New Powertrain Units Based on TNGA

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Mitsumasa Yamagata
Chief Engineer, Powertrain Product Planning Division
Toyota Motor Corporation
New Powertrain Units Based on TNGA

1. Toyota’s Initiatives

2. New Powertrain Units
   1) New 2.0-liter Powertrain
   2) New 4WD System
New Powertrain Units Based on TNGA

1. Toyota’s Initiatives

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   1) New 2.0-liter Powertrain
   2) New 4WD System
By 2050, our goal is to reduce CO₂ emissions from new cars by 90% (compared to 2010)
The vast majority of vehicles (conventional engine vehicles, HVs, & PHVs) have an engine. Thus, increasing the fuel economy of powertrains is necessary for reducing CO₂ emissions.
Responding to environmental issues while pursuing the joy of cars

Energy Conservation

Fuel Diversification

When widely-used, eco-friendly cars can contribute to environmental protection

Pursuing the Joy of Cars
Raise Production Efficiency

(1) Respond flexibly to customer needs

(2) Promptly provide products to customers

Uniform processing and assembly standards

Uniform process and facility specifications

Processing Tools (uniform)

(1) Develop lines that can flexibly produce different models at high speed
(2) Accelerating global deployment with the standardization of process and facility specifications
Current Development

- **EGR**
- **VVT-iE**

ZR

- **Valvematic**

AR

- **D-4S**

Development using TNGA

Standardized structural and elemental technologies

**Engine modularization**

<table>
<thead>
<tr>
<th>Cylinder capacity</th>
<th>No. of cylinders</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4</td>
</tr>
<tr>
<td>b</td>
<td>6</td>
</tr>
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<td>c</td>
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Consolidate and streamline engine types

Current

New Engines

*App. 40% reduction*

Achieve increases in development efficiency while contributing to higher productivity
Lineup of new powertrain models to meet diverse needs

Engines: 9 models, 17 variations
Transmissions: 4 models, 10 variations
HV systems: 6 models, 10 variations

3.5-liter twin-turbo
Dynamic Force Engine (2.5L)
THS II (1.8L)
THS II (2.5L)
Multi-stage THS II
Direct Shift-8AT
Direct Shift-10AT

(TNGA-based module development for achieving rapid introduction of 19 models and 37 variations by end of 2021)

(Variations consist of front-wheel drive or rear-wheel drive, passenger or commercial vehicle, conventional or HV, differences in torque capacity, etc.)
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New Powertrain Units

1) New 2.0-liter Powertrain

- **Engine**
  - 2.0-liter Dynamic Force Engine

- **Transmission**
  - Direct Shift-CVT
  - New 6MT
  - THS II for 2.0-liter Engines

2) New 4WD System

- Dynamic Torque Vectoring AWD
- New E-Four
Diverging Use of CVT and AT Where Trends Intersects
Powertrain evolution targeted by TNGA

1. Improved maximum thermal efficiency (deeper)
2. Expanded high fuel-efficiency area (wider)
3. Improved engine torque
4. Use of high efficiency area (wider gear range)
5. High-responed control

Improve and maximize efficiency of powertrain systems (engines/transmissions/HV systems)
Performance of new powertrains

Achieve both better driving performance and better environmental performance

<table>
<thead>
<tr>
<th>Conventional engine-powered vehicle</th>
<th>HV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel economy (U.S. combined fuel economy) (contribution by powertrain)</td>
<td>Dynamic Force Engine (2.0L) &amp; Direct Shift-CVT</td>
</tr>
<tr>
<td>Current powertrain (2ZR-FE + CVT)</td>
<td>18% shorter</td>
</tr>
<tr>
<td>Acceleration time (contribution by powertrain)</td>
<td>18% improvement</td>
</tr>
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</table>

New powertrains achieve improvement in fuel economy and greater improvement in dynamic performance
New engines

Dynamic Force Engine (2.0-liter)
Achieves one of the world’s best levels of both output and thermal efficiency
Performance of new engines

Improved output and torque through optimal combustion while supporting emission controls in each country

Output and torque curve

Emissions Performance

Japan: 2018 regulations
U.S. SULEV30
Europe: Euro6 (RDE)
China: National 6 etc.
Direct Shift–CVT
New CVT Development Concept

- Improved transmission efficiency
- Use of high-efficiency engine range
- Highly responsive shift control
New CVT Development Concept

- Improved transmission efficiency
- Use of high-efficiency engine range
- Highly responsive shift control
- Reduced mechanical loss (increased belt efficiency, etc. through the addition of a launch gear)
- Wider range
- Improved shift tracking (narrower belt angle, improved shift control, etc.)
New CVT Development Concept

