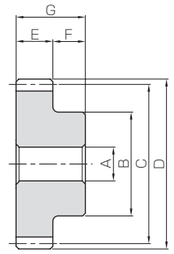
Specifications	
Precision grade	JIS grade N8 (JIS B1702-1: 1998)
Gear teeth	Standard full depth
Pressure angle	20°
Material	SCM440
Heat Treatment	Thermal refining only
Tooth hardness	225 to 285HB
Surface treatment	Black oxide coating



S1

To order Hardened Plus, please specify Catalog No. + H.

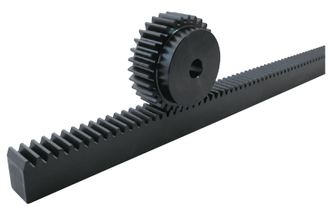
Catalog Number	Module	No. of teeth	Shape	Bore A_{H7}	Hub dia. B	Pitch dia. C	Outside dia. D	Face width E	Hub width F	Total Length G	Allowable torque (N·m) Bending strength	Allowable torque (N·m) Surface durability	Allowable torque (kgf·m) Bending strength	Allowable torque (kgf·m) Surface durability
KKS1.5-20	***m*1.5**	20	S1	8	24	30	33	15	14	29	37.2	7.38	3.79	0.75
KKS1.5-25		25			30	37.5	40.5				50.2	12.6	5.12	1.29
KKS1.5-30		30		10	38	45	48				63.4	19.7	6.47	2.01
KKS2-20	***m*2**	20	S1	12	32	40	44	20	16	36	88.1	18.1	8.98	1.84
KKS2-25		25			40	50	54				119	30.9	12.1	3.15
KKS2-30		30			50	60	64				150	48.3	15.3	4.92
KKS2.5-20	***m*2.5**	20	S1	15	40	50	55	25	18	43	172	36.2	17.5	3.69
KKS2.5-25		25			50	62.5	67.5				232	62.0	23.7	6.32
KKS2.5-30		30			65	75	80				294	96.7	29.9	9.86
KKS3-20	***m*3**	20	S1	15	50	60	66	30	20	50	297	63.8	30.3	6.51
KKS3-25		25		20	60	75	81				401	109	40.9	11.2
KKS3-30		30			75	90	96				507	171	51.7	17.4
KKS4-20	***m*4**	20	S1	20	65	80	88	40	25	65	705	156	71.9	16.0
KKS4-25		25			80	100	108				951	268	97.0	27.4
KKS4-30		30			90	120	128				1203	419	123	42.7
KKS5-20	***m*5**	20	S1	22	82	100	110	50	25	75	1377	314	140	32.0
KKS5-25		25		25	105	125	135				1858	538	189	54.9
KKS5-30		30			120	150	160				2349	841	240	85.8

Backlash (mm)	Weight (kg)	Catalog Number
0.10~0.22	0.12	**KKS1.5-20**
	0.20	**KKS1.5-25**
	0.29	**KKS1.5-30**
0.12~0.26	0.27	**KKS2-20**
	0.43	**KKS2-25**
	0.66	**KKS2-30**
0.14~0.28	0.50	**KKS2.5-20**
	0.82	**KKS2.5-25**
	1.28	**KKS2.5-30**
0.14~0.32	0.90	**KKS3-20**
	1.36	**KKS3-25**
	2.07	**KKS3-30**
0.18~0.38	2.07	**KKS4-20**
	3.29	**KKS4-25**
	4.64	**KKS4-30**
0.20~0.44	3.90	**KKS5-20**
	6.23	**KKS5-25**
	8.87	**KKS5-30**

[Caution on Product Characteristics]
① The allowable torques shown in the table are calculated values according to the assumed usage conditions. Please see Page 24 for more details.
② The backlash values shown in the table are the theoretical values for the backlash in the normal direction of a pair of identical gears in mesh.

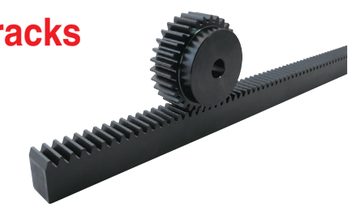
[Caution on Secondary Operations]
① Please read "Cautions on Performing Secondary Operations" (Page 26) when performing modifications and/or secondary operations for safety concerns.
② Avoid performing secondary operations that narrow the tooth width, as it affects precision and strength.

KKS-H Hardened Spur Gear recommended mating racks



KKRF-H/KKRFD-H Hardened Racks

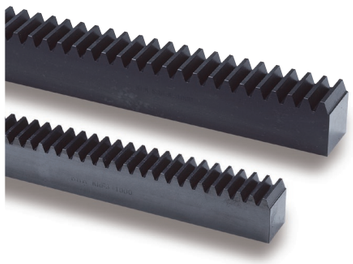
KKS Thermal Refined Spur Gear recommended mating racks



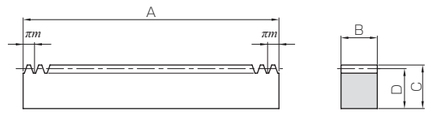
KKRF/KKRFD Thermal Refined Racks

Hardened Racks

J Series



Specifications	
Precision grade	KHK R 001 grade 5 ＊
Gear teeth	Standard full depth
Pressure angle	20°
Material	SCM440
Heat treatment	Thermal refined, teeth induction hardened
Tooth hardness	50 ～ 60HRC ＊＊
Surface treatment	Black oxide coating



RF

＊ The precision grade of J Series products is equivalent to the value shown in the table.
＊＊ Due to the decarburization layer of about 0.5 mm thickness, the rectangular surface have (less than HB187) hardness.

Catalog No.	Module	No. of teeth	Shape	Total length	Face width	Height	Height to pitch line	Allowable force (N)		Allowable force (kgf)		Weight
				A	B	C	D	Bending strength	Surface durability	Bending strength	Surface durability	(kg)
KKRF1.5-1000H	***m*1.5**	212	RF	999.03	15	20	18.5	3140	1710	320	175	2.18
KKRF2-1000H	***m*2**	160		1005.31	20	25	23	5570	3090	568	315	3.63
KKRF2.5-1000H	***m*2.5**	128		1005.31	25	30	27.5	8710	4890	888	499	5.43
KKRF3-1000H	***m*3**	106		999.03	30	35	32	12500	7110	1280	725	7.53
KKRF4-1000H	***m*4**	80		1005.31	40	45	41	22300	12900	2270	1310	12.9
KKRF5-1000H	***m*5**	64		1005.31	50	50	45	34800	20400	3550	2080	17.8

Catalog No. ● : J Series (Available-on-request)	Module	No. of teeth	Shape	Total length	Face width	Height	Height to pitch line	Mounting hole dimensions			No. of mounting holes	Mounting screw size
				A	B	C	D	E	F	G		
●**KKRFD1.5-1000HJ**	***m*1.5**	212	RD	999.03	15	20	18.5	8	49.51	180	6	M5
●**KKRFD2-1000HJ**	***m*2**	160		1005.31	20	25	23	10	52.65	180	6	M6
●**KKRFD2.5-1000HJ**	***m*2.5**	128		1005.31	25	30	27.5	12	52.65	180	6	M8
●**KKRFD3-1000HJ**	***m*3**	106		999.03	30	35	32	14	49.51	180	6	M10
●**KKRFD4-1000HJ**	***m*4**	80		1005.31	40	45	41	18	52.65	180	6	M12
●**KKRFD5-1000HJ**	***m*5**	64		1005.31	50	50	45	20	62.65	220	5	M14

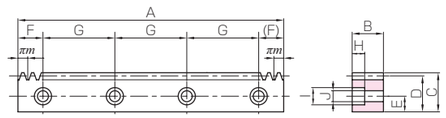
[Caution on Product Characteristics]
① The allowable forces shown in the table are the calculated values according to the assumed usage conditions. Please see Page 190 for more details.
② The backlash of racks differ depending on the size of the mating pinion. Please calculate the backlash from the backlash value of the mating pinion. Also, please refer to the data in the section called 'Backlash of Rack Tooth (Amount of Tooth Thinning)' on Page 193.

