THE ENVIRONMENT AND THE AUTOMOBILE INDUSTRY

1 Introduction

This article presents overall trends throughout the year for emissions regulations and fuel economy standards (CO_2), and some new cars of environment friendly technology installed released in 2018.

2 Overview

For air pollution conditions[1], the 2017 environmental standard achievement rate for nitrogen dioxide (NO_2) is 100% for ambient air monitoring stations and 99.7% for roadside air pollution monitoring stations (in 2017, 100% for ambient air monitoring stations and 99.7% for roadside air pollution monitoring stations). The environmental standard achievement rate for suspended particulate matter (SPM) is 99.8% for ambient air monitoring stations and 100% for roadside air pollution monitoring stations (in 2016, 100% for both ambient air monitoring stations and roadside air pollution monitoring stations). In recent years, the environmental standards have been achieved nationwide. The annual average concentration of NO_2 and SPM are continuing their downward trend (NO_2 shown in Fig. 1). The environmental impact of vehicles is steadily decreasing, and vehicles are no longer the source of pollution they once were. Regarding the 99.7% environmental standard achievement rate for NO_2, only the Matsubarabashi station in Ota-ku, Tokyo among 393 valid monitoring stations did not achieve the environmental standard. At that level, controlling local road conditions and traffic flow will be more effective than further tightening regulations on individual vehicles.

Items with a lower achievement rate are PM 2.5 at 89.9% for ambient air monitoring stations and 86.2% for roadside air pollution monitoring stations (in 2015, 88.7% for ambient air monitoring stations and 88.3% for roadside air pollution monitoring stations). While the overall achievement rate is improving, there are regions with low environmental standard achievement rates (by prefecture) at ambient air monitoring stations in northern Kyushu and the area of Shikoku facing the Seto Inland Sea (Fig. 2). The standard achievement rate remains extremely low for photochemical oxidant (Ox), at 0% for both ambient air monitoring stations and roadside air pollution monitoring stations. This situation needs to be improved. Although regulations on NO_2 and hydrocarbon (HC), which are components involved in generating Ox, have been made stricter and have been effective, there is no sign of improvement. The necessity of measures that account for the emission ratio of nitrogen oxides that are causative agents and volatile organic compounds has been mentioned[1].

In 2018, the test cycle for emissions evaluations was changed from JC08 test cycle to WLTC. The regulation values are based on the twelfth report on the Future Policy for Vehicle Emission Reduction[2] and are at the

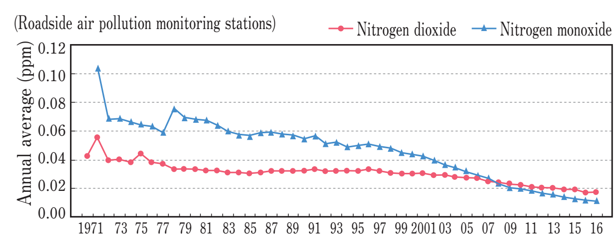

Fig. 1 Annual Average of NO, NO_2 Concentration at Roadside Air Pollution Monitoring Stations

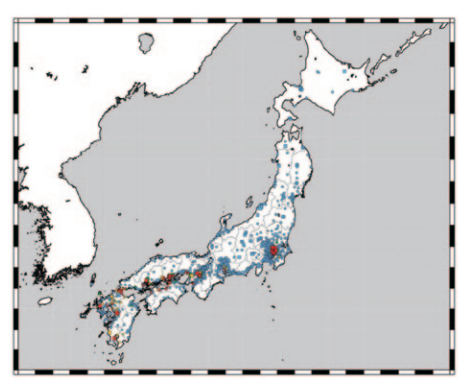

Fig. 2 Nationwide Achievement Status of PM 2.5 Environmental Standard in 2018

Table 1 Trends in CO_2 Emissions Based on Transport Organizations in Transportation Sector

	Value of most recent year (million tons)	Share (%)	Compared to 2005 (%)	Compared to 2013 (%)	Compared to previous year (%)
Personally-owned vehicles	61	28.4%	−20.5%	−8.2%	2.0%
Other passenger vehicles	46	21.4%	−3.2%	−3.4%	−4.8%
Trucks	78	36.5%	−13.7%	−3.2%	−0.9%
Trains, ships, air planes	29	13.8%	−5.0%	−4.9%	−0.8%
Total	213	100%	−12.7%	−4.9%	−1.0%

* Other passenger vehicles include private vehicles other than personally-owned vehicles (company vehicles), taxis, buses, and motorcycles
* Emissions of trains, ships, and airplanes for freights and passengers included

same level as that of the JC08 test cycle in gasoline vehicles and LPG vehicles. Recent changes include the introduction of an advanced on-board diagnostics system (OBD) targeting heavy-duty vehicles applied since October 2018, and the gradual expansion of the applicable scope. In February 2019, it was announced that PM emissions regulations will start in December 2020 for vehicles and motorcycles with a direct injection engine that uses gasoline as fuel.

