Development of K II Series Hypoid Geared Motor

*The motor industry was looking for a geared motor that would downsize, reduce loss and provide high torque. This led our company to develop the **K II** series, right angle geared motor, which is composed of a gear reducer using a hypoid gear and an induction motor.*

*This geared motor produces 3.5 times the rated torque of the **K II** series because it uses case hardening gears, improving the allowable radial and axial load. To prevent grease leaking, the type of oil seal and the design of the case housing was improved. This geared motor can be attached from either direction for the Hypoid geared hollow shaft type, so it saves space as well.*

*This article introduces the structure, features, and the ease of use with the **K II** series.*

1. Introduction

Standard AC motors are used in a wide variety of industries as power sources for many types of industrial equipment. Our products have been used as the industry standard by many customers.

In recent years, demands for motors and gearheads with downsizing, energy efficiency and less maintenance required, are increasing. In order to meet such demands, the **K II** Series was developed from the conventional **K** Series. It is equipped with a high-performance gearhead and its permissible torque is up to 3.5 times more than that of the conventional **K** Series. Features of the **K II** Series are introduced in this article.

2. K II Series

Figure 1 shows the exterior of the **K II** Series. The **K II** Series comes with a parallel shaft type in motor frame sizes 60mm (2.36 in.) to 90mm (3.54 in.), as well as a hypoid geared motor in frame sizes 80mm (3.15 in.) and 90mm (3.54 in.).

2.1. Features of the K II Series

The strength of the **K II** Series gearhead was increased in order to maximize the motor torque. The greatest characteristic of this gearhead is that the permissible torque has been improved by implementing the carburizing heat treatment and by enlarging bearing diameters. Comparing the permissible torque of the **K II** Series with that of the **K** Series, it has become 2 times greater with the parallel shaft gearheads and up to 3.5 times greater with the hypoid geared motors.

As a leading example of the difference in torque characteristics of the **K** and **K II** Series, the comparison of a maximum permissible torque at 90W (1/8 HP)is shown below. Figure 2 shows parallel shaft gearheads and Figure 3 shows hypoid geared motors. Because the permissible radial load and permissible axial load have improved, it is possible to reduce motor size by changing the existing motor to the **K II** Series motor (excluding certain motors).

The permissible radial load and permissible axial load at 25W (1/30 HP) are shown in Table 1 as an example. The permissible radial load indicates its maximum value and it varies depending on the gear ratio and shaft types.

(a) Parallel Shaft Type (b) Hypoid Geared Motor Hollow Shaft Type (c) Hypoid Geared Motor Solid Shaft Type

Figure 1 Exterior of the K II Series (Frame Size 90mm)

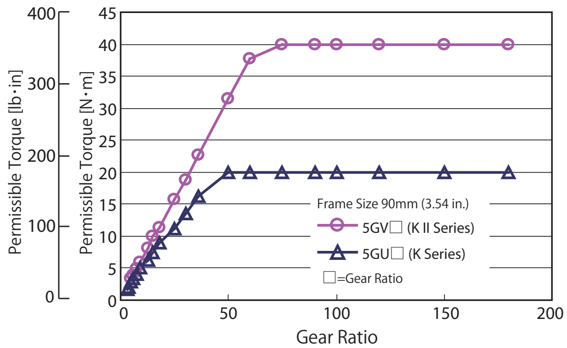

Figure 2 Comparison of Max. Permissible Torque of Parallel Shaft Gearhead 90W (1/8 HP)

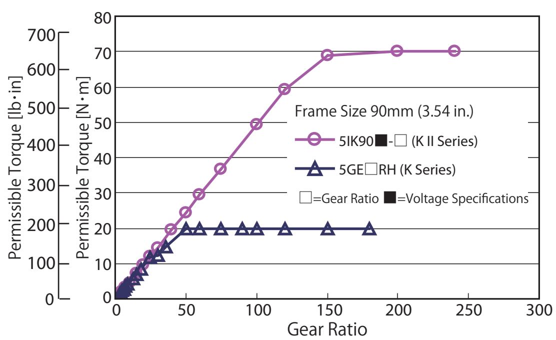

Figure 3 Comparison of Max. Permissible Torque of Hypoid Geared Motor 90W (1/8 HP)