[Caution on Secondary Operations]
① Please read "Caution on Performing Secondary Operations" (Page 194) when performing modifications and/or secondary operations for safety concerns.
② Due to the gear teeth being induction hardened, no secondary operations can be performed on tooth areas including the bottom land (approx. 2 mm to 3 mm). Please use wire EDM or other carbide tools to modify the length.

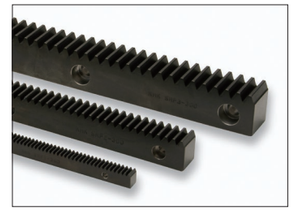
[Caution on J series]
① As available-on-request products, requires a lead-time for shipping within 2 working-days (excludes the day ordered), after placing an order. Please allow additional shipping time to get to your local distributor.
② Number of products we can process for one order is 1 to 20 units. For quantities of 21 or more pieces, we need to quote price and lead time.
③ No black oxide is re-applied after adding secondary operation of adding mounting holes.

J Series

Hardened Racks



RD

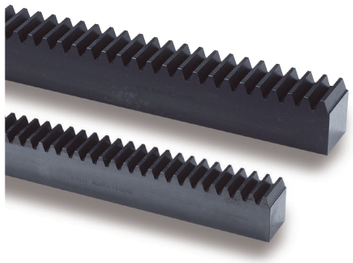


Counterbore dimensions			Allowable force (N)		Allowable force (kgf)		Weight	Catalog No.
H	I	J	Bending strength	Surface durability	Bending strength	Surface durability	(kg)	● : J Series (Available-on-request)
6	10	6	3140	1710	320	175	2.14	●**KKRFD1.5-1000HJ**
7	11	7	5570	3090	568	315	3.58	●**KKRFD2-1000HJ**
8.6	14	9	8710	4890	888	499	5.31	●**KKRFD2.5-1000HJ**
10.8	17.5	11	12500	7110	1280	725	7.32	●**KKRFD3-1000HJ**
13	20	14	22300	12900	2270	1310	12.6	●**KKRFD4-1000HJ**
15.2	23	16	34800	20400	3550	2080	17.2	●**KKRFD5-1000HJ**

Recommended Mating Pinions

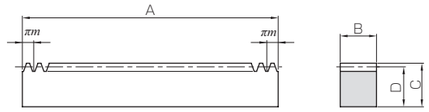
KKS-H Hardened Spur Gears

Thermal Refined Racks with Machined Ends J Series



Specifications	
Precision grade	KHK R 001 grade 4 ＊
Gear teeth	Standard full depth
Pressure angle	20°
Material	SCM440
Heat treatment	Thermal refining only
Tooth hardness	225 ～ 285HB ＊＊
Surface treatment	Black oxide coating

＊ The precision grade of these products is equivalent to the value shown in the table.
＊＊ Due to the decarburization layer of about 0.5 mm thickness, the rectangular surface have (less than HB187) hardness.



RF

Catalog No.	Module	No. of teeth	Shape	Total length	Face width	Height	Height to pitch line	Allowable force (N)		Allowable force (kgf)		Weight
				A	B	C	D	Bending strength	Surface durability	Bending strength	Surface durability	(kg)
KKRF1.5-500 **KKRF1.5-1000**	***m*1.5**	106 212	RF	499.51 999.03	15	20	18.5	3450	953	352	97.2	1.09 2.18
KKRF2-500 **KKRF2-1000**	***m*2**	80 160	RF	502.65 1005.31	20	25	23	6130	1760	625	179	1.82 3.63
KKRF2.5-500 **KKRF2.5-1000**	***m*2.5**	64 128	RF	502.65 1005.31	25	30	27.5	9580	2810	977	287	2.71 5.43
KKRF3-500 **KKRF3-1000**	***m*3**	53 106	RF	499.51 999.03	30	35	32	13800	4120	1410	421	3.76 7.53
KKRF4-500 **KKRF4-1000**	***m*4**	40 80	RF	502.65 1005.31	40	45	41	24500	7530	2500	768	6.47 12.9
KKRF5-500 **KKRF5-1000**	***m*5**	32 64	RF	502.65 1005.31	50	50	45	38300	12000	3910	1220	8.88 17.8

Catalog No. ● : J Series (Available-on-request)	Module	No. of teeth	Shape	Total length	Face width	Height	Height to pitch line	Mounting hole dimensions			No. of mounting holes	Mounting screw size
				A	B	C	D	E	F	G		
●**KKRFD1.5-500J** ●**KKRFD1.5-1000J**	***m*1.5**	106 212	RD	499.51 999.03	15	20	18.5	8	24.76 49.51	150 180	4 6	M5
●**KKRFD2-500J** ●**KKRFD2-1000J**	***m*2**	80 160		502.65 1005.31	20	25	23	10	26.33 52.65	150 180	4 6	M6
●**KKRFD2.5-500J** ●**KKRFD2.5-1000J**	***m*2.5**	64 128		502.65 1005.31	25	30	27.5	12	26.33 52.65	150 180	4 6	M8
●**KKRFD3-500J** ●**KKRFD3-1000J**	***m*3**	53 106		499.51 999.03	30	35	32	14	24.76 49.51	150 180	4 6	M10
●**KKRFD4-500J** ●**KKRFD4-1000J**	***m*4**	40 80		502.65 1005.31	40	45	41	18	26.33 52.65	150 180	4 6	M12
●**KKRFD5-500J** ●**KKRFD5-1000J**	***m*5**	32 64		502.65 1005.31	50	50	45	20	31.33 62.65	220	3 5	M14

Counterbore dimensions			Allowable force (N)		Allowable force (kgf)		Weight	Catalog No.
H	I	J	Bending strength	Surface durability	Bending strength	Surface durability	(kg)	● : J Series (Available-on-request)
6	10	6	3450	953	352	97.2	1.07 2.14	●**KKRFD1.5-500J** ●**KKRFD1.5-1000J**
7	11	7	6130	1760	625	179	1.78 3.58	●**KKRFD2-500J** ●**KKRFD2-1000J**
8.6	14	9	9580	2810	977	287	2.64 5.31	●**KKRFD2.5-500J** ●**KKRFD2.5-1000J**
10.8	17.5	11	13800	4120	1410	421	3.63 7.32	●**KKRFD3-500J** ●**KKRFD3-1000J**
13	20	14	24500	7530	2500	768	6.21 12.6	●**KKRFD4-500J** ●**KKRFD4-1000J**
15.2	23	16	38300	12000	3910	1220	8.56 17.2	●**KKRFD5-500J** ●**KKRFD5-1000J**

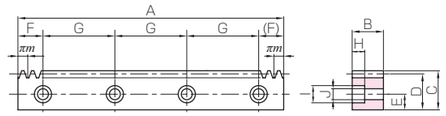
[Caution on Product Characteristics]
① The allowable forces shown in the table are the calculated values according to the assumed usage conditions. Please see Page 190 for more details.
② The backlash of racks differ depending on the size of the mating pinion. Please calculate the backlash from the backlash value of the mating pinion. Also, please refer to the data in the section called 'Backlash of Rack Tooth (Amount of Tooth Thinning)' on Page 193.