In terms of vehicle traffic noise, another regional environmental problem, 532,200 houses (6.1%) of the total of 8,721,400 houses evaluated exceeded the environmental standard for either daytime (6 to 22 o'clock), nighttime (22 to 6 o'clock), or both, the same level as in 2018[3].

In contrast, in terms of global environmental issues, CO_2 emissions from the transportation sector in 2017 were 213 megatons (Mt), a 0.8% decrease from the previous year[4]. Vehicles, the main source of emissions, accounted for 86.2%. CO_2 emissions from vehicles have exhibited a significant decrease of 20% since peaking in 2001. In addition to the continuing decrease in CO_2 emissions from freight shipment, emissions from passenger vehicles other than personally-owned vehicles have decreased considerably in comparison to the previous year (Table 1). This effect is attributed to the hybrid vehicles starting to spread among vehicles used exclusively as taxis, and the trend is expected to continue. In the U.S., rapid improvement has recently been observed in fuel economy and CO_2 emissions. In 2017, the corporate average fuel economy was 24.9 miles per gallon (MPG), and the effect of stricter regulations is starting to appear worldwide[5].

In terms of fuel economy standards directly related to CO_2 emissions, the heavy-duty vehicle fuel economy standards for 2025 were established on March 29, 2019[6], based on the report collated in December 2017. Discussions of standards after the existing 2020 standards for passenger cars are underway[7]. If the aim is to significantly reduce energy consumption further in comparison to the 2020 fuel economy standards, the key issue will be how EVs and PHEVs are handled and how technologies that improve fuel efficiency are reflected in ways other than in the test cycles performed in Europe and the U.S. Since fuel economy standards are related to tax and related measures, there is a non-negligible possibility that evaluation methods of EVs and PHEVs will affect their future spread and power relationships, and the direction of the discussions is drawing attention.

In terms of fuel economy trends over the last few years, many technologies that improve fuel economy are continuously being incorporated and hybridization has continued. In the area of internal combustion engines, Nissan introduced a variable compression ratio engine to markets outside Japan. In addition, the Mazda SKYACTIV-X, which incorporates high efficiency combustion that is partially self-igniting, is expected to be introduced to the market in the near future. In contrast, recently there have been more than a few cases where fuel economy deteriorated when the model was redesigned, although this issue attracts little attention since it is not actively discussed. The era where it is normal for the fuel efficiency to improve every time the model is modified is starting to change. The main reasons are as follows.

- Weight was increased since safety systems such as collision mitigation braking systems and driving support mechanisms have been enhanced or previously optional systems have become standard equipment.
- Since 2016, the motivation to make further improvements seems to have dropped among companies that have achieved the 2015 fuel economy standards for corporate average fuel economy (CAFE), which resulted in lower fuel economy in some redesigned models.
- Performance in areas outside the test cycle fuel economy, such as a sporty feel, was improved.

This may be because the limit of improvements in fuel economy achievable through powertrains, which include engines and transmission systems, and through various vehicle technologies has been reached, creating a situation where improvements are gradually clearly becoming difficult to make in terms of cost effectiveness.

3 Trends in Environmentally Friendly Technologies for Individual Vehicles Seen in Models Released in 2018

This section presents the models that may attract attention in terms of technologies that improve fuel economy and emissions among those released in 2018. The specifications for fuel economy values and the figures are based on manufacturer press releases and catalog information.

In July 2018, the Subaru Forester was fully redesigned (Fig. 3). A model newly installed with a hybrid system called the e-Boxer was released. The e-Boxer is a hybrid system that combines a 2.0 L gasoline engine with a 10 kW motor. A characteristic of the e-Boxer is that it is installed in a 4WD system with a proven track record within the company. Not many hybrid vehicles are 4WD vehicles and in most of the few that are, the wheels on the side not driven by the engine are driven by electric power. This clearly distinguishes the e-Boxer from other systems. While the e-Boxer achieves a fuel economy of 18.6 km/L in the JC08 test cycle and exceeds the 2020 fuel economy standards by 10 to 20% (the achievement rate differs based on the vehicle weight), there is only a slight difference between vehicles with that system and the 2.5 L gasoline vehicle in the same lineup in terms of fuel economy in the WLTC (13.2 km/L). The vehicle with the e-Boxer offers no advantage if the next-stage fuel economy standards are set using the WLTC. It is estimated that Subaru is planning to release an improved model or PHEV based on the vehicle installed with the e-Boxer, as its next step. In October, the XV Advance installed with the same system was released.

