The Permanently engaged gear mechanism in TOYOTA Stop & Start System (Idle stop system)


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1. Outline

The "Permanently engaged gear Stop & Start System" (P.E.S.S. mechanism) has improved engine start quality by permanently engaging ring and starter pinion gears, using an one way clutch (O.W.C.) and a ball bearing. Through our experience with serial production of pinion shift starter idle stop system, we concluded that "decrease in noise and vibration" and "possibility to start engine at any time" were necessary to realize wide spread use of such systems. To this end, we chose to permanently engage the gears. This mechanism also achieved "adaptability to all transmission types" and "maintenance free starter system".

This P.E.S.S. mechanism is a world first development, which aims to be both a pioneer and a de facto standard in the recent age of environment.

2. Detail of Technology

Fig.1 shows the sectional view and operation outline of the P.E.S.S. mechanism.

The P.E.S.S. mechanism operates as follows;

At engine start: the O.W.C. is engaged at the moment the ring gear is rotated by the starter pinion. The starter's driving force is transferred to the engine crankshaft.

After engine runs: the O.W.C. freewheels and the ring gear stops. The engine's driving force is transferred to the transmission.

The ring gear is permanently engaged with the pinion gear of the starter motor. This realizes a quick and silent start when the engine restarts. Moreover, smooth engine restarts are possible at any time (Fig.2), also because of this permanent engagement. It is not necessary to wait until the engine has stopped completely, which is different from a conventional pinion shift starter.

The basic principle of the O.W.C. at engagement is shown in Fig. 3. O.W.C. has been mainly used with automatic transmissions, so ATF is the normally used lubricant. The change of the friction coefficient of ATF is small. But in this mechanism, the O.W.C. is arranged in the crank case, so the lubricant is engine oil. It is the first time in the world O.W.C. is used in engine oil which has such an extreme change in friction coefficient. It is necessary to understand friction coefficient with the real vehicle for securing the engagement reliability of the O.W.C.. Minimum friction coefficient in the real vehicle is derived, and engagement angle "α" that will guarantee the engagement reliability was set.

Moreover, the shock torque is loaded to the O.W.C. at the engine stall. In the grasp of the O.W.C.'s longevity, it is important to understand the variety of torque input scene and frequency.

Fig.4 shows the relation between input torque and durability of the newly developed O.W.C.. (T-N curve at minimum μ) Points show the frequencies of each driving mode in actual use. The O.W.C. can guarantee full life durability.

Fig.5 shows relation between sound insulation ability of the vehicle and the start noise level of the engine unit. The start noise level in the passenger compartment was reduced by 4dB, and realized an acceptable start noise even for vehicles with low sound insulation capabilities.

Two large diameter oil seals were used to layout the P.E.S.S. mechanism in engine oil.

Fig.6 shows that the lip temperature of the inner oil seal, used at speeds of 40m/s, far faster than conventional engines 30m/s, will increase about 40degC. So, a low radial load seal, a low friction lip coating, an oil jet on cylinder block end face, and a splash plate were added to decrease lip temperature to an equal level compared to a mass production engine's oil seal.

3.Summary

The Permanently engaged gear Stop & Start System was introduced to the European market from August of 2008.

We expect approximately 10% reduction in CO_2 and fuel consumption in rush hour city traffic. The wide spread use of this mechanism can further contribute to the improvement of the global environment.

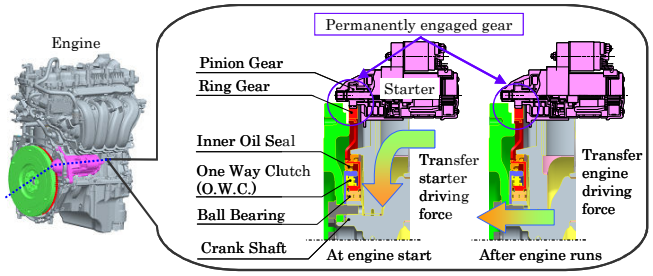

Fig.1 Permanently Engaged Gear Mechanism

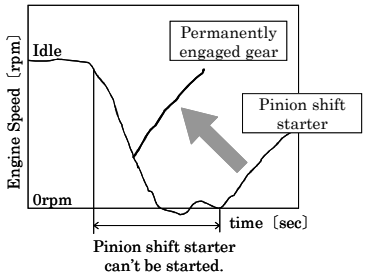

Fig.2 Restart Time

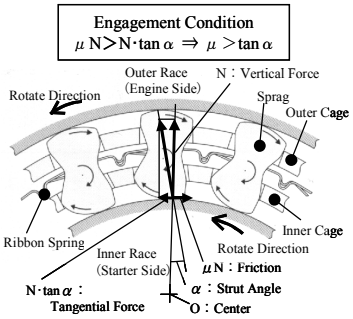

Fig.3 Basic Principle of O.W.C. at Engagement

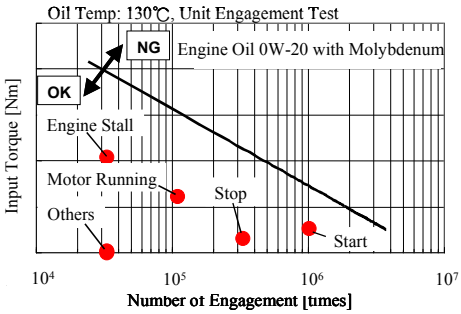

Fig.4 T-N Diagram of the One Way Clutch

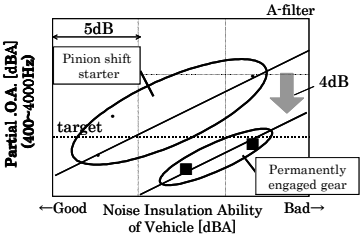

Fig.5 Noise Level inside the Vehicle at Engine Start

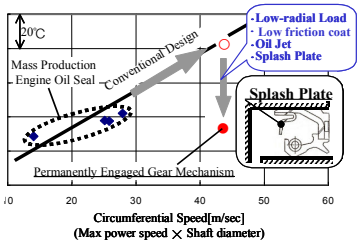

Fig.6 Inner Oil Seal Lip Temperature

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