- Improved transmission efficiency
- Use of high-efficiency engine range
- Highly responsive shift control
- Reduced mechanical loss (increased belt efficiency, etc. through the addition of a launch gear)
- Wider range
- Improved shift tracking (narrower belt angle, improved shift control, etc.)
Belt transmission efficiency deteriorates on the low and high sides.
A launch gear was adopted on the low side and a shift to belt drive made on the high side to achieve high efficiency over a wider range.
Efficiency is higher during belt drive and transmission efficiency is substantially higher over the entire driving range.
Achieves Both Wider Range and Higher Efficiency

Achieves a wide range at the top of the 2.0-liter class and transmission efficiency at the world's highest levels
There are instances where a switch is made from belt to gear when the power is on in low vehicle speed range (kick down, etc.).
Improved Launch Performance

When Starting From a Full Stop

Launch Acceleration G-force Comparison

The launch gear achieves powerful, smooth acceleration
While driving in an urban environment, the transmission switches from gear drive to belt drive to achieve high fuel economy driving in a consistent high-efficiency engine rotation range.
By expanding the range and increasing efficiency, fuel economy is improved by 6%.
New CVT Development Concept

Improved transmission efficiency

Use of high-efficiency engine range

Highly responsive shift control

Reduced mechanical loss (increased belt efficiency, etc. through the addition of a launch gear)

Wider range

Improved shift tracking (narrower belt angle, improved shift control, etc.)
Enhanced Direct Sensation While Driving

Conventional CVT

Direct Shift-CVT
Enhanced Direct Sensation While Driving

By adding a launch gear, the belt load is reduced, allowing the pulley to be more compact and reducing the belt angle to improve shifting speed by 20%.
Sharper and more nimble shifting is possible, and when the driver wants strong acceleration, a powerful and rhythmical feeling of acceleration can be achieved.
1) New 2.0-liter Powertrain

- **Engine**
  - 2.0-liter Dynamic Force Engine

- **Transmission**
  - Direct Shift-CVT
  - THS II for 2.0-liter engines
  - New 6MT

2) New 4WD System

- Dynamic Torque Vectoring AWD
- New E-Four
New 6-Speed MT
By making the transmission lighter and more compact, transmission efficiency at the world’s highest levels is achieved.
iMT Control: intelligent Manual Transmission

Smooth gear shifting operation is automatically supported according to the engine RPM
New THS II
(2.0-liter)
A hybrid system that emphasizes driving
Engine rotation is increased linearly to produce lengthened and comfortable acceleration.

**Linear and Lengthened Acceleration Sensation**

- Reduce initial engine rotation and increase rotation linearly.
- Battery power supplements acceleration.

**Improved Acceleration Sensation**

- New control vs. Conventional control.

**Engine RPM**
- Conventional control.
- New control.

**Battery power**
- Conventional control.
- New control.
Lineup of New Powertrain Models to Meet Diverse Needs

With the introduction of a new 2.0-liter powertrain, Toyota is announcing a total of 11 models among a total of 19 models.
Deployment of the New 2.0-liter Powertrain

To be produced locally in Japan, China, North America, South America, and Europe in stages for prompt global deployment
Vehicles equipped with the new powertrains are expected to increase to about 80% by 2023 (Japan, U.S., Europe, and China)

Contribution of the powertrain alone to the average reduction of new vehicle CO₂ emissions is expected to be at least 18% (compared to 2015)
New Powertrains Based on TNGA

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The 4WD market is expected to grow even further and the need for further improvements in product performance will increase.
Conventional engine-powered vehicle

Company C
Company A
Conventional
Company B
Company D

New

Conventional

HEV

Conventional

New

4WD Performance

Improved

4WD Performance

Improved

(company estimate)

Achieve both better driving performance and better environmental performance
The new system achieves improved basic performance both in on- and off-road situations and exceptional driving performance.
Toyota developed a new 4WD system that combines new automatic and independent control of left and right rear torque with an automatic 2WD switching function.
Toyota developed the new E-Four, which greatly increases rear output torque and automatically controls optimal power distribution to the front and rear wheels.
We will deploy eight models of the new 4WD system for various applications including passenger vehicles, commercial vehicles, and HEVs.
The new series will be expanded to 28 models, about 70% of total new 4WD system sales in 2023.
For Our Customers’ Smiles

For meeting diverse regional needs and for our customers’ smiles
TOYOTA