[Caution on Secondary Operations]
① Please read "Caution on Performing Secondary Operations" (Page 194) when performing modifications and/or secondary operations for safety concerns. KHK Quick-Mod Gears, the KHK's system for quick modification of KHK stock gears is also available.
② If gear tooth hardening, or thermal refining, is applied, the decarburization layer (approx. 0.5 mm thickness) on the rectangular surfaces cannot have the hardness you designate.

[Caution on J series]
① As available-on-request products, requires a lead-time for shipping within 2 working-days (excludes the day ordered), after placing an order. Please allow additional shipping time to get to your local distributor.
② Number of products we can process for one order is 1 to 20 units. For quantities of 21 or more pieces, we need to quote price and lead time.
③ No black oxide is re-applied after adding secondary operation of adding mounting holes.

J Series

Thermal Refined Racks



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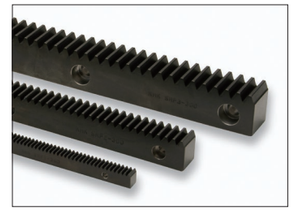
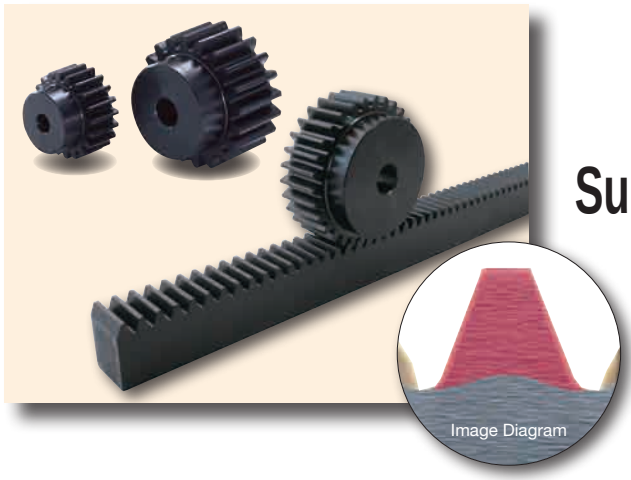


Recommended Mating Pinions

KKS Thermal Refined Steel Spur Gears

New Product



Hardened Plus compatible products
SS/SSA/SSCP Spur Gears
KS/KSSCP Thermal Refined Spur Gears

Surface hardening comes as standard.

The surface durability is increased **about 4 times** with Hardened Plus.
Ideal as a mating pinion for hardened racks (H Series) and laser hardened racks (HL Series).
Use to improve the durability of gears.

Hardened Plus

Hardening is provided additionally to standard products when ordered.
Products with (H) at the end of the Catalog No. support Hardened Plus.

Quick delivery, hardening completed in 4 working days

Gear tooth induction hardening is completed in 4 working days excluding the day the order is placed.

The surface durability is increased about 4 times

The surface durability is increased **about 4 times**.

Product unit price + hardening unit price

The hardening unit price is added to the product unit price.
For details, please see the table below.

Catalog No. + H
is the order method.

Example: Catalog No.: SS3-20, when hardening is added
⇒ SS3-20H

Induction hardening specification

Area: Tooth surface hardening
Hardness: HRC50 to 60
Depth: 1 mm or more

Hardness and depth of gear-teeth induction hardening

The hardening method and the state of the hardened teeth area vary depending on the size of gears.
The hardening depth is where the Vickers hardness from the tooth surface to the deep area is up to HV450 (from JIS G 0559: 2008).
Note that hardening specifications of Hardening Plus above will be near the standard pitch diameter of the gear.

Note 1: The surface durability values shown in the table are calculated values according to the assumed usage conditions. Please calculate the actual surface durability in the KHK Web Catalog.
Note 2: The gear precision decreases by about one grade after hardening.
The bore dimension tolerance H7 will also be ungraded.
Note 3: Black oxide processing cannot be performed again after hardening.

Selection Hints

Please select the most suitable products by carefully considering the characteristics of items and contents of the product tables. It is also important to read all applicable "CAUTION" notes shown below before the final selection.

1. Caution in Selecting the Mating Gears

① Basically, all spur gears, internal gears and racks can be paired as long as the module and pressure angle match. Products with different materials, tooth widths, or methods of cutting the teeth can be mated.

② When using a pinion with an internal gear with a small difference in the numbers of teeth, there are possibilities of involute interference, trochoid interference and trimming interference. See the internal gear interference portion of the technical section to avoid problems in assembling these items. (Page 182)

2. Caution in Selecting Gears Based on Gear Strength

The gear strength values shown in the product pages were computed by assuming a certain application environment. Therefore, they should be used as reference only. We recommend that each user computes their own values by applying the actual usage conditions. Also, KSUSF F-loc hub spur gears, KDSF F-loc hub spur gears and various F series that use the friction coupling method to fasten the gear shaft need addi-tional consideration for starting torque. The table below contains the assumptions established for various products in order to compute gear strengths.

■ Calculation of Bending Strength of Gears

Item \ Catalog Number	KMSGA KMSGB	KSSGS	KSSG KSSAG	KSSS,KSS KSSA,KSSY KSSAY,KSSR	KSUS KSUSA KSUSF	KBSS	KKSG	KKS	KNSU	KPU KPS KPSA	KDSF KDS
Formula NOTE 1	Formula of spur and helical gears on bending strength (JGMA401-01)								The Lewis formula		
No. of teeth of mating gears	Same number of teeth (30 for KSSGS, KSSS, KSSR)						Racks		—		
Rotational speed	600rpm			100rpm					100 rpm		
Design life (durability)	Over 10^7cycles								—		
Impact from motor	Uniform load								Allowable bending stress (kgf/mm²)		
Impact from load	Uniform load								1.38 (40℃ with No Lubrication)	1.15 (40℃ with No Lubrication)	*m* 0.5 4.0 *m* 0.8 4.0 *m* 1.0 3.5 (40℃ with Grease Lubrication)
Direction of load	Bidirectional										
Allowable bending stress at root σ_{Flim} (kgf/mm²) NOTE 2	47	24.5	19 (24.5) Note 3	19 (24.5) Note 4	10.5	4	30	32			
Safety factor S_F	1.2										

■ Calculation of Surface Durability (Except where it is common with bending strength)

Item								
Formula NOTE 1	Formula of spur and helical gears on surface durability (JGMA402-01)							
Kinematic viscosity of lubricant	100cSt(50℃)							
Gear support	Symmetric support by bearings Note 5						Supported on one end	
Allowable Hertz stress σ_{Hlim} (kgf/mm²)	166	99	90 (62.5) Note 3	49 (62.5) Note 4	41.3	—	112	79
Safety factor S_H	1.15							

[NOTE 1] The gear strength formula is based on JGMA (Japanese Gear Manufacturers Association) specifications, "MC Nylon Technical Data" by Nippon Polypenco Limited and "Duracon Gear Data" by Polyplastic Co. The units for the rotational speed (rpm) and the stress (kgf/mm²) are adjusted to the units needed in the formula.

[NOTE 2] The allowable bending stress at the root σ_{Flim} is calculated from JGMA401-01, and set to 2/3 of the value in the consideration of the use of planetary-, idler-, or other gear systems, loaded in both directions.

