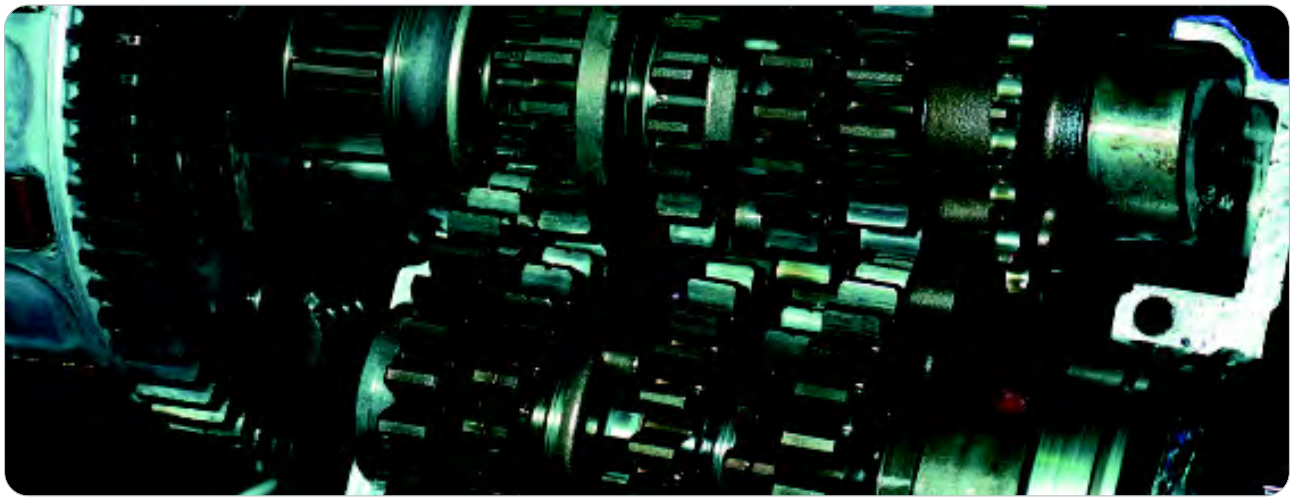
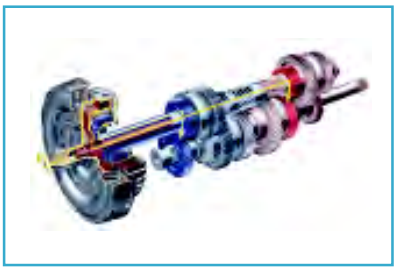


5. Gearboxes

Gearboxes are important subsystems in almost every industrial application. Together with the electrical motors (or with other prime movers) they form the drive train that is needed in most processes. Due to the variety of the existing applications, the industry requirements are the most diverse ranging from so called standard components up to the fully customized solutions that include advanced co-engineering.

Knowledge is power. HCH remains a driving force behind the gearbox industry through our research and close working relationships. We recognize that standard solutions are just as important as innovation. HCH gearbox bearing solutions minimize downtime and improve operational efficiency. But of course, no level of innovation is complete without technical support. Our gearbox specialists provide world-class assistance on everything from making bearing recommendations, to validating new gearbox designs, and even defusing crises on shop floors.



Innovation continuously increases the standard of technically based products. Technological leaps are getting greater - a development which is taking place in the gear construction sector.

General requirements for gearboxes

Optimized design and production

To be competitive, gear boxes must be designed to enable cost-effective design and production processes for the right level of performance. This requires an understanding of the gear boxes as a system. Only then can you evaluate the influence of a light alloy casing on gear and bearing behavior, for example, or the effect of contaminated lubrication on overall performance. HCH engineering capabilities can complement your own technical expertise throughout the design project.

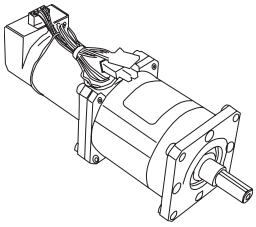
High performance

Demands on gearbox performance typically include high speeds under combined load on the input shaft and relatively heavy radial loads on the intermediate shaft. Not to mention external loads at low speed on the output shaft. Furthermore, the stiffness behavior of the complete system and the overall effects of an oil-splashed, contaminated lubrication are also highly demanded. Working together with HCH, you can achieve the enhanced performance by our expertise, from the analysis of your specific needs, to design optimization and verification in our virtual test rigs, and to analyzing gear box working conditions in the field.