Table 1 Permissible Radial Load and Permissible Axial Load of Frame Size 80mm (3.15 in)

	Parallel Shaft Gearhead Frame Size 80mm (3.15 in), 25W (1/30 HP)		Hypoid Geared Motor Frame Size 80mm (3.15 in), 25W (1/30 HP)	
	K Series	K II Series	K Series	K II Series
Permissible Radial Load [N] (lbs)	200 (45)	450 (101)	250 (56)	1200 (270)
Permissible Axial Load [N] (lbs)	50 (11)	100 (22)	100 (22)	300 (67)

*The value of the parallel shaft gearhead indicates the position at 10mm (0.30in) from the shaft end. The value of hypoid geared motor hollow shaft type indicates the position at 10mm (0.30in) measured from the installation surface.

2.2. Parallel Shaft Gearhead

By employing the carburizing heat treatment and larger bearing diameters, the **K II** Series parallel shaft gearhead has achieved a longer service life of 10,000 hours, which is twice as long as the K Series.

The structure of a parallel shaft gearhead is shown in Figure 4. For the **K** Series, a bearing was held with a bearing retainer plate and housing. In contrast, the **K II** Series does not have a housing, which was used to be supported by two bearing retainer plates. Instead, its structure was changed so that a bearing is directly held with a gear case and gear flange, enabling the bearing diameters to be enlarged.

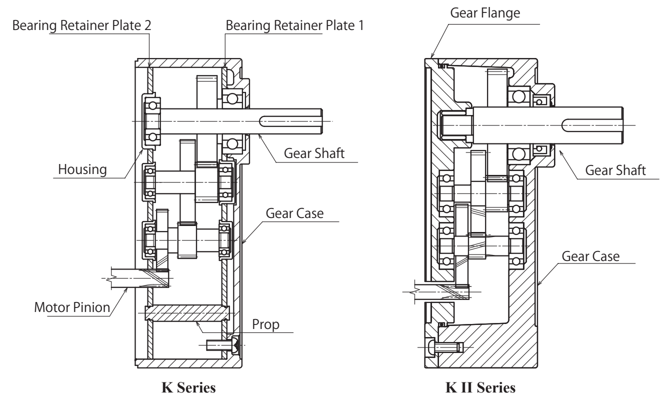

Figure 4 Structural Comparison of Parallel Shaft Gearheads

Also, the finishing treatment on the tooth surface is applied to some gears. Compared to the **K** Series, noise has been reduced up to approximately 6dB due to this additional treatment. Figure 5 shows the comparison of noise level at gear ratio 12.5 for 90W (1/8 HP) for the **K** and **K II** Series.

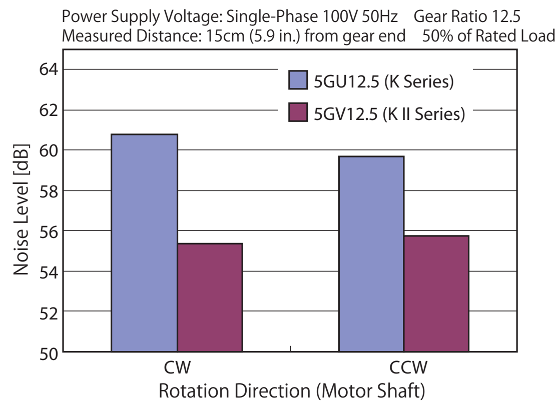

Figure 5 Noise Level Comparison of Parallel Shaft Gearhead 90W (1/8 HP)

3. Hypoid Geared Motor

A hypoid geared motor is often used in transportation devices, such as conveyors, and can save space, as opposed to a parallel shaft gearhead, because a motor can be mounted perpendicularly to the drive shaft.

