Toyota Develops TNGA-based Powertrain Units for Smooth, Responsive, 'As Desired' Driving

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Toyota City, Japan, December 6, 2016 — Toyota Motor Corporation, in pursuit of superb driving and environmental performance, and based on the Toyota New Global Architecture (TNGA) structural reform for making ever-better cars, has developed advanced engines and transmissions and further evolved its hybrid systems. Toyota intends to deploy these new powertrain units in a rapidly broadening range of vehicle models, starting in 2017.
Using TNGA, Toyota has been changing the automobile from its very structure, lowering hood heights, lowering the center of gravity and implementing other innovations to improve driving performance. To enhance fundamental vehicle performance in terms of running, turning and stopping, it initiated a comprehensive review centered on vehicle platforms and is now, since the release of the fourth-generation Prius in 2015, expanding the use of new platforms throughout its product lineup. At the same time, it has been developing new powertrain units, which form the core of an automobile, that significantly improve both driving and environmental performance.

Toyota's newly developed powertrain units are light and compact and have a low-center of gravity. In-depth reconsideration of fundamental vehicle performance has resulted in engines with high-speed combustion and in highly efficient multi-geared transmissions. Furthermore, to standardize the basic structure of these new units, modular design (unified design) was used, building a foundation for the future making of "well-built cars."

While it was a given that the new powertrain units would be designed to have a high level of environmental performance, development focused on achieving driving performance that would "change how Toyota cars drive", under the theme "Direct & Smooth."

For Toyota, the starting point of making cars is "fun to drive"?the feeling of joy that comes when behind the wheel. Toyota aims to make cars with driving performance that responds to the will of the driver and are, at the same time, highly fuel efficient, among having other environment-friendly attributes. The new powertrain units announced today, in themselves, provide approximately 10 percent better power performance[*2] and approximately 20 percent better fuel economy. Combining the new powertrain units with the overall evolution of the vehicle body, including aerodynamics, weight reduction and others, can open the way to even greater power performance and fuel economy.

New 2.5-liter Direct-injection, Inline 4-cylinder Gasoline Engine

Toyota has named its new line of internal-combustion power plants "Dynamic Force Engines". To bring out the new engines' potential to the fullest, their basic structure was completely rethought using TNGA, and their overall structure and configuration were wholly innovated to achieve high-level driving and environmental performance. Work will continue to make the new engines even more advanced.

The new engines employ high-speed combustion technology and a variable control system. They also achieve greater thermal efficiency, resulting in high output, due to a reduction in energy losses associated with, among others, exhaust and cooling systems and the movement of mechanical parts. Their lineup includes a 2.5-liter engine that has one of the world's best thermal efficiencies[*3]?40 percent when used in gasoline-powered

vehicles and 41 percent when used in hybrid vehicles (HVs). This new, thoroughly reconsidered and greatly evolved engine features numerous new technologies, such as technologies for minute control that make it highly responsive and allow it to generate ample torque at all speeds.

New 8-speed and 10-speed Automatic Transmissions (Direct Shift-8AT & Direct Shift-10AT)

Toyota has developed two new automatic transmissions?the 8-speed Direct Shift-8AT and the 10-speed Direct shift-10AT. For both, various measures were taken to minimize energy loss and heighten transmission efficiency. Gear tooth surfaces were processed using a new technique for a lower coefficient of friction when the gears engage, and the configuration of the friction material used inside the clutch was optimized to reduce clutch torque loss by approximately 50 percent during rotation (compared to a conventional 6-speed transmission). These and other efforts resulted in achieving one of the world's best transmission efficiencies[*3]. The new automatic transmissions are more compact and lighter than comparative conventional transmissions, lowering a vehicle's fuel requirements. And their lower center of gravity results in both improved straight-driving stability and better cornering stability.

Furthermore, widened gears and a newly developed high-performance compact torque convertor combine for a broader gear lockup range. The resulting quick and smooth response to accelerator pedal operation creates an "as desired" direct driving feel.