[NOTE 3] For KSSG Ground Spur Gears, with module 0.8 or less, thermal refining is applied. Allowable bending stress and allowable hertz stress values are shown in parentheses.**[NOTE 4]** For KSSS Spur Pinion Shafts, with module over 1.5, tooth induction hardening is not applied. Allowable bending stress and allowable hertz stress values are shown in parentheses.

[NOTE 5] KSSS Spur Pinion Shafts with module 1 or less (KSA configuration) are set to cantilever support as they are single shaft types.

When selecting KHK standard gears, glance over the Cautions on Product Characteristics and Cautions on Performing Secondary Operations in the respective dimension tables.

① Products not listed in this catalog or materials, modules, number of teeth and the like not listed in the dimensional tables can be manufactured as custom items. Please see Page 16 for more details about custom-made orders.

② The color and shape of the product images listed on the dimension table page of each product may differ from the actual product. Be sure to confirm the shape in the dimension table before selection.

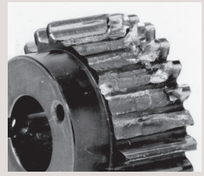
③ The details (specifications, dimensions, prices, etc.) listed in the catalog may be changed without prior notice. Changes are announced on the KHK website.

The most important factor in selecting gears is the gear strength.

Step 1 **Determine the actual load torque applied to the gear and the gear type suitable for the purpose.**

■ Definition of Bending Strength of Gears

The allowable bending strength of a gear is defined as the allowable tangential force at the pitch circle based on the mutually allowable root stress of two meshing gears under load.



Example of failure due to insufficient bending strength

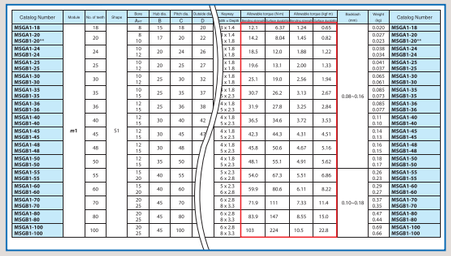
■ Definition of Surface Durability

The surface durability of a gear is defined as the allowable tangential force at the pitch circle, which permits the force to be transmitted safely without incurring surface failure. The allowable gear tooth load of a gear is defined as the allowable tangential force at the pitch circle based on the mutual gear tooth strength of two meshing gears under load.

Example of wear due to insufficient surface durability

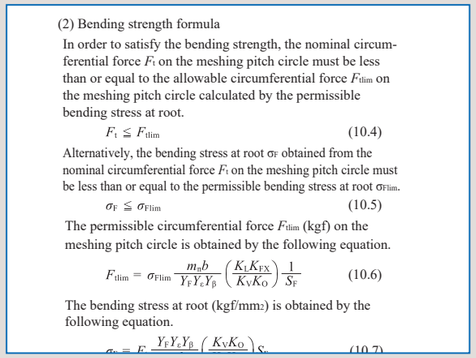
Step 2 **Select provisionally from the allowable torque table of the Master Catalog based on the load torque.**

■ For provisional selection from the Master Catalog



Step 3 **We recommend that each user computes their own values by applying the actual usage conditions to determine the suitability of the gear strength.**

Calculate the strength formally using the various gear strength formulas.
Please see Page 71 of our technical reference book for more details.



(2) Bending strength formula

In order to satisfy the bending strength, the nominal circumferential force F_t on the meshing pitch circle must be less than or equal to the allowable circumferential force F_{tlim} on the meshing pitch circle calculated by the permissible bending stress at root.

$$F_t \leqq F_{tlim} \qquad (10.4)$$

Alternatively, the bending stress at root σ_F obtained from the nominal circumferential force F_t on the meshing pitch circle must be less than or equal to the permissible bending stress at root σ_{Flim}.

$$\sigma_F \leqq \sigma_{Flim} \qquad (10.5)$$

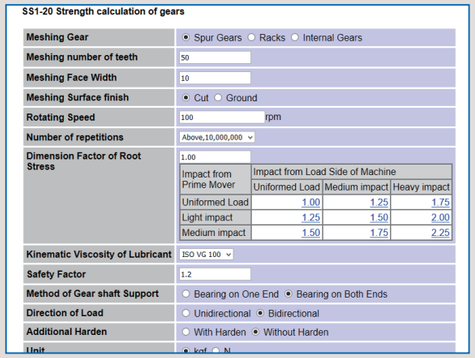
The permissible circumferential force F_{tlim} (kgf) on the meshing pitch circle is obtained by the following equation.

$$F_{tlim} = \sigma_{Flim} \frac{m_n b}{Y_F Y_\varepsilon Y_\beta} \left(\frac{K_L K_{FX}}{K_V K_O} \right) \frac{1}{S_F} \qquad (10.6)$$

The bending stress at root (kgf/mm2) is obtained by the following equation.

$$\sigma_F = F_t \frac{Y_F Y_\varepsilon Y_\beta}{} \left(\frac{K_V K_O}{} \right) S_F \qquad (10.7)$$

Strength confirmation is simple when using the website.



SS1-20 Strength calculation of gears

Meshing Gear	◉ Spur Gears ○ Racks ○ Internal Gears
Meshing number of teeth	50
Meshing Face Width	10
Meshing Surface finish	◉ Cut ○ Ground
Rotating Speed	100 rpm
Number of repetitions	Above,10,000,000
Dimension Factor of Root Stress	1.00

Impact from Prime Mover	Impact from Load Side of Machine		
	Uniformed Load	Medium impact	Heavy impact
Uniformed Load	1.00	1.25	1.75
Light impact	1.25	1.50	2.00
Medium impact	1.50	1.75	2.25

Kinematic Viscosity of Lubricant	ISO VG 100
Safety Factor	1.2
Method of Gear shaft Support	○ Bearing on One End ◉ Bearing on Both Ends
Direction of Load	○ Unidirectional ◉ Bidirectional
Additional Harden	○ With Harden ◉ Without Harden
Unit	◉ kgf ○ N

Application Hints

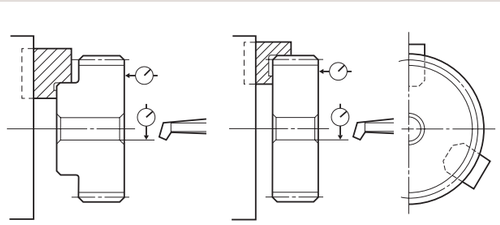
In order to use KHK stock gears safely, carefully read the Application Hints before proceeding.
If there are questions or you require clarifications, please contact our technical department or your nearest distributor.
TEL: (646) 396-GEAR FAX: (516) 437-6700 E-mail: qtcsupport@qtcgears.com

1. Cautions on Handling

① KHK products are packaged one by one to prevent scratches and dents, but if you find issues such as rust, scratches, or dents when the product is removed from the box after purchase, please contact the supplier.
② Depending on the handling method, the product may become deformed or damaged. Resin gears and ring gears deform particularly easily, so please handle with care.

2. Cautions on Performing Secondary Operations

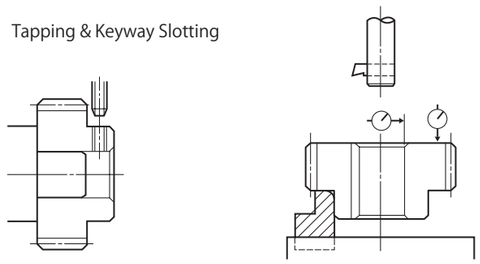
① If reboring, it is important to pay special attention to locating the center in order to avoid runout.
② The reference datum for gear cutting is the bore. Therefore, use the bore for locating the center. If it is too difficult to do for small bores, the alternative is to use one spot on the bore and the runout of the side surface.
③ If reworking using scroll chucks, we recommend the use of new or rebored jaws for improved precision. Please exercise caution not to crush the teeth by applying too much pressure. Any scarring will cause noise during operation.