3.1 Features of Hypoid Gear

Gears such as a worm gear, bevel gear and hypoid gear are available to configure a gearhead with a right-angle shaft.

The worm gear consists of a threaded worm and a worm wheel. It generates low noise. Because the movement between the worm and wheel gear faces is entirely sliding, the worm gear has a disadvantage of low transmission efficiency. Figure 6 shows a worm gear.

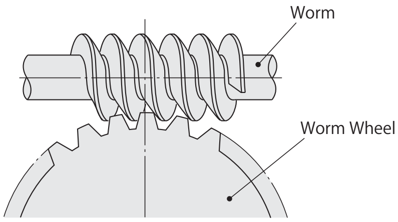

Figure 6 Worm Gear

The bevel gear works as the small and large gears intersect, and its mechanism achieves high transmission efficiency. There are different types of bevel gears such as a straight bevel gear, skew bevel gear and spiral bevel gear, and the latter one offers lower noise operations. Because the small and large gears intersect with one another, the structure of each shaft becomes cantilevered, resulting in lower strength for some gears. Figure 7 shows a spiral bevel gear.

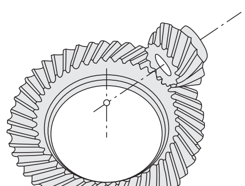

Figure 7 Spiral Bevel Gear

A hypoid gear is a gear type where the axis of the spiral bevel gear does not intersect with the axis of the meshing gear. It falls into an intermediate category of spiral bevel gears and worm gears. The pitch circle diameter of the small gear is larger than the spiral bevel gear and therefore, the small gear offers more strength and higher meshing ratio. Also, it is possible to increase the gear ratio by reducing the number of teeth on the small gear.

The areas where the two gears mesh slide extensively and it is extremely complicated to mesh, as well as to manufacture. However, because it has many advantages as previously indicated, it is used for power transmission on automobiles. Figure 8 shows a hypoid gear.

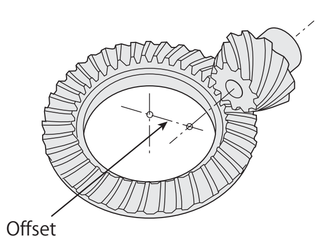

Figure 8 Hypoid Gear

3.2. Structure

As shown in Figure 9, the **K II** Series hypoid geared motor employs a hypoid gear at the motor shaft, which enables a larger gear to be used for the output shaft, resulting in an increase in torque. Also, gear stages can be reduced depending on the gear ratio.

As mentioned earlier, it is very difficult for hypoid gears to mesh and therefore, it is necessary to finely adjust the backlash and meshing position between the gears. For this reason, its structure is built in a manner that the motor and gearhead cannot be separated once they are assembled.

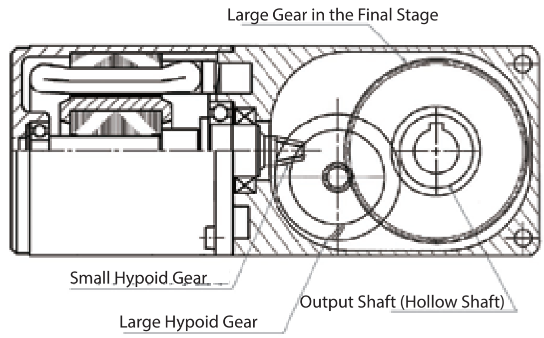

Figure 9 Structural Drawing of Hypoid Geared Motor

3.3. High Strength

In order to improve the strength of a geared motor, it is necessary to increase the strength of gears and the bearings that support the gears. The **K II** Series employs the following methods to achieve this:

3.3.1 Enlarged Gear Size

The most effective way to increase the gear strength is to use a larger gear. The **K II** Series' structure enables an enlarged gear to be used at the final stage by reducing the speed at the first and second stage, and bringing the output shaft at the center of a case.