In July, the Honda Clarity PHEV was released (Fig. 4). The EV operating range is 114.6 km in the JC08 test cycle and 101.0 km in the WLTC, with respective fuel economies of 28.0 km/L and 24.2 km/L. The median value of the travelling distance per day for a passenger vehicle is around 30 km and the EV travelling distance of the Honda Clarity is several times higher. For the time being, this provides an optimal solution to minimizing the environmental burden without compromising convenience, as the vehicle can mostly be used as an EV on a daily basis, and only needs gasoline for long-distance trips. However, its price currently makes rapid adoption and popularization. At the same time, a breakthrough might be achieved if these vehicles trigger the introduction of that technology to light-duty vehicles.

Fig. 3 Subaru Forester Advance

Fig. 4 Honda Clarity PHEV

Fig. 5 Mercedes-Benz C200

In July, the Mercedes-Benz C-Class was partially redesigned (Fig. 5). Although called a partial redesign, there were a significant number of changes at around 6,500 modified locations including some in the powertrain. The C200 is particularly notable in reducing displacement from 2.0 L to 1.5 L while adopting a 48 V mild hybrid system (belt-driven starter generator (BSG)) that is expected to see greater adoption. The motor-generator of the BSG is 10 kW, which is the same as in the Forester described above. Fuel economy is 13.6 km/L in the JC08 test cycle and 12.9 km/L in the WLTC. However, fuel economy has actually decreased from the model prior to the redesign, and the achievement rate of the 2015 fuel economy standards has dropped from exceeding the standards by 5% to simply meeting them. In comparison to the model (C180) installed with a normal, non-hybrid 1.6 L turbocharged engine, the C200 lags behind in terms of fuel economy even when accounting for the difference in vehicle weight category due to an increase in compo-

Fig. 6 Mitsubishi Outlander PHEV

nents. Based on the specifications, the effects of the improvements in fuel economy resulting from the BSG and downsizing seem to be extremely limited at present. In March 2019, the E300, which has the same system, was introduced to the market.

In August, the Mitsubishi Outlander PHEV was completely redesigned (Fig. 6). The EV operating range is 65.0 km in the JC08 test cycle and 57.6 km in the WLTC, with respective fuel economies of 18.6 km/L and 16.4 km/L. This 4WD vehicle has a motor with a maximum output of 60 kW to the front wheels and a motor with a maximum output of 70 kW to the rear wheels. In addition, it features an engine in which the displacement has been expanded from the conventional 2.0 L to 2.4 L to achieve a higher expansion ratio. The vehicle aims to improve both environmental and cruising performance by mainly using the engine during high speed cruising while using EV cruising, powered as a strong motor, as a base.

In December, the Toyota Prius was partially redesigned. Although no notable modifications were made to the powertrain, environmental performance changed as the fuel economy value of the model with the best fuel economy decreased from 40.8 km/L (JC08 test cycle) to 39.0 km/L. The main reason for the decrease in the fuel economy value is presumed to be the increase in weight due to the standardization of safety equipment. Despite the fact that the performance itself has not deteriorated, its reign as the vehicle with the best fuel economy in Japan, exceeding 40 km/L, only lasted two years.

In January 2019, the Leaf e+ was released (Fig. 7). With the Leaf e+, the previous cruising range of 322 km (in the WLTC test cycle) was extended to 458 km (in the WLTC test cycle, corresponding to 570 km in the JC08 test cycle). Energy density was improved by 25%. Although weight increased, the maximum output of the motor was boosted to 160 kW, making it possible to improve performance aspects such as shortening the acceleration time during high speed cruising. For the cruising range determined by multiplying fuel economy in the JC08 test cycle by the tank capacity, some models, such as sports cars do not reach 570 km. It is not clear if the same sequence applies to cruising on actual roads while using air conditioning. However, it is significant that a vehicle that can compete with conventional gasoline vehicles on a level playing field in terms of cruising range, which has been an issue for EVs, is being distributed as a mass market product.

