

Development of a Compact Ultra-Flat Torque Converter Equipped with a High-Performance Damper

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ABSTRACT

By optimizing parameters related to damping performance and adopting a layout that incorporates the turbine into the damper components, a "Turbine Twin-Damper" lock-up damper was developed that achieves both damping performance and compactness. To reduce losses in the fluid flow channel, a smaller torus was developed that reduce the width of the torus by about 30%. Through the combination of this Turbine Twin-Damper and smaller torus, attenuation of the torque fluctuation transmitted to the transmission to 1/2 or less compared to a conventional product was achieved without increasing the overall width of the torque converter. As a result, the engine speed at cruise fell by 400rpm, and fuel economy improved.

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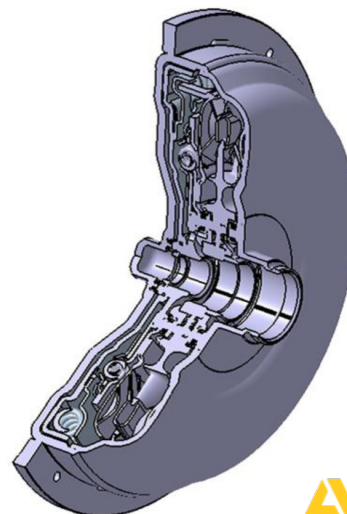
INTRODUCTION

In recent years, trends in measures to achieve better fuel economy have included downsized turbo in engines and expansion of the gear ratio range in transmissions [1] [2]. Since these measures enable low-speed, high-power engine operation, a beneficial effect on fuel efficiency can be anticipated. However, when compared to conventional engines, such operating conditions increase torque fluctuation from engine caused by cylinder pressure, which induces vibration and noise, in some cases degrading quietness and other marketability features.

Torque converters are equipped with lock-up dampers in order to suppress the torque fluctuation that causes vibration and noise. In terms of functionality, the lock-up damper must suppress torque fluctuation sufficiently to reconcile marketability and fuel efficiency. At the same time, there has been strong demand for more compact dimensions. For FWD (front wheel drive) vehicles in particular, it is important that the overall width be compact [3]. Besides compactness, lightness of weight is similarly desirable, once an appropriate moment of inertia has been ensured. Lower inertia helps to improve engine revving and aspects of driving performance represented by acceleration forces (dynamic performance). In addition, it enables quicker shifting, since only small torque is generated in response to change in speed during shifting.

A system was developed that is optimal with respect to three key aspects of dampers that were investigated: (1) sufficient damping performance, (2) the compactness required for FWD cars, and (3) an amount of inertia that feeds dynamic performance. Honda has been

mass-producing a lock-up damper with a larger torsion angle from 2000 torque converter model. This paper describes the development of a new "Turbine Twin-Damper" lock-up damper system that enables operation at low engine number of revolution to achieve even greater fuel economy and marketability. [Figure 1](#) shows an overall view of the torque converter that was developed. The following sections describe the development goals that led to development of the torque converter, the technical challenges and how they were overcome, and the performance improvements in an actual vehicle.



1374 [Figure 1. Developed Torque Converter](#)



DEVELOPMENT GOALS

In order to strike a balance between improved fuel efficiency and marketability, the following development goals were established with respect to damper performance and torque converter performance:

1. Damping performance : torque fluctuation of -50% from existing
2. Overall width of torque converter : same as existing
3. Effect on departure acceleration : -2% or less change in performance

Overview of Structure

Figure 2 shows cross-sectional views of the developed torque converter and the current product, and compares the two converters in terms of structure and typical specifications. With respect to the torque transmission passage in particular, Figure 3 shows the torque passage that was developed for the new product, while Figure 4 shows a conventional torque passage.