3.3.2 Revision of Heat Treatment Method for Materials

The carburizing heat treatment is applied on gears that require high strength. It is a method to penetrate carbon on the surface of materials. By hardening only near the gear surface, it significantly improves the tooth-bending strength and surface pressure strength. An internal area where carbon concentration is low has less hardness and therefore, the gear becomes strong even with impact loads.

3.3.3. Employment of Skew Bevel Gear

Skew bevel gears are used at each stage. The meshing ratio was improved with this employment because the load share per gear is reduced, resulting in the gearhead's ability to handle larger loads. Also, by improving the gear accuracy and assembly precision, compared to conventional products, the tooth surface contact area has been increased, achieving higher strength.

3.3.4 Enlargement of Bearing Diameter

The largest possible bearings are used for a gear case with high rigidity and the housing of gear flange.

3.4. Sealing Structure

The lubricating property of the **K II** Series hypoid geared motor is a relatively soft mineral grease. As preventive measures for grease leakage, an O ring is installed at the contact surface between the gear case and gear flange, and oil seals are installed at the driving units of output shaft and motor shaft as shown in Figure 10.

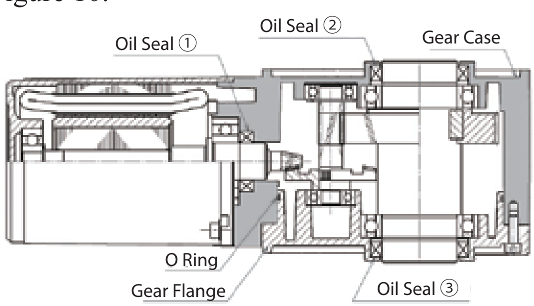

Figure 10 Sealing Structure of Hypoid Geared Motor

3.4.1 Oil Seal

There are two major causes of grease leakage from oil seals; one is due to worn lips, caused by frictional dust from the gear; the other is due to performance degradation caused by highly frequent bi-directional operation. In order to prevent the grease from leaking, highly reliable oil seals are installed in 3 areas including the I/O shaft, as shown in Figure 10.

1) Principle of Oil Seal (1)

The contact sliding surface of oil seals is required to stop leaking fluids, such as grease, while sliding relative to the the shaft surface. However, sliding surfaces abrade away when in direct contact with one another. In order to prevent this, oil films are placed between the two surfaces, sealing the gap tightly with the fluid lubrication. Figure 11 shows the sealing condition of an oil seal.

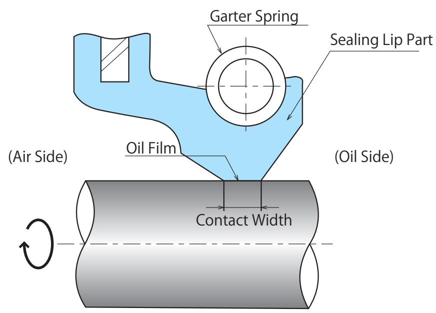

Figure 11 Oil Seal's Sealing Condition and Oil Film Formation

Angles of a sealing lip part differ between the air side and oil side. When the shaft starts to rotate, pressure occurs on the sliding surfaces depending on the angles and therefore, a very small amount of air is sucked in from the air side. This is called the oil seal pumping action. Figure 12 shows the lip part and suction direction.

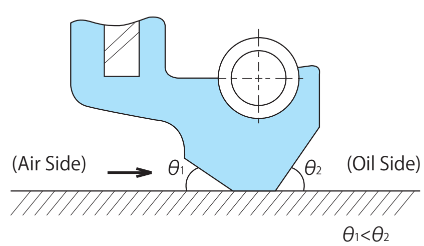

Figure 12 Angle of Lip Part and Direction of Air Suction

The seal performance under actual conditions is affected by the following conditions: surface roughness of the shaft, sliding speed, environment, temperature, pressure, and types and amounts of sealed fluids.