Cost-effective

As the person working with or responsible for operations, your priority is to get maximum return on money invested. It takes high operational reliability, energy efficiency and minimal service requirements - throughout the life of the gear unit. To do this, you have to be able to focus on optimizing the drive system integrated in the process. This is true for all types of industrial processes, such as steelmaking, mining and cement, as well as for harbor cranes and movable bridges, for example.

5.1 Geared Motors



Manufactured in relatively high volumes, geared motors are designed to meet specific multipurpose demands, in applications like material handling, packaging machines and automation. Fierce competition in a global marketplace means that manufacturers must find ways to achieve more cost-effective design and production processes, while continuing to improve technical performance. Designing a more competitive geared motor is a challenging task. Demands on bearing arrangements typically include high speeds under combined loads on the input shaft and relatively heavy radial loads on the intermediate shaft. Equally important, you can optimize performance by increasing torque, decreasing heat and noise levels.

HCH has the unique capability to offer high-level engineering capabilities and high performance products. HCH offers a complete range of high performance bearings optimally suited for geared motors: deep groove ball bearings and tapered roller bearings. Working together with HCH, you can achieve the enhanced performance you are looking for by increasing torque and decreasing both heat generation and noise levels.

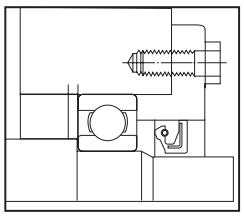
HCH bearings for gear motors

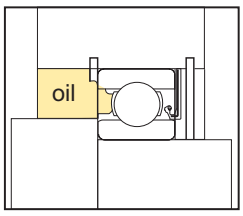
To meet our customers' strict demand for the bearings in geared motors, HCH provides bearings with following characteristics:

> Improved bearing internal sealing structure (for RS and 2RS type)
> Long-life high performance applied ultra clean bearing ma terial
> Low friction with precise bearing manufacturing process
> Optimized clearance for customized unique gear design

Oil leakage must be absolutely avoided in geared motors. This is a growing challenge since increasingly aggressive lubricants are being introduced, threatening reliable sealing performance. To meet the performance challenges, for sealed bearings, HCH has provided a variety of optimized bearing internal structure to prevent oil emission and dust invasion. Moreover, working with HCH, specific technical suggestions can be available from HCH expertise throughout your design project. For example, excellent external sealing structure to increase transmitted torque and decrease heat generation, or the lubricant selection to better oil compatibility.

Together, we can help increase torque or downsize, double the service life, aim for 100% operational reliability and improve energy efficiency.





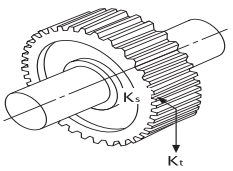
Note: When the oil seal and the bearing are in very close proximity, internal bearing clearances are sometimes too small to accommodate the additional heat generated by friction between the seal and shaft. Internal bearing clearances must also be selected with caution.

5.2 Planetary & Helical Gear Units

Small to medium planetary and helical gear units must meet the tough challenges of specific applications such as wheel drives in agriculture and construction vehicles; and slewing drives in construction equipment and wind turbines. They operate under heavy-duty cycles with heavy radial loads, shock loads and tilting movements. These gear units must provide reliable performance in highly contaminated conditions as well.

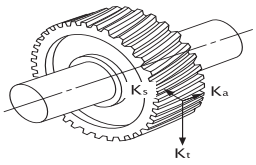
HCH bearings for planetary and helical gear units

The type and size of the bearings needed for a specific application are determined by the results of a life calculation carried out for the bearings. In close cooperation with gear manufacturers, based on extensive testing, HCH has developed calculation methods and programs that are among the most advanced in the rolling bearing industry for planetary and helical gear units.