Lathe Operations

④ The maximum bore size is dictated by the requirement that the strength of the hub is to be higher than that of the gear teeth. The maximum bore size should be 60% to 70% of the hub diameter (or tooth root diameter), and 50% to 60% for keyway applied modifications.
⑤ In order to avoid stress concentration, round the keyway corners.

Tapping & Keyway Slotting



⑥ To avoid problems of reduced gear precision and other manufacturing difficulties, do not attempt to machine the gears to reduce face widths.
⑦ When induction-hardening S45C products, thermal stress cracks may appear. Also, note that the precision grade of the product declines by 1 or 2 grades, as deformation on material may occur. If you require tolerance for bore or other parts, machining is necessary after heat treatment.

Induction Hardening

If you apply induction hardening to the gear teeth of S45C products, you need to designate the hardness and where to apply the heat treatment. Below is an example of common specifications and KHK's specifications for hardening:

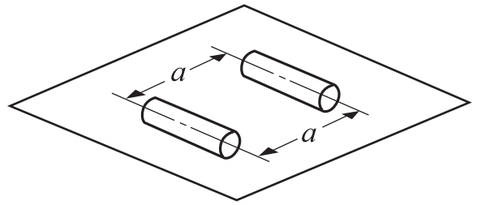
● Common Specifications for Heat Treatment
Hardening location: Gear tooth surface or tooth surface and tooth root
Hardness: Within the range of 45 to 60 HRC and 10 HRC width
(Example: 48 to 58 HRC)

● KHK's Specifications for Heat Treatment
Hardened location: Tooth surface, or Tooth surface and Tooth root
Hardness: 50 to 60 HRC

＊Hardness and Depth of Gear-teeth Induction Hardening
The hardening method and the state of the hardened teeth area vary depending on the size of gears.
Since different hardening treatment is applied in accordance with the module and number of teeth, the hardness level you designate is referred to as the hardness of the reference diameter. For some of our products, the hardness at tooth tip / root may not be equal to the hardness you designated.
As to the effective case depth for S45C, it is specified by JIS, as "The distance from the surface of the case to the area with hardness HV450." The case depth differs from area to area of a tooth.

3. Points of Caution during Assembly

① KHK stock spur gears are designed to give the proper backlash when assembled using the center distance given by the formula below (center distance tolerance of H7 – H8). For the backlash of each product, please refer to the dimension table.
Backlash may be adjusted by changing the center distance of mating gears. For more information, please consult the technical section on gear backlash (page 56) in our separate technical reference book.



$a=m(Z_1+Z_2)/2$

Where
a : Center distance
m : Module
Z_1 : No. of teeth of pinion
Z_2 : No. of teeth of gear

② The table below indicates the tolerance on the total length of KHK stock spur gears. Please refer to this data when designing gear boxes or other components.

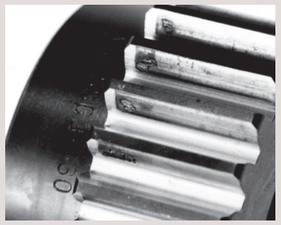
■ Total Length Tolerance for Spur and Helical Gears

Total Length (mm)	Tolerance
30 or less	0 −0.10
31 to 100	0 −0.15
Over 100	0 −0.20

[Note] The following products are excluded from this table: Spur pinion shafts, Injection molded spur gears, F-loc hub spur gears, and MC nylon products.

③ Spur gears produce no thrust forces; however, be sure to fasten them firmly with stepped shafts, or collars, to prevent shifting toward the shaft.
Keyways are generally used in fastening gears to a shaft, and they should be secured by applying drilled holes for set screws, or applying flats to the shaft, in case of fastening only with set screws.
There are also methods of secure settings using a Mecha-Lock, a POSI-LOCK, or a Spannring, which are parts for engaging the hole and the axis.
④ Verify that the two shafts are parallel. Incorrect assembly will lead to uneven teeth contact which will cause noise and wear. (Check the assembly by painting a thin layer of red lead primer or the like on the gear teeth, meshing them together and rotating them.)

■ Test example: Abrasion occurred on KSSG3-30 due to poor edge contact (only 30% with proper contact).



Poor tooth contact and pitting

Gear oil (equivalent to JIS gear oil category 2 No. 3)
The design conditions were load torque at 278 rpm, 42.5 kg/m (12 kW), 1.5 times the allowable bending strength, and 3 times the allowable surface durability torque.
The pitting occurred on the poor tooth contact area after 60 hours of continuous operation.

4. Cautions on Starting

① Check the following items before starting.
• Are the gears installed securely?
• Is there uneven tooth contact?
• Is there adequate backlash?
Be sure to avoid zero-backlash.
• Has proper lubrication been supplied?
② If gears are exposed, be sure to attach a safety cover to ensure safety. Also, be careful not to touch rotating gears.
③ Gears can be lubricated with the "grease lubrication method", "splash lubrication method (oil bath method)", or "forced lubrication method (circulation lubrication method)".
For initial operation, the lubricant may deteriorate markedly, so check the condition of the lubricant after starting.
For more technical information, please see the section "Gear Lubrication" (Page 112) of our technical reference book.
④ If there is any abnormality such as noise or vibration during startup, check the gears and assembly condition.
"High gear accuracy", "smooth gear teeth surface" and "correct tooth contact" are some of the measures against gear noise. For more technical information, please see the section "Gear Noise and Countermeasures" (Page 119) of our technical reference book.

KHK considers safety a priority in the use of our products.
When handling, adding secondary operations, assembling, and operating KHK products, please be aware of the following issues in order to prevent accidents.

⚠ Warning: Precautions for preventing physical and property damage

1. When using KHK products, follow relevant safety regulations (Occupational Safety and Health Regulations, etc.).
2. Pay attention to the following items when installing, removing, or performing maintenance and inspection of the product.
① Turn off the power switch.
② Do not reach or crawl under the product.
③ Wear appropriate clothing and protective equipment for the work.

⚠ Caution Cautions in Preventing Accidents

1. Before using a KHK product, read the precautions in the catalog carefully in order to use it correctly.
2. Avoid use in environments that may adversely affect the product.
3. Our products are manufactured under a superior quality control system based on the ISO9000 quality management system; if you notice any malfunctions upon purchasing a product, please contact the supplier.

Features

KHK stock racks are made for high precision linear motion applications. We offer a large selection of racks ranging from module 0.5 to 10 and lengths from 100 to 2000 mm. The following table lists the main features.