2) Employment of High Performance Oil Seal

Oil seals employed in the **K II** Series hypoid geared motor are equipped with the following lips; the primary sealing lip, which prevents grease from leaking with tension forces; the foreign object removal lip, which prevents frictional dust inside of the gear from entering; and the auxiliary lip, which prevents external foreign objects from entering. A cross section of an oil seal is shown in Figure 13.

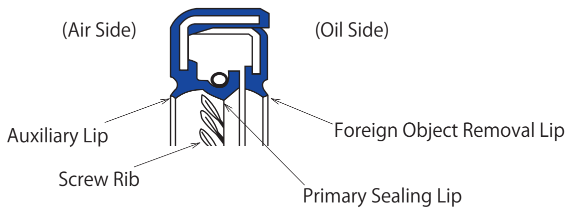

Figure 13 Cross Section of Oil Seal

A screw rib is placed on the employed oil seal in order to help improve the pump capacities. The pump capacity of an oil seal with a screw is shown in Figure 14. In addition to the initial pump capacity (Q1) at the sliding area of the lip end, this screw rib enhances the pump capacity (Q2). For this reason, it is used to improve resistance properties against environmental disturbance at the early stage of its usage.

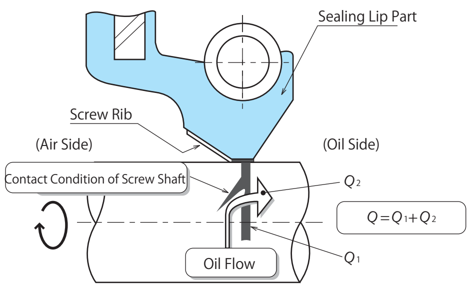

Figure 14 Pump Capacity of Oil Seal with a Screw

The comparison of pump capacities with and without a screw is shown in Figure 15. It indicates that the initial pump capacity of an oil seal is higher with a screw.

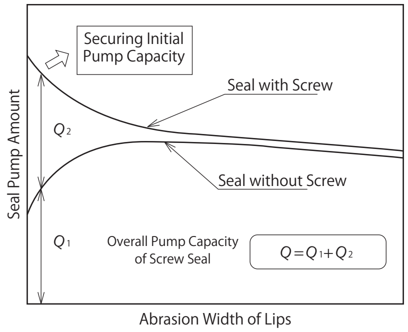

Figure 15 Comparison of Seal Pump Capacity with and without Screw

3.4.2 Countermeasures for Foreign Objects

If there is a foreign object inside of a gearhead, the object gets caught with the oil seal lip, which causes the lip to be damaged, resulting in a grease leak. For this reason, thorough cleansing is conducted to remove any foreign objects that may be adhered to parts.

3.4.3. Blocking Grease Pathway to Oil Seal

Because grease has a high fluidity, it is in direct contact with the oil seal when the gear parts rotate (Refer to Figure 16 (a)). When this continues, it becomes a cause for the grease to leak outside of the gearhead.

In order to prevent the grease from contacting the oil seal directly, the structure was designed to block the grease pathway by shortening the gap between the shaft and the case in a radial direction (Refer to Figure 16 (b)). This structural change protects against the grease leakage because only the fresh grease for the initial lubrication continues to remain in the oil seal area.

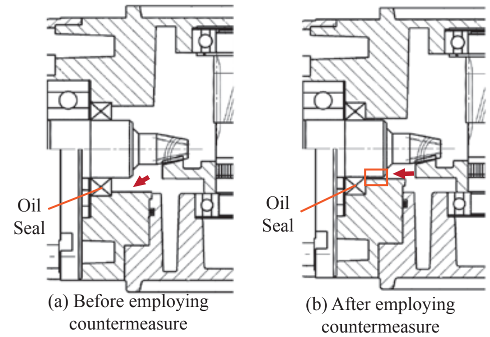

Figure 16 Blocking Structure of Grease Pathway

3.5. Installation

As shown in Figure 17, a hypoid geared motor has less side drop from the equipment compared to a parallel shaft gearhead. Also, connecting parts such as a coupling are not required when installing a hollow shaft type to an equipment. Therefore, this type can be used as a shaft-mounted gearhead.

