Trends of Bearing and Related Products for Automotive Power Train Applications

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Due to recent trends of smaller, lighter and shorter engine accessories, and wider poly-V-ribbed belt application for accessory drives, rolling bearings for automobiles are used in more and more severe conditions as higher vibration, higher rotational speed, and higher temperature. Bearings for engine accessories have been improved and diversified due to various operating conditions and required performance.

Here, trends of representative bearings for power train applications including valve drive applications are described.

Key Words: rolling bearing, technical trend, application, automotive power train

1. Introduction

History of today's automobiles (gasoline-fuel automobiles) is said to have started when Gottlieb Daimler and Carl Benz produced in 1886 four and three wheel vehicles respectively. Since then, automobiles have made remarkable progress in more than 100 years, and in the 21st century further improvement is expected with the theme of global environment, safety and comfort. Needless to say, rolling bearings continue to greatly contribute even today to this further improvement of automobiles by challenging to such technical issues as low friction and supporting stiffness. Among automotive rolling bearings, engine accessory bearings are used in severe conditions requiring vibration resistance, high rotational speed, high temperature resistance and environmental conformity. Diversified and specialized specifications are applied in each bearing design to satisfy different environments and performance for engine accessories. This report shows trends and technical issues of power train bearings (engine drive train and engine valve train bearings) ensuing "Recent trend on automotive drive train bearings and bearing related products" reported in the previous issue.

2. Various Engine Accessory Bearings

Today's engines including advanced electronic control devices do not differ so much in their basic function of lubrication, cooling, control, fuel and electric systems although they are controlled from many various sensors and electronic devices.

However, trends for extensive adoption of aluminum material, downsizing, integration, lighter and more compactness are the same with many other automotive and industrial machine components. Technical issues and future trends are reviewed here focusing on recent rolling bearings for typical engine accessories.

2.1 Alternator Bearings

Compact and high output alternators integrated of a built-in IC regulator and rotor-fan are in common use now. At the same time, poly-V-ribbed belts have been developed and prevailed. They have high transmissibility of engine vibration and high belt tension fluctuation in spite of their smaller belt expansion.

Alternator bearings driven by this poly-V-ribbed belt are exposed to extremely high load and high vibration never seen before. Consequently, bearing manufacturers are faced with technical problems of raceway flaking (Fig. 1) with microstructural change (WEA: white etching area) never experienced before in bearing manufactures. Koyo developed a new material and heat treatment based on the investigation on its mechanism, and through the research on lubrication, succeeded finally in developing a new ether oil base anti-flaking grease. The new grease is widely used for many engine accessory bearings for its cost advantage compared with solution through materials and/or heat-treatment.

(The paper of flaking causing structural change was introduced in Koyo Engineering Journal, 150, too, as "A New Type of Microstructural Change due to Rolling Contact Fatigue on Bearings for the Engine Auxiliary Devices")
High efficiency type alternators (Fig. 2)\(^2\) and water cooled alternators have been developed in order to improve power generation efficiency and lower noise level, and for these rotor support bearings, extremely high heat resistance is required in most cases.

Koyo has already developed alternator bearings for high temperature applications of 180°C and 200°C, based on those for generally required temperature of 150°C, and they are now in mass production in the series (Fig. 3).

Recently, a starter generator (Fig. 4)\(^3\), a new type of alternator with an added function as a starter is already in the market. The purposes of a starter generator are: easy drive change from a motor to an engine, smooth re-start after a vehicle or an engine stops, and regeneration of brake energy while hybrid vehicles are running. By adding starter function, higher belt tension is required and higher load is imposed on the bearing at start time, and then a higher capacity bearing is needed. For drastic reduction in fuel consumption in the future, hybrid technology of an electric motor and gasoline engine as exemplified in idle stop is requisite. Starter generators are thought to be increasingly used in the future as essential accessories for hybrid vehicles.

Fig. 2 High efficiency type alternator\(^2\)

Fig. 3 Heat resistant bearings for alternators

Direct fuel injection diesel engines are also widely used to achieve lower fuel consumption and lower emission\(^4\).

