Diesel Engines

1 Introduction

In 2013, 1.094 million automotive diesel engines for four-wheeled vehicles were produced in Japan, 106.0% of the previous year. In terms of engine types, 375,000 diesel engines were produced for passenger vehicles (114.2% of the previous year), 644,000 for trucks (101.6% of the previous year), and 85,000 for buses (106.4% of the previous year).

Although the overall production of diesel engines in 2013 was roughly the same as in 2012, production of diesel engines for passenger vehicles and trucks fluctuated on a monthly basis (Fig. 1). In contrast, the production of diesel engines for buses remained relatively steady throughout the year. Over the whole year, the production of each type of engine remained flat.

In Japan, 2012 was notable for the launch of various hybrid diesel engine trucks and diesel engine passenger vehicles. This was probably due to even greater focus on fuel economy, resulting in the development of clean emissions technologies, and the effects of the price of gasoline and diesel as a countermeasure against global warming. This trend is likely to become even more significant in the future.

Outside Japan, automakers concentrated on the launch of trucks compliant with the Euro VI emissions regulations.

2 Engine Trends in Japan

2. 1. Overview

2. 1. 1. Diesel engines for passenger vehicles

Honda Motor Co., Ltd. announced a 1.6-liter class diesel engine for the Civic. Mazda Motor Corporation also announced a 2.2-liter diesel engine for the Axela.

2. 1. 2. Diesel engines for commercial vehicles

More diesel engines for commercial vehicles are incorporating clean emissions technologies. Engine-based measures include intake air controls that combine cooled exhaust gas recirculation (EGR) and variable geometry turbochargers to lower nitrogen oxides (NOx) and high-pressure fuel injection (common rail systems and unit injectors) to improve combustion. Furthermore, aftertreatment-based measures include diesel particulate filters (DPFs) to decrease the amount of soot emitted from the engine and selective catalyst reduction (SCR) to lower NOx.

2014 is likely to see the launch of a number of vehicles that comply with the 2015 fuel economy standards. As a result, these vehicles will probably feature new engine power characteristics, different drivetrain gear ratios, and combinations with hybrid systems.

2. 2. New engine characteristics

2. 2. 1. Honda 1.6-liter i-DTEC (Fig. 2)

Featuring improved engine stiffness and combustion pressure, the 1.6-liter i-DTEC engine uses an aluminum open-deck cylinder block to achieve substantially reduced weight. The mechanical friction of each part was also reduced, achieving the same levels of low friction as a modern gasoline engine.

2. 2. 2. Mazda SH-VPTS (Fig. 3)

This engine uses a common rail multi-hole piezo injector system with ten injector holes to further improve combustion. A variable valve lift (VVL) mechanism (Fig. 4) was also applied to the exhaust valves to restrict

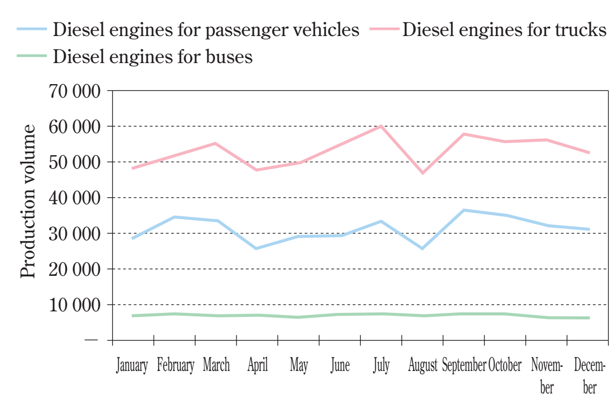

Fig. 1 Diesel engine production in 2013.

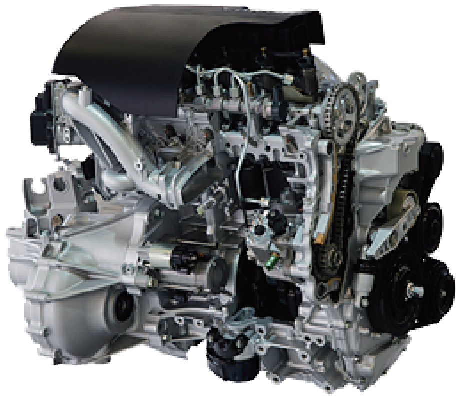

Fig. 2 Honda 1.6-liter i-DTEC.

Fig. 3 Mazda SH-VPTS.

semi misfires, which may occur during warming up after engine start. This system functions by opening the exhaust valves slightly during the intake stroke to generate a flow of high-temperature residual gas from the exhaust port back into the cylinder. This increases the temperature of the air and promotes higher temperatures on compression, thereby improving ignition stability.