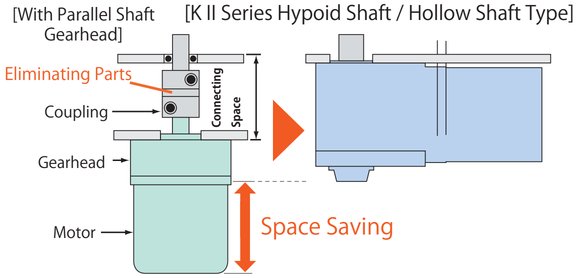

Figure 17 Installation Comparison of Parallel Shaft and Hollow Shaft

As shown in Figure 18, the **K II** Series hypoid geared motor is installed vertically, symmetrically centered around the output shaft. The measurements of vertical directions for the motor and gearhead are also the same. When installing onto a compact conveyor, as shown in Figure 19, the geared motor does not hang from the equipment because of its compact size.

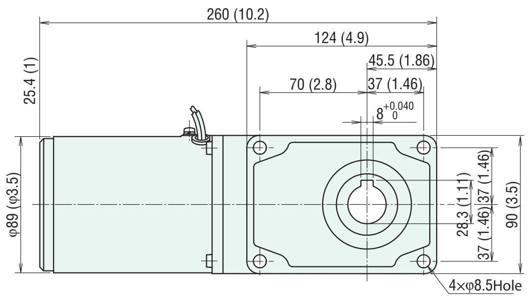

Figure 18 Diagram of K II Series Hypoid Geared Motor

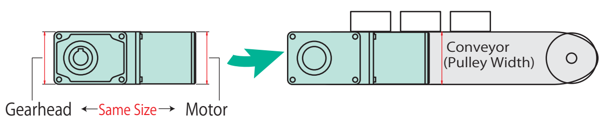

Figure 19 Installation Example to a Conveyor

The hollow shaft type can be installed on both sides of the output shaft. Even when an installation position is changed, as shown in Figure 20, it is possible to unify the lead wire outlet direction of the geared motor. Because one geared motor can be installed on any side - left, right, front or back side of the conveyor, it greatly expands the possibility of installation options. Also, an end tap has been integrated into the tip of the output shaft for the solid shaft type, and thus it can be used to help prevent the pulley from becoming detached.

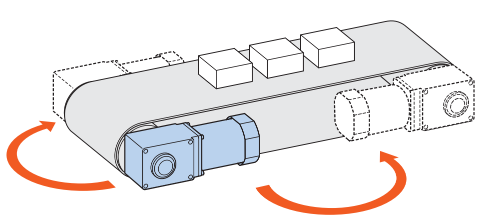

Figure 20 Greater Possibility of Installation Options

4. Summary

The **K II** Series has higher strength compared to the conventional **K** Series. The parallel shaft gearhead has achieved low noise and longer service life. Redesigning the structure of hypoid geared motors and employing new types of oil seals enabled the **K II** Series products to have a tight structure against grease leakage compared to the conventional products. Because its installation configuration was also thoroughly reviewed during the redesigning process, it can be installed in a compact manner.

Thanks to these changes, the **K II** Series will significantly contribute to high performance and save space for customers' equipment. Finally, we must thank NOK Corporation for letting us cite their literature in the explanations of "Principle of Oil Seal" in chapter 3.

Reference Literature:
(1) NOK Corporation "Easy to Understand Sealing Technology" (1999, pp22-31, Institute of Industrial Research)