Fig. 7 Nissan Leaf e+

1 Front panel 3 Side deflector
2 High roof 4 Front air spoiler

Fig. 8 Vehicle body air resistance reduction in Hino Profia

For heavy-duty vehicles, the scope of emissions regulations in 2016 was expanded to light- and medium-duty trucks in 2017, and to tractors in 2018. This has led to the release of upgraded models by various manufacturers.

In May, the Hino Profia Tractor was upgraded. Achieving the heavy-duty vehicle fuel economy standards in the tractor category has proven difficult. However, this upgraded model not only complies with the 2016 emissions regulations, but also meets the 2015 fuel economy standards and even exceeds them by 5% in some grades. In contrast to the conventional 12-speed AMT, the lineup includes a 16-speed AMT (Pro Shift 16) with a wider gear range. One of the elements that led to improved fuel economy is the optimization of the shape of the vehicle body to reduce of air resistance (Fig. 8). Under the new heavy-duty vehicle fuel economy testing

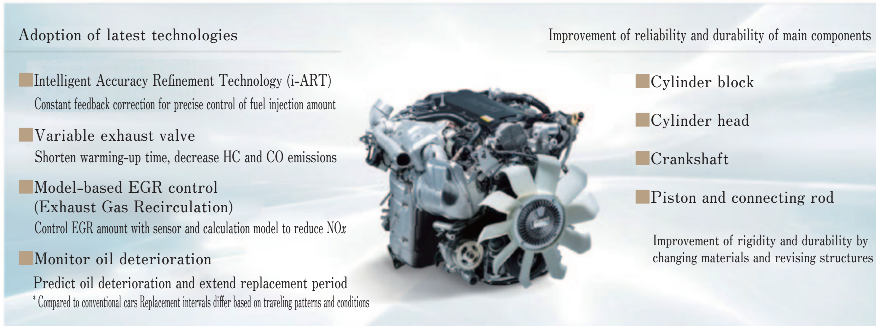

Fig. 9 Adopted technologies in engine installed in Isuzu Elf

method, it is possible to use some of the actual measured values for the cruising resistance value, which was previously uniform in each category. Changes in the testing method might trigger similar improvements in fuel economy.

In October, the Isuzu Elf was upgraded. Although previous Isuzu light-duty trucks did not have NOx aftertreatment devices, this upgraded model has a urea SCR installed in addition to a diesel particulate filter (DPD) placed directly under the manifold. Fuel economy was improved by adopting i-ART (Fig. 9). Vehicles installed with start-stop systems (excluding some 4WD vehicles) have either achieved the 2015 fuel economy standards or exceeded them by 10%.

In January 2019, the UD Trucks Quon was upgraded. The key feature is the introduction of an 8 L engine (Fig. 10). Whereas a 9 to 13 L engine is generally installed in heavy-duty vehicles with a gross vehicle weight in the 25-ton class, the upgraded Quon has a downsized engine. In this class of heavy-duty vehicles of this class, displacement per weight is small to begin with, leaving little room for improvement from downsizing. Since there are legal restrictions of the gross vehicle weight, the increased vehicle weight due to the addition of exhaust aftertreatment or other devices decreases maximum carrying capacity accordingly, worsening product appeal. This is where downsizing to reduce weight becomes important. With the 8 L engine, weight was reduced by 300 kg compared to the existing 10.5 L engine while ensuring an output of 262 kW. The upgraded Quon achieved the 2016 fuel economy standards and exceeded the 2015 fuel economy standards by 5% while addressing the issue of weight, and therefore provided a high-level response to contradictory requirements.

Fig. 10 UD Trucks GH8 Engine

4 Conclusion

Since the new fuel economy standards did not yet apply in 2018, there was some stagnation in terms of fuel economy improvement in new models. Reasons for that stagnation include fundamental causes such as conventional technologies, including those of internal combustion engines, offering little room for further improvement, and the emphasis on prioritizing the enhancement of safety systems to appeal to users. In terms of internal combustion engines, expectations are being placed on measures for new regulations such as the Real Driving Emissions (RDE) test. Progress in introducing and spreading technologies that improve fuel economy was observed in the 1990s (e.g., the Miller cycle, GDI lean burn, and the first-generation Prius) and in the 2010s. This matches the periods when emissions regulations were applied (to gasoline passenger vehicles). It is impossible to predict whether that trend in fuel economy improvements will be maintained when RDE and particle number (PN) regulations are put into effect. Until now, it had been possible to take a giant step after a period of temporary stagnation. However, electrification now changes the equation completely. The next few years will be crucial in determining a course for the future in relation to the delicate balance between technology, cost, politics and economics, and infrastructure.

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