In the case of the Direct Shift-10AT, even though the number of gears has been increased to 10 (compared to eight gears in the case of the Direct Shift-8AT), the use of close-ratio gears optimizes the range of use of each gear, particularly in the low-to-mid speed range. The resulting smooth gear changes, which are among the world's quickest[*3], create a rhythmical and comfortable sensation that is suitable for a premium rear-wheel-drive vehicle.

Through such measures, fundamental vehicle performance in practical driving situations ranging from driving around town to driving on the highway has been improved to a degree that drivers can distinctly experience. Smooth response to accelerator pedal operation enables "as desired" vehicle departure and, in overtaking maneuvers, it allows lag-free and rhythmical acceleration that meets driver expectations, even in cases of sudden and heavy accelerator pedal use.

Advancement of Toyota Hybrid System II (THS-II)

Applying size-reducing, weight-reducing and loss-reducing technologies used in the fourth-generation Prius, Toyota has enhanced its hybrid system for 2.5-liter engines and developed the new, high-performance Multistage THS II for rear-wheel-drive vehicles.

THS II for 2.5-liter engines excels in both power and fuel-economy performance due to the synergistic effect of size-reducing, weight-reducing and loss-reducing technologies coupled with the high thermal efficiency and output of a new TNGA-based engine.

Multistage THS II gives hybrid vehicles an all-new driving image with its start-from-stop acceleration performance and abundant direct feel. In addition to improving system efficiency at high speeds, intermittent use of the engine at high speeds has also been made possible, further improving high-speed fuel economy.

The system for plugin hybrid vehicles (PHVs) has also been enhanced. A new dual-mode drive system allows the electric motor, which was hitherto used only as a generator, to provide direct driving power, resulting in powerful driving, even when in EV mode. Further enhancing the system for PHVs is a large-capacity lithium-ion battery that largely increases the EV-mode cruising range to 60 kilometers or more[*4].

Roll-out of New Powertrain Units

Through TNGA-based car-making, efficiencies have been achieved in the development of the base technologies of the new powertrain units, along with improvements in quality, making possible the concerted release of affordable, high-quality products. This will lead to Toyota being able to quickly provide its customers with ever-better cars and to further promote widespread use of environment-friendly, fuel-efficient vehicles.

Within the five years to the end of 2021, Toyota plans to introduce 17 versions of nine engines, including the 2.5-liter engine announced today, 10 versions of four transmissions, including multi-geared automatic transmissions and a new kind of continuously variable transmission, and 10 versions of six hybrid systems.

In this way, through TNGA-based modular development, Toyota will roll out numerous types of new powertrain units within a short timeframe, successively introducing them in various vehicle models, starting with the launch of a new-model vehicle in 2017.

By the end of 2021, Toyota aims to have the new powertrain units feature in 60 percent or more of Toyota-brand and Lexus-brand vehicles sold annually in Japan, the United States, Europe and China. Toyota forecasts that Toyota and Lexus vehicles sold that year in those markets will account for a CO2 reduction in those markets of 15 percent or more, counting the fuel-efficiency-improvement contributions made by the new powertrain units alone.

Review and Strengthening of Development Structure of Powertrain Company

Toyota intends to review and strengthen the development structure of its in-house Powertrain Company. Conventional engine-powered vehicles account for the vast majority of vehicles currently on the market, and HVs and PHVs, the advance of which is expected to continue, also have internal-combustion engines. In addition to promoting development of engines and transmissions, which are seen to remain mainstay for some time to come, toward the coming electrification of vehicles, Toyota is accelerating its development of hybrid technologies (electrification technologies), such as those used in electric motors, batteries and power control units (PCUs).

1. Sharing technologies to raise the collective ability of the Toyota Group

   Toyota has long conducted research and development of key technologies and systems based on its stance to "acquire through in-house creation". The accumulation of knowledge, know-how and experience is what allows Toyota to turn failure into improvements. This approach has been the backbone of Toyota research and development and is viewed as why Toyota was able to develop a practical hybrid system, launch the "Prius"?the world's first mass-production HV, and develop and be quick to market with the "Mirai" fuel cell vehicle (FCV).