	New <Turbine Twin-Damper>	Previous <Single Damper>
Cross-Section of Torque Converter (→ : Torque Passage)		
Width of Torque converter	69mm	71mm
Angle of Lockup Damper	Over 40deg	21deg
Torus diameter*width	230*31mm	232*47mm
Torque Capacity Ratio @ $\epsilon=0$	30 Nm/rpm ² *10 ⁶	←

Figure 2. Comparison of Features

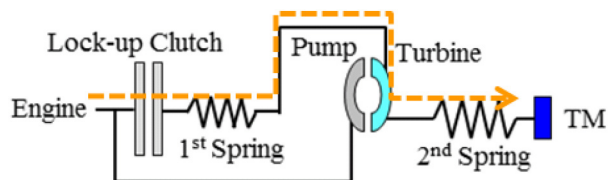


Figure 3. Torque Passage of Turbine Twin-Damper

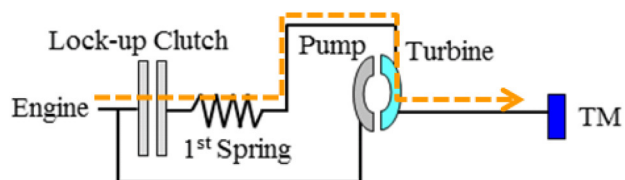


Figure 4. Torque Passage of Single Damper

SELECTION OF DAMPER SYSTEM

Verification of Damping Performance via Simulation

The performance of the damper system was verified through simulation. With limitations on the overall width of the torque converter, the damper system was selected by considering its impact on dynamic performance while meeting the damping performance objectives.

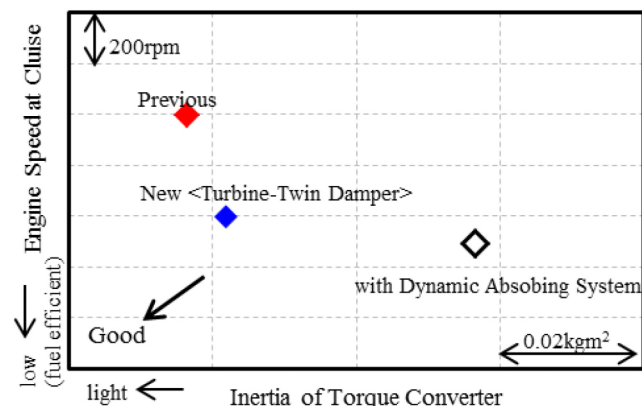


Figure 5. Effect of Lowering Engine Speed at Cruise

Figure 5 shows the inertia of the torque converter according to different damper systems on the horizontal axis, and the lower limit on engine rpm at which the vehicle can cruise at the same speed on the vertical axis. Compared to the conventional product, the new product has slightly higher inertia, but thanks to a significant improvement in damping performance, it is able to reduce the engine speed at which cruising is possible. The lozenge in the Figure 5 indicates an engine equipped with a dynamic vibration absorber such as a centrifugal pendulum-type damper. This enables further reduction in engine speed, but the change in inertia is large.

Figure 6 shows the influence of the inertia of the torque converter on dynamic performance at full-throttle takeoff (vehicle acceleration G after 0.5 seconds). Compared to the conventional product, the new product increased inertia slightly, but with almost no reduction in departure acceleration performance.

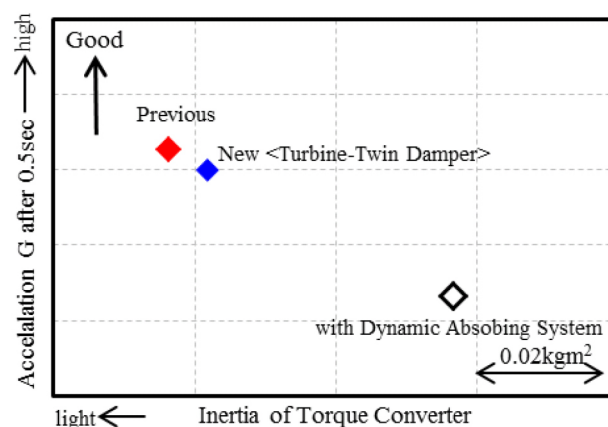


Figure 6. Influence of Acceleration G