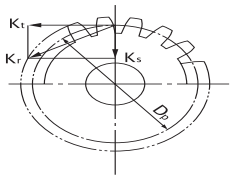
The loads operating on gears can be divided into three main types according to the direction in which the load is applied; i.e. tangential (Kt), radial (Ks), and axial (Ka). Loads acting on planetary shaft gears are depicted in the pictures.The load magnitude can be found by using or formulas:

$$K_t = \frac{19.1\times10^6 \cdot H}{D_p \cdot n}\ N \quad = \frac{1.95\times10^6 \cdot H}{D_p \cdot n}\ kgf$$



$$K_s = K_t \cdot \tan\alpha \ \text{(Spur gear)} = K_t \cdot \frac{\tan\alpha}{\cos\beta} \ \text{(Helical gear)}$$

$$K_r = \sqrt{K_t^2 + K_s^2} \qquad K_a = K_t \cdot \tan\beta \ \text{(Helical gear)}$$



where,

K_t : Tangential gear load (tangential force), N
K_s : Radial gear load (separating force), N
K_r : Right angle shaft load (resultant force of tangential force and separating force), N
K_a : Parallel load on shaft, N
H : Transmission force , kW
n : Rotational speed, r/min
D_p : Gear pitch circle diameter, mm
α : Gear pressure angle
β : Gear helix angle

Because the actual gear load also contains vibrations and shock loads as well, the theoretical load obtained by the above formula should also be adjusted by the gear factor fz as shown in the table below:

Gear factor fz

Gear type	fz
Precision ground gears (Pith and tooth profile errors of less than 0.02mm)	1.05~1.1
Ordinary machined gears (Pith and tooth profile errors of less than 0.1mm)	1.1~1.3

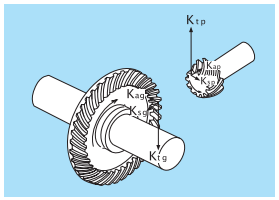
We will help you settle questions concerning the design of bearing mating components, lubrication and sealing, mounting and dismounting, etc.

5.3 Bevel & Bevel-helical Gear Units

Bevel and bevel-helical gear units are designed for tough applications such as mining conveyors, paper mills, extruders, continuous casters or harbour cranes. They must provide high operational reliability in harsh conditions such as hot, humid and dusty environments, at very low speed and with heavy loads.

HCH bearings for bevel and bevel-helical gear units

By applying a systematic approach and modular thinking, HCH has developed advanced load and life calculation ways for bevel and bevel-helical gear units. Gear loads acting on straight tooth bevel gears and spiral bevel gears on cross shafts are shown in the pictures on the left side. In general, the relationship between the gear load and the pinion gear load, due to the right angle intersection of the two shafts, is as follows:



Loads on bevel gears

$K_{sp} = K_{ag}$

$K_{ap} = K_{sg}$

where,

K_{sp}, K_{sg}: Pinion and gear separating force, N

K_{ap}, K_{ag}: Pinion and gear axial load, N

The calculation methods for these gear loads are shown in table as following:

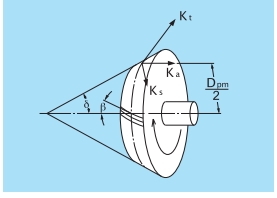
Pinion	Rotation direction	Clockwise	Counter clockwise	Clockwise	Counter clockwise
	Helix direction	Right	Left	Left	Right
Tangential load K_t		$K_t = \frac{19.1 \times 10^6 \cdot H}{D_{pm} \cdot n}$	$\left\{ \frac{1.95 \times 10^6 \cdot H}{D_{pm} \cdot n} \right\}$		
Straight[1] bevel gears — Separating force K_s	Driving side	$K_s = K_t \left[\tan\alpha \frac{\cos\delta}{\cos\beta} \right]$			
Straight[1] bevel gears — Axial load K_a	Driven side	$K_a = K_t \left[\tan\alpha \frac{\sin\delta}{\cos\beta} \right]$			
Spiral[1),2)] bevel gears — Separating force K_s	Driving side	$K_s = K_t \left[\tan\alpha \frac{\cos\delta}{\cos\beta} + \tan\beta \sin\delta \right]$		$K_s = K_t \left[\tan\alpha \frac{\cos\delta}{\cos\beta} - \tan\beta \sin\delta \right]$	
	Driven side	$K_s = K_t \left[\tan\alpha \frac{\cos\delta}{\cos\beta} - \tan\beta \sin\delta \right]$		$K_s = K_t \left[\tan\alpha \frac{\cos\delta}{\cos\beta} + \tan\beta \sin\delta \right]$	
Spiral[1),2)] bevel gears — Axial load K_a	Driving side	$K_a = K_t \left[\tan\alpha \frac{\sin\delta}{\cos\beta} - \tan\beta \cos\delta \right]$		$K_a = K_t \left[\tan\alpha \frac{\sin\delta}{\cos\beta} + \tan\beta \cos\delta \right]$	
	Driven side	$K_a = K_t \left[\tan\alpha \frac{\sin\delta}{\cos\beta} + \tan\beta \cos\delta \right]$		$K_a = K_t \left[\tan\alpha \frac{\sin\delta}{\cos\beta} - \tan\beta \cos\delta \right]$	

where,

D_{pm} :Mean pitch circle diameter, mm

δ :Pitch cone angle

Herein, to calculate gear loads for straight bevel gears, the helix angle $\beta = 0$.

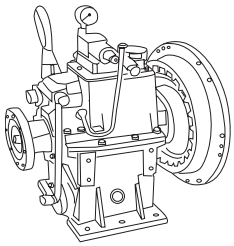


Bevel gear diagram

For spiral bevel gears, the direction of the load varies depending on the direction of the helix angle, the direction of rotation, and which side is the driving side or the driven side. The directions for the separating force (Ks) and axial load (Ka) shown in the left picture are positive directions. The direction of rotation and the helix angle direction are defined as viewed from the large end of the gear. The gear rotation direction in the picture is assumed to be clockwise (right).

As a rule, design engineers have only a few months to develop a new gear. Usually there is no opportunity to test a gear under field conditions before it is delivered to a customer. That is why the support of HCH is of particularly great importance.

5.4 Customized gear units



Large, customized gear units are tailored to the specific demands within industries such as cement, steel, mineral processing, wind power and traditional power generation. The tough operating conditions can include high torque, heavy external loads, shock loads, high environmental contamination and varying speeds. Reliability and performance are crucial, placing strong demands on the design process. Worth to mention, until now, an increasing precision of calculation methods, constantly increasing computing power and improved technological know-how - e.g. in the fields of materials technology, strength and tribology - have utilized reserve capacities: the gear-weight/driving-torque ratio has been reduced by 80% over the last 20 years.

HCH bearings for customized gear units

HCH offers high-level engineering capabilities and high performance products, both standard and special executions for specific positions by understanding your demands of:

>High operational reliability
>High load carrying capacity
>Low friction
>Exact radial and axial guidance of the shafts for exact meshing

Our goal is to work together with you to discover the golden opportunities in your gear unit designs - whatever the industry or type of gear unit.

What is more, HCH offers the unique ability to combine high-level engineering services with high performance products and condition monitoring systems. HCH rolling bearings have contributed considerably to current developments. Through targeted research and development, constant increases in quality and an intensive exchange of experience with gear manufacturers and users, we have increased our bearings' functionality and operational reliability and at the same time minimized power losses. Gearboxes that are fitted with high-quality rolling bearings have become generally more efficient and more reliable, and as a result more competitive.

Oil leakage is a common problem in many oil-lubricated machines, including gear motors. It lowers the machine's perceived quality. It can cause environmental contamination and in the long run it can cause the machine to run without lubricant. Many efforts are spent by HCH engineers to design effective oil sealing systems that could cope with the following parameters:

> Space and weight constraints
> Chemical aggressivity of additivated oils (that can cause premature ageing of many rubber materials)
> Relatively high temperatures
> Pressure differentials (that can deformate the seal and make it ineffective)
> Shaft displacements and deflection
> Shaft hardness and surface finishing
> Assembling methods