   However, Toyota realizes that it would be difficult to heighten the pace of development and commercialization of electrification technologies for further reducing CO2 emissions if Toyota addressed such as it has done until now, relying only on its own resources. Toyota will continue to carefully select that which it deems necessary to "acquire through in-house creation". But, from now on, it will also promote the sharing of technologies within the Toyota Group and increase the number of fields covered by joint research. It will strengthen joint development that uses cross-group obeya (project rooms with displays for sharing and reviewing goals, policies, timelines, progress and problems, etc.), efficiently use group resources to quickly establish advanced technologies and aim for increases in three areas: in the collective ability of the Toyota Group, in the speeding of development and in the scale of proliferation and expansion of environmental technologies.

2. Strengthening the development structure for hybrid technologies, which are core technologies for electrification

Key hybrid technologies, such as those found in electric motors, batteries and PCUs, are also key technologies used in vehicles that are powered by electricity, such as PHVs, FCVs and EVs. For the electrification of vehicles, to greatly accelerate the development of hybrid technologies, which Toyota positions as the core technologies of environmental technology development, Toyota plans to increase its number of hybrid technology-development personnel. Specifically, it plans to reorganize its development structure starting in 2017 and increase its number of people involved in hybrid technology development by approximately 30 percent within the five years to the end of 2021. Beyond then, as well, it plans to further strengthen its human resources for hybrid technology development as needed.

To contribute to the preservation of Earth's environment, Toyota is aiming to reduce new-vehicle CO2 emissions by 90 percent (compared to 2010 levels) by 2050. Based on its principle policy of conserving energy, which is the cornerstone of its development of environment-friendly technologies, by furthering the evolution of engines and transmissions and by promoting widespread use of HVs and PHVs, Toyota is endeavoring to improve fuel efficiency as a means of reducing CO2 emissions. And with a view to the future and an eye on limiting the consumption of fossil fuels centered on petroleum, to respond to the diversification of energy sources, Toyota is advancing its development of zero-emission vehicles, such as FCVs, which use hydrogen, and EVs.

To further reduce CO2 emissions, Toyota is continuing its development of environmental technologies and its commercialization of environment-friendly vehicles from the perspective that environmental contributions cannot be achieved without widespread use of environment-friendly vehicles.

Going forward, through TNGA-based ever-better car-making, to accelerate the commercialization of ever-better cars that are both fun to drive and that contribute to Earth's environment and to accelerate the reduction of CO2 emissions, Toyota will strengthen its undertakings by rallying the collective ability of the Toyota Group.

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*1 Comparison of average amount of CO_2 emitted by Toyota and Lexus vehicles actually sold in 2015 in Japan, United States, Europe and China and average amount of CO_2 emitted by Toyota and Lexus vehicles planned to be sold in 2021 in Japan, United States, Europe and China, including vehicles equipped with newly developed powertrain units
Estimated CO_2-reduction contribution made only by newly developed powertrain units based on certified data in each country or region

*2 In terms of time needed for a gasoline-powered vehicle to accelerate from 0 miles per hour to 60 miles per hour and for a hybrid vehicle to accelerate from 40km/h to 70km/h

*3 As of November 2016, according to Toyota survey

*4 Developmental target value (in the JC08 test cycle); measured by Toyota

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Toyota's Approach to Developing Environmental Technologies
Reducing CO2 Emissions through Sure and Steady Steps and Widespread Application

As fuel consumption regulations continue to strengthen in various countries, and as many automobile manufacturers advance their commercialization of electric-powered vehicles, such as plug-in hybrids (PHVs) and electric vehicles (EVs), Toyota is working to further evolve conventional fossil-fuel-powered engines and transmissions. The reason: To steadily promote reduction in CO2 emissions.