Higher fluctuation of engine rotation in direct fuel injection diesel engines is causing accessory belts problems of squeal, flapping noise and lower life. For alternators with higher inertia torque, Koyo has already developed a one-way clutch pulley for an alternator which solves the problem of squeal noise of an accessory belt by integrating a one-way clutch in the drive pulley to absorb fluctuation of belt tension and contributes to longer belt life (Fig. 5).

Fig. 4 Starter generator\(^3\)

Fig. 5 Clutch pulleys for alternators

2. 2 Tensioner and Idler Bearings

The increase of serpentine belt systems in the 1990s brought about a large change in the layout of engine accessory belts. As for tensioner and idler bearings corresponding to the increased need of auto-tensioners with automatic belt tension adjustment function, Koyo developed auto-tensioners for accessories and are already in commercial production, (Fig. 6)\(^6\). The belt pulley section has been manufactured by stamping or machining, but owing to disadvantages of a V-ribbed pulley in moldability and cost, an injection molded pulley (resin pulley) of engineering plastics is expected to be more utilized in view of design flexibility and productivity (Fig. 7). The weakness of a resin pulley is generally poor heat- and wear-resistance. But Koyo has already developed a phenolic resin pulley with heat resistance up to 180°C level and sufficient wear resistance in addition to reinforced polyamide resin pulley, and manufactured on commercial base (Fig. 8). At one time, a cogged belt was widely used for a timing belt due to its lower noise, simple layout, and less lubrication and an adjusting tensioner and fixed idler was increasingly used for a while. However, this tends to be replaced again by a timing chain due to easy maintenance,
durability and space saving.

In addition, a larger change in the engine construction is supposed to be realized in accordance with the recent trend toward an electrically driven valve system.

![Fig. 6 Auto-tensioners for accessory drive belts](image)

As this was not sufficient for water resistance when water leaks, Koyo developed a triple lip seal with a slinger having good water resistance as the third lip axially placed (Fig. 11). As for rubber material, hydrogenated nitrile rubber with good heat resistance and good compatibility with a coolant was newly developed and employed in place of conventional nitrile rubber. Today water pump bearings with triple lip seals are widely used in Japan and tend to be increasingly used in the world, too.

![Fig. 7 Phenolic resin pulleys](image)

2. 4 Air Conditioner Compressor Pulley Bearings

A clutch is built in a compressor drive shaft for an automobile air conditioner and is operated intermittently depending on necessity. An electromagnetic clutch is conventionally used for a clutch system. However, a direct drive type accessory belt is increasing in accordance with common usage of an air conditioner compressor with variable capacity. This type has no electromagnetic clutch and is driven by a pulley having torque control and rotational fluctuation absorbing mechanisms. This pulley has narrower width compared to an electromagnetic pulley, and applied bearing can be placed in the center position of the pulley, and then smaller moment is loaded on the bearing. Koyo developed a light-weight and compact multi-point contacts single row bearing (MPC Bearing: Multi-Point Contact) (Fig. 13) in order to replace a conventional double row angular contact ball bearing (Fig. 12). This bearing is now under evaluation for mass production. In the future, the installation rate of air conditioners for passenger cars in Europe is expected to be increased, and then, MPC bearings will be increasingly used in accordance with the increase of air conditioner systems.
3. Low Fuel Consumption Technology for Valve Systems

Worldwide movement for the global warming control and environmental protection is heightened and the target value of Japanese fuel economy in 2010 has been established (Fig. 14). Corresponding to this trend, variable valve timing and variable lift mechanisms for valve systems have been realized to the vehicles as a fuel saving technology.

Particularly rocker arms have been improved in fuel saving (especially at low speeds) by utilizing rolling elements for sliding contact area with cams. However, more and more low torque is required for bearings.

To prevent the increase in number of parts and process cost, bearings are required of cost reduction and smaller size and lighter weight. Koyo has successfully developed a stamped steel rocker arm unit, which is already in practical use (Fig. 15).

4. Conclusion

This report described on the trends and technical issues on typical power train bearings. The control systems and accessories for power train systems will be further diversified in the near future as hybrid vehicles will spread more and more from an environment point of view.

It is our keen desire to continue to propose new technologies to be realized in the next 100 years of the 21st century by deepening and combining the automotive bearing technology accumulated in the long years and the special environmental technology.

References
