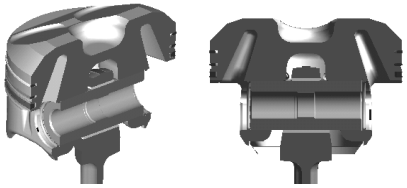

Fig.3 Light Weight Piston and Conrod

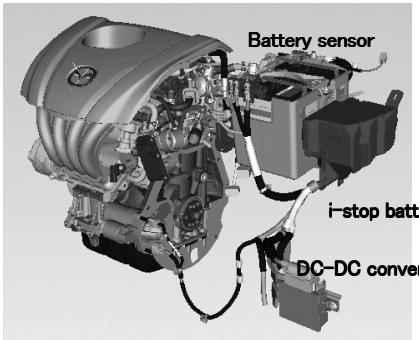

Fig.4 i-stop Power Source System

3. Summary

The newly developed ultra high CR engine has been installed in the Demio since June 2011 and on sale. Since automobiles will be continuously installed with ICEs, without efficiency enhancement of ICEs, they cannot contribute to environmental improvement. This engine technology is applicable to all vehicle lines and the worthy first installment of the series.