In 1997, Toyota launched sales of the "Prius" as the world's first mass-production hybrid vehicle (HV). Now, nearly 20 years later, hybrid vehicles have gradually grown in use, mainly in Japan, the United States and Europe. But, on a global scale, they have yet to become widespread. The widespread use of PHVs and EVs, which have already been introduced, mainly in Japan, the United States and Europe, is expected to take time. The vast majority of cars in use or on the market are conventional engine-powered vehicles that consume large amounts of fossil fuels, such as gasoline and diesel fuel, and they will continue to emit large volumes of CO2, as from before.

It is expected that it will take quite some time for the proliferation of vehicles that use electricity?some of which emit very little CO2 and some of which have no emissions at all?to make headway and for their effect on reducing CO2 emissions to become apparent. Therefore, to be able to stop the advance of global warming, finding other ways of reducing CO2 emissions, which are thought to play a role in the rise of global temperatures, is an urgent issue.

For the time being, the vast majority of cars in use or on the market will remain to be conventional engine-powered vehicles, and HVs and PHVs, the use of which is expected to increase, also have internal-combustion engines. As such, considering that fossil fuels will continue to serve as automotive fuel for some time to come, improving the environmental performance of engines and transmissions can promote a measureable reduction in CO2 emissions that is proportional with an increase in the number of vehicles.

Toyota believes that developing conventional powertrain technologies is a sure, steady, realistic and effective means of reducing CO2 emissions.

Further Reducing CO2 Emissions through Fuel Diversification

Beyond the reduction of CO2 emissions through the widespread use of HVs and PHVs is the need to achieve zero CO2 emissions. The widespread use of zero-emission vehicles, such as fuel cell vehicles (FCVs) and EVs, is a must. The only way to achieve such is to use non-fossil-fuel hydrogen and electricity as automotive power sources and to develop powertrain technologies for vehicle electrification, such as fuel cell systems, motors and batteries, and power control units.

Toyota believes that hydrogen and electricity are important alternatives to fossil fuels for use in automobiles. As such, it intends to advance its development and commercialization of zero-emission FCVs and EVs, which emit no CO2 during driving and are effective in making large contributions to the environment.

Taking into consideration the energy situation and fuel infrastructure in various countries and regions, as well as consumer preferences and other factors in the market environment, Toyota is endeavoring to promote the widespread use of FCVs and EVs, while considering the appropriate roles for each, and is aiming for even greater reductions in CO2 emissions.

However, the road to fuel diversification is not an easy one. Such cannot be achieved by automobiles alone. Essential is the existence of a supply infrastructure (fuel infrastructure) for new fuels that can allow peace of mind in the use of automobiles that run on new types of fuel. For energy companies, that means new investment. Support by governments and municipalities is also indispensable.

Also necessary is the understanding of society and our customers and their acceptance of new fuels. This is because new fuels are different in many ways?such as in terms of fueling locations, fueling times, fueling methods and fuel costs?from fuels such as gasoline and diesel fuel, with which we are familiar after so many years of use. New fuels could also mean fueling that is not as convenient as that in the case of the cars our customers are using today. This means that "diversification" must apply to not only fuels but to customer values, as well.

This is especially true when it comes to FCVs, which use hydrogen?a fuel with which people rarely come in contact in daily life. Because hydrogen can be produced from various primary energy sources, beyond its environmental benefits, it is seen as an important energy resource that will be used in the future as a way to heighten energy security. FCVs, which use electricity created through a chemical reaction involving hydrogen and which can be driven without emitting CO2, have high potential as a form of "the ultimate eco-car". Toyota has been developing FCVs for more than 20 years. But issues still exist. These include understanding of hydrogen on the part of society and our customers and the availability of hydrogen stations. Much time is still required for the widespread use of FCVs and the realization of a hydrogen society.

Aware of such, Toyota was quick to initiate an FCV commercialization project, resulting in the launch of the "Mirai" FCV in Japan in 2014, followed by sales in the United States and Europe. Toyota has taken up the challenge.

This is just the beginning of what Toyota sees as a long-running challenge to make a hydrogen society a matter of fact and to make FCVs everyday vehicles.

Toyota, while promoting efforts to conserve energy, intends to accelerate its response to fuel diversification and to work as one with the entire Toyota Group to achieve greater reductions in CO2 emissions.