■ Racks

Catalog Number Note 1	Module	Total length mm Parentheses show no. of teeth	Material	Heat Treatment	Tooth Surface Finish	Gear accuracy KHK R 001 Note 3 Parentheses show JIS B 1702-1	Features
KMRGF/KMRGFD	1.5 to 3	500	SCM415	Tooth area carburized	Ground	1	A ground rack made of carburized chromoly steel. Our highest-performance rack, with accumulated pitch error of 10μm or less. J Series products are also available.
KKRGF-H KKRGFD-H	1.5 to 3	500, 1000	SCM440	Thermal refined, gear teeth induction hardened	Ground	1	Heat treated ground gears with high precision and strength has excellent cost-performance ratio. J Series products are also available.
KKRG/KKRGF KKRGD	1 to 3	100, 500, 1000	SCM440	Thermal refined	Ground	1	High strength and abrasion-resistant for precision linear motion.
KKSRG/KKSRGF KKSRGFD/KKSRGFK	0.5 to 6	100, 300, 500, 1000	S45C	Gear teeth induction hardened NOTE2	Ground	3	Reasonably priced ground racks with abrasion-resistant characteristics. J Series products are also available.
KKRF-H/KKRFD-H	1.5 to 5	1000	SCM440	Thermal refined, gear teeth induction hardened	Cut	5	A high-strength, long-life, tough hardened rack suitable for compact designs. J Series products are also available.
KSRF-H KSRFD-H	1.5 to 6	1000	S45C	Gear teeth induction hardened	Cut	5	Stable hardened racks with high strength, long life span are reasonably priced. J Series products are also available.
KSRF-HL KSRFD-HL	1.5 to 6	1000, 1500, 2000	S45C	Gear teeth laser hardened	Cut	4	Hardened racks with high strength due to the laser hardened tooth surfaces and with a low price tag. J Series products are also available.
KKRF/KKRFD	1.5 to 5	500, 1000	SCM440	Thermal refined	Cut	4	Increased strength with SCM440 material which is thermal refined. J Series products are also available.
KSRAF/KSRAFD KSRAFK	1.5 to 4	1000	S45C	—	Cut	4	This gear rack has the same tooth height and face width sizes, more compact and reasonably priced in comparison to SRF Racks J Series products are also available.
KSR/KSRF KSRFD/KSRFK	0.5 to 10	100, 300, 500, 1000, 1500, 2000	S45C	—	Cut	4	Low cost, large selections of modules and number of teeth. J Series products are also available.
KSUR/KSURF KSURFD	1 to 4	500, 1000	SUS304	Solution treated	Cut	5	Suitable for food machinery due to SUS304's rust resistant qualities.
KDRF/KDRFD KDRFK	1 to 3	500, 1000	Polyacetal	—	Cut	5	Plastic racks with little dimensional change, absorb lesser water than MC Nylon racks. J Series products are also available.
KPR/KPRF	1 to 3	500, 1000	MC901	—	Cut	5	Light-weight products made of MC Nylon can be used without lubrication.
KBSR	0.5 to 1	300	Free cutting brass (C3604)	—	Cut	4	Small pitch racks made of free-cutting brass (C3604), excellent workability and high rust resistance.
KSRO/KSROS	1 to 6	500, 1000	S45C	—	Cut	4	Convenient in applications where the rack has the reciprocal motion. S Type is easy to install.
KSURO	1 to 3	500, 1000	SUS303	—	Cut	5	Same dimensions as SRO racks, except in stainless steel. Use where rust-resistance is required.
KDR	0.8 to 2	2000	Duracon (M25-44)	—	Injection Molded	8	Used in applications due to its flexibility, where metal racks do not have this attribute. Pinions and accessories are also available.
KRHG/KRHGF	1 to 3	100, 500, 1000	SCM440	Thermal refined	Ground	1	Excellent products with high precision and strength, and low noise and abrasion characteristics. J Series products are also available.
KSRH/KSRHF KSRHFD	2 to 3	100, 500, 1000	S45C	—	Cut	5	Effective in reducing noise and vibration due to larger contact ratio of helical gears.
KSRHEF	1.5 to 6	1000	S45C	—	Cut	4	General-purpose helical racks with product dimensions and helix angle (19° 31′ 41″) according to EU specifications.

■ Pinion

KSHE	1.5 to 6	(18 to 30)	S45C	—	Cut	(N8)	A product designed so that the helix angle is 19° 31′ 41″ and the distance of the pinion traveled in one turn is an integer (mm).

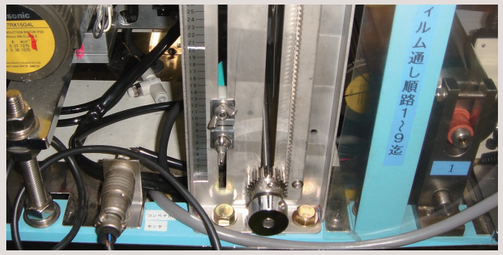
[NOTE 1] The catalog numbers in the above tables with a suffix of F have both ends machined so that they can be butted against each other to make any desired length. The items with (D) and (K) have mounting screw holes for easier assembly.
[NOTE 2] Products with module less than 0.8 are thermal refined, without their gear teeth being induction hardened.
[NOTE 3] Precision grade standard of racks are set by KHK. Please see "Precision of Racks" in Selection Hints section for details.

● For safe handling and to prevent damage such as deformation, KHK stock racks have round chamfering at the corners of the top land of the gear tooth.
This rounded chamfered shape is patented by KHK. It is also effective for reducing noise.
● Black products are KHK stock gears that have an applied black oxide coating for rust resistance;
this "blackness" is a product characteristic of KHK stock gears.

Application Examples

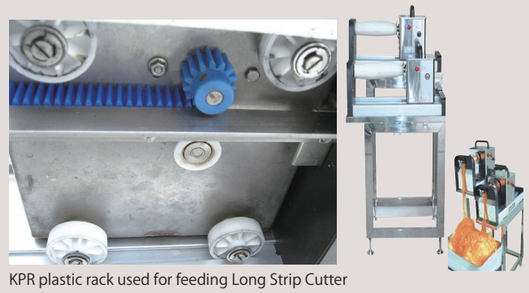
KHK stock racks & pinions are adopted in driving devices for all kinds of linear motion systems, including transport devices.

■ Automatic packaging machine manufactured by Toyota Machinery Co., Ltd.



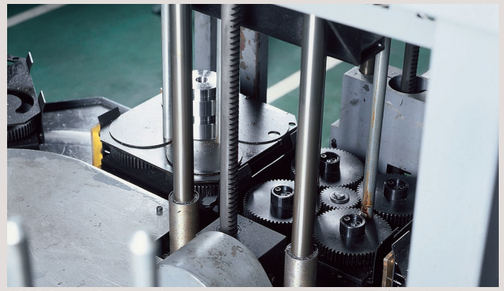
KSUR stainless steel rack used for film winding tension part

■ Dremax Long Strip Cutter



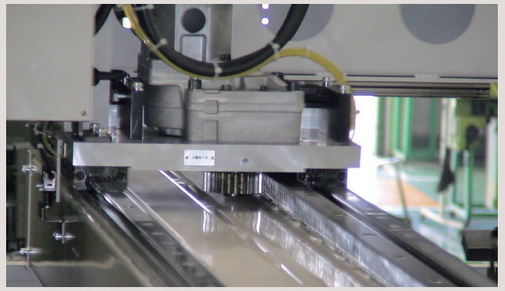
KPR plastic rack used for feeding Long Strip Cutter

■ Lathe Auto Loader



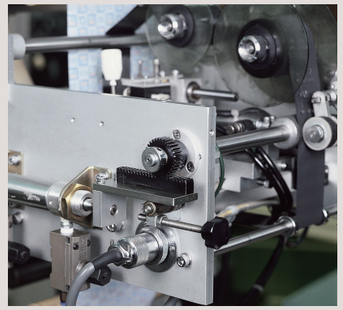
KSRO Round Rack used as a workpiece storage device (lifting/lowering table)