A 2-stage turbocharger (Fig. 5) was adopted to increase torque while lowering emissions and improving fuel economy. This utilizes one small or one large turbocharger in accordance with the driving conditions, resulting in high torque and response at low engine speeds, and high power at high engine speeds. At the same time, the 2-stage turbocharger ensures a sufficient amount of air (oxygen) under heavy EGR conditions.

3 Engine Trends outside Japan

3. 1. Overview

3. 1. 1. Diesel engines for passenger vehicles

Sales of new diesel engine vehicles in Europe in-

Fig. 4 Variable valve lift (VVL) mechanism.

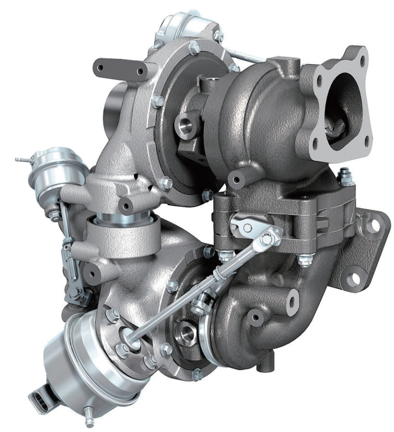

Fig. 5 2-stage turbocharger.

creased rapidly from the second half of the 1990s due to the adoption of clean emissions technologies. Sales of diesel engine vehicles exceeded those of gasoline engine vehicles for the first time in 2007.

European automakers have focused on the development of diesel engines that emit low levels of CO_2. Diesel engine vehicles emit less CO_2 than gasoline engine vehicles, as illustrated in Table 1, which compares the CO_2 emissions and fuel economy of a Volkswagen (VW) Golf with a diesel engine and gasoline engine of the same displacement.

At the same time, the European Union (EU) has tightened the CO_2 emissions regulations to a maximum of 120 g/km from 2015 and plans to introduce even more stringent regulations in the future. For this reason, diesel engine hybrid vehicles are beginning to be launched in addition to conventional diesel engine vehicles.

3. 1. 2. Diesel engines for commercial vehicles

In 2013, automakers launched various diesel engines compliant with Euro VI emissions regulations. These Euro VI-compliant vehicles utilize EGR, measures to lower NOx emissions from the engine, and DPF-based exhaust aftertreatment systems. As a result, most of the commercial vehicles and exhaust aftertreatment systems

Table 1 CO_2 emissions and fuel economy of diesel and gasoline engine vehicle (VW Golf S).

	CO_2 emissions		Fuel economy	
	g/km	%	km/L	%
Gasoline	166	100	14.1	100
Diesel	118	71	22.2	157

* Data: European market VW Golf S
* Fuel economy was measured over the EC combined test cycle.
Source: VW catalog

Fig. 6 DAF PACCAR MX-11.

Fig. 7 Navistar MaxxForce 13.

for North America, Europe, and Japan have virtually the same specifications.

3. 2. New engine characteristics

3. 2. 1. DAF PACCAR MX-11 (Fig. 6)

DAF Trucks Ltd. announced a newly developed 11-liter (1,900 Nm/291 kW or 2,100 Nm/320 kW) diesel engine series that incorporates an exhaust aftertreatment system for compliance with Euro VI. This engine series utilizes a dual overhead camshaft (DOHC) valve train system.

3. 2. 2. Navistar MaxxForce 13 (Fig. 7)

This engine uses a dual-stage turbocharger system with a low-displacement turbocharger at the first stage to improve torque and response at low engine speeds, and a high-displacement turbocharger at the second stage to realize high power.

4 Research and Development Trends

Diesel engines for both passenger and commercial vehicles utilize similar technology to improve emissions and fuel economy. These include high-performance turbochargers, intercoolers, cooled EGR, and electronically controlled fuel injection in the engine, combined with SCR or DPF in the aftertreatment system.

Future research will have to find ways of improving the performance of these existing technologies for compliance with emissions regulations that are becoming increasingly stringent. One issue is controlling the emission of black smoke in accordance with increasing EGR rates in transient engine load regions to lower engine NOx emissions. As this will require more accurate control of the air/fuel (A/F) ratio during transient operation, it is likely that automakers will make progress in the development of A/F ratio control technology. Another likely trend is the development of more advanced A/F control technology using two-stage turbochargers, which have already been adopted in some diesel engines.

Another key technology is emissions temperature control to improve the efficiency of aftertreatment systems such as SCR and DPF. A/F ratio control is also an important element for these systems, and automakers are likely to accelerate research and development into this field.

Homogeneous-charge compression ignition (HCCI) technology is capable of lowering emissions of both NOx and soot. Although regarded as an extremely promising technology, it has been hampered by the high cost of developing ignition controls for transient operation and poor reliability. Despite these drawbacks, active research and development is still under way.

A wide range of technologies for improving fuel economy and lowering NOx and other emissions have been developed in recent years on both the engine and aftertreatment sides. A critical element to increase the performance of these items in the future will be the development of even more precise control technologies.