■ Lathe Gantry Loader



KKRG Ground Rack used as a workpiece conveying device

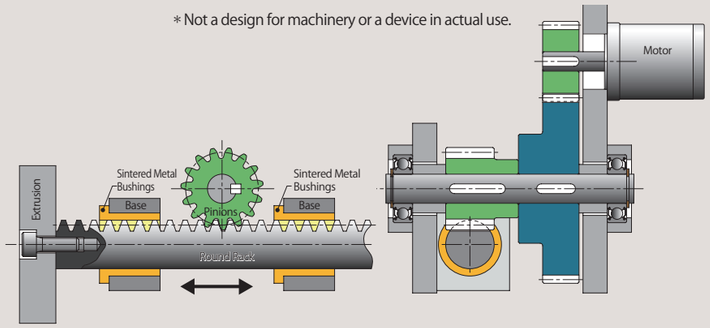
■ Packaging Machine



KSR Rack used for label feeding

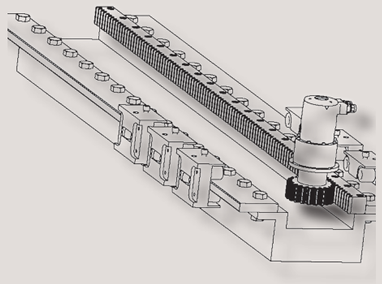
■ Extruder (design example)

＊Not a design for machinery or a device in actual use.



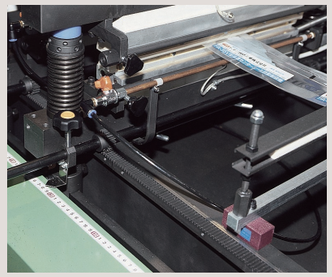
KSRO Round Rack used for extruders (can also become a lifting/lowering device by setting up vertically)

■ Rack Drive Linear Guide



Example of table moving device that uses rack & pinion

■ Film Sealer



KSR rack used for positioning

Selection Hints

Please select the most suitable products by carefully considering the characteristics of items and contents of the product tables. It is also important to read all applicable "CAUTION" notes shown below before the final selection.

1. Caution in Selecting the Mating Gears

① With the exception of helical racks, KHK stock racks can mate with any spur gears of the same module. Products with different tooth width can also be mated as a pinion.

② There are limited choices of mating gears for KKRHG/KKRHGF, KSRHEF, and KSRH Ground Helical Racks and Helical Racks. Be sure to check the helix direction (right or left) when selecting.

■ Mating Helical Gear Selection Chart (○ Allowable × Not allowable)

Catalog Number and Direction of Helix		KKRHG KKRHGF		KSRHEF	KSRH/KSRHF KSRHFD	
		RH	LH	RH	RH	LH
KKHG	LH	○	×	×	×	×
	RH	×	○	×	×	×
KSHE	LH	×	×	○	×	×
KSH	LH	×	×	×	○	×
	RH	×	×	×	×	○

2. Caution in Selecting Gears Based on Gear Strength

Allowable bending strength and surface durability values shown in product tables were computed by assuming a certain application environment. They should be used as reference only. We recommend that each user computes their own values by applying the actual usage conditions. The table below contains the assumptions established for various products in order to compute gear strengths.

■ Calculation of Bending Strength of Gears

Item \ Catalog Number	Racks: KMRGF KMRGFD	KKRGF-H KKRGFD-H KKRF-H KKRFD-H	KKRG/KKRGF KKRGD/KKRHG KKRHGF/ KKRHGFD KKRF/KKRFD	KSRG/KSRGF KSRGFD/KSRGFK KSRF-H/KSRFD-H	KSRF-HL KSRFD-HL	KSRAF/KSRAFD KSRAFK/KSR/KSRF KSRFD/KSRFK/KSRO KSROS/KSRH/KSRHF KSRHFD/KSRHEF	Pinions: KSUR KSURF KSURFD KSURO	KBSR	KSHE	Racks: KDRF KDRFD KDRFK	KPR KPRF	KDR
Formula NOTE 1	Formula of spur and helical gears on bending strength (JGMA401-01)									The Lewis formula		
No. of teeth of mating gears	30								Racks	(30)		
Rotational speed	100rpm									(100 rpm)		
Design life (durability)	Over 10^7cycles									Allowable bending stress (kgf/mm²)		
Impact from motor	Uniform load									1.0 (40℃ with No Lubrication)	1.15 (40℃ with No Lubrication)	*m* 0.8 4.0 *m* 1.0 3.5 *m* 1.5 1.8 NOTE 4 *m* 2.0 1.2 (40℃ with Grease Lubrication)
Impact from load	Uniform load											
Direction of load	Bidirectional											
Allowable bending stress at root σ_{Flim} (kgf/mm²) NOTE 2	47	32		20 NOTE 3			10.5	4	30			
Safety factor S_F	1.2											

■ Calculation of Surface Durability (Except where it is common with bending strength)

Formula NOTE 1	Formula of spur and helical gears on surface durability (JGMA402-01)									
Kinematic viscosity of lubricant	100cSt (50℃)									
Gear support	Supported on one end.									
Allowable Hertz stress σ_{Hlim} (kgf/mm²)	166	112	79	90 NOTE 4	80	52.5	41.3	-	49	112
Safety factor S_H	1.15									

[NOTE 1] The gear strength formula is based on JGMA (Japanese Gear Manufacturers Association) specifications, "MC Nylon Technical Data" by Nippon Polypenco Limited and "Duracon Gear Data" by Polyplastic Co.
The units for the rotational speed (rpm) and the stress (kgf/mm²) are adjusted to the units needed in the formula.

[NOTE 2] The allowable bending stress at the root σ_{Flim} is calculated from JGMA401-01, and set to 2/3 of the value in the consideration of the use of planetary-, idler-, or other gear systems, loaded in both directions.

[NOTE 3] For KSRG, or KSRGF Ground Racks, with a module less than *m*0.8, the allowable bending stress and allowable hertz stress are respectively 24.5 (kgf/mm²) and 62.5 (kgf/mm²).

[NOTE 4] The values for DR *m* 1.5 racks were assumed by KHK. Usage conditions for KSSDR (DR Rack Pinion) are the same as for the SSCP Pinion, shown on Page 241.

When selecting KHK standard gears, glance over the Cautions on Product Characteristics and Cautions on Performing Secondary Operations in the respective dimension tables.

① Products not listed in this catalog or materials, modules, number of teeth and the like not listed in the dimensional tables can be manufactured as custom items. Please see Page 16 for more details about custom-made orders.

② The color and shape of the product images listed on the dimension table page of each product may differ from the actual product. Be sure to confirm the shape in the dimension table before selection.

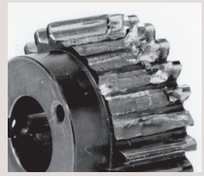
③ The details (specifications, dimensions, prices, etc.) listed in the catalog may be changed without prior notice.

The most important factor in selecting gears is the gear strength.

Step 1 **Determine the actual load torque applied to the gear and the gear type suitable for the purpose.**

■ Definition of Bending Strength of Gears

The allowable bending strength of a gear is defined as the allowable tangential force at the pitch circle based on the mutually allowable root stress of two meshing gears under load.



Example of failure due to insufficient bending strength

■ Definition of Surface Durability

The surface durability of a gear is defined as the allowable tangential force at the pitch circle, which permits the force to be transmitted safely without incurring surface failure. The allowable gear tooth load of a gear is defined as the allowable tangential force at the pitch circle based on the mutual gear tooth strength of two meshing gears under load.

Example of wear due to insufficient surface durability

Step 2 **Select provisionally from the allowable torque table of the Master Catalog based on the load torque.**

■ For provisional selection from the Master Catalog

Catalog No.	Module	Effective no. of teeth	Shape	Total length A	Face width B	Height C	Height to pitch line D	Allowable force (N) Bending strength	Allowable force (N) Surface durability	Allowable force (kgf) Bending strength	Allowable force (kgf) Surface durability
KRG1-100 KRG1-500	*m*1	29 159	R1	98 505	10	15	14	1530	641	156	65.3
KRG1.5-100 KRG1.5-500	*m*1.5	20 105	R1	101 505	15	20	18.5	3450	1440	352	147
KRG2-100 KRG2-500	*m*2	14 79	R1	98 505	20	25	23	6130	2560	625	261
KRG2.5-100 KRG2.5-500	*m*2.5	11 63	R1	100 505	25	30	27.5	9580	4010	977	408
KRG3-100 KRG3-500	*m*3	9 52	R1	101 505	30	35	32	13800	5770	1410	588

Catalog No.	Module	No. of teeth	Shape	Total length A	Face width B	Height C	Height to pitch line D	Allowable force (N) Bending strength	Allowable force (N) Surface durability	Allowable force (kgf) Bending strength	Allowable force (kgf) Surface durability
KRGF1-1000	*m*1	318	RF	999.03	10	15	14	1530	641	156	65.3
KRGF1.5-1000	*m*1.5	212	RF	999.03	15	20	18.5	3450	1440	352	147
KRGF2-1000	*m*2	160	RF	1005.31	20	25	23	6130	2560	625	261
KRGF2.5-1000	*m*2.5	128	RF	1005.31	25	30	27.5	9580	4010	977	408
KRGF3-1000	*m*3	106	RF	999.03	30	35	32	13800	5770	1410	588

Catalog No.	Module	No. of teeth	Shape	Total length A	Face width B	Height C	Height to pitch line D	Mounting hole dimensions E	F	G	No. of mounting holes
KRGD1-500	*m*1	159	RD	499.51	10	15	14	6	39.75	140	4
KRGD1.5-500	*m*1.5	106	RD	499.51	15	20	18.5	8	39.75	140	4
KRGD2-500	*m*2	80	RD	502.65	20	25	23	10	41.32	140	4
KRGD2.5-500	*m*2.5	64	RD	502.65	25	30	27.5	12	41.32	140	4
KRGD3-500	*m*3	53	RD	499.51	30	35	32	14	39.75	140	4

Step 3 **We recommend that each user computes their own values by applying the actual usage conditions to determine the suitability of the gear strength.**

Calculate the strength formally using the various gear strength formulas.

Please see Page 71 of our technical reference book for more details.

(2) Bending strength formula

In order to satisfy the bending strength, the nominal circumferential force F_t on the meshing pitch circle must be less than or equal to the allowable circumferential force F_{tlim} on the meshing pitch circle calculated by the permissible bending stress at root.

$$F_t \leqq F_{tlim} \quad (10.4)$$

Alternatively, the bending stress at root σ_F obtained from the nominal circumferential force F_t on the meshing pitch circle must be less than or equal to the permissible bending stress at root σ_{Flim}.

$$\sigma_F \leqq \sigma_{Flim} \quad (10.5)$$

The permissible circumferential force F_{tlim} (kgf) on the meshing pitch circle is obtained by the following equation.

$$F_{tlim} = \sigma_{Flim} \frac{m_n b}{Y_F Y_\varepsilon Y_\beta} \left(\frac{K_L K_{FX}}{K_V K_O} \right) \frac{1}{S_F} \quad (10.6)$$

The bending stress at root (kgf/mm2) is obtained by the following equation.

$$\sigma_F = F_t \frac{Y_F Y_\varepsilon Y_\beta}{} \left(\frac{K_V K_O}{} \right) S \quad (10.7)$$

3. Cautions on Selecting Racks By Precision

The precision standards of KHK stock racks are established by us.
The table below indicates the tolerance ranges of our racks.

① Pitch Errors of Racks (KHK R 001)

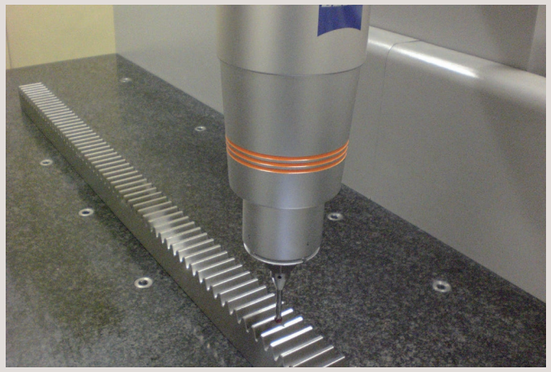
Our precision grades for pitch errors are established by referring to JIS Standards. The precision grades are set from 1 to 8, in accordance with the tolerance of a single pitch error (S.P.E.), adjacent tooth-to-tooth error (T.T.E.), and the total composite error (T.C.E.) for each module and length.

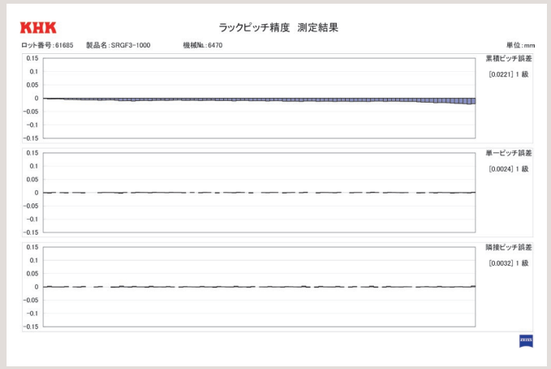
■ Precision Grades of Racks (KHK R 001) **Unit: μm**

Grade	Pitch Error	Over *m*0.4 to 1 CP2.5		Over *m*1 to 1.6 CP5		Over *m*1.6 to 2.5 –		Over *m*2.5 to 4 CP10		Over *m*4 to 6 CP15		Over *m*6 to 10 CP20	
		Rack Length (nominal)											
		1000 or less	1001 up to 2000	1000 or less	1001 up to 2000	1000 or less	1001 up to 2000	1000 or less	1001 up to 2000	1000 or less	1001 up to 2000	1000 or less	1001 up to 2000
1	S.P.E.	10	–	10	12	11	12	11	13	13	14	14	16
	T.T.E.	10	–	11	13	12	14	13	15	14	16	16	18
	T.C.E.	28	–	29	33	30	35	32	37	35	40	40	45
2	S.P.E.	14	–	14	17	15	17	16	18	18	20	20	23
	T.T.E.	16	–	16	19	17	19	18	21	20	24	24	27
	T.C.E.	39	–	41	48	43	49	46	53	50	57	58	64
3	S.P.E.	20	–	20	24	21	25	23	26	25	29	29	32
	T.T.E.	22	–	24	28	25	29	27	31	30	34	34	40
	T.C.E.	56	–	57	67	60	70	64	74	71	80	81	91
4	S.P.E.	28	–	29	33	30	35	32	37	35	40	40	45
	T.T.E.	33	–	34	42	38	43	40	46	44	50	51	57
	T.C.E.	79	–	81	95	85	99	91	105	100	115	115	130
5	S.P.E.	39	–	41	48	43	49	46	53	50	57	58	64
	T.T.E.	49	–	51	59	53	62	57	69	66	75	76	85
	T.C.E.	110	–	115	135	120	140	130	145	140	160	160	180
8	S.P.E.	206	206	212	212	219	219	–	–	–	–	–	–
	T.T.E.	330	330	339	339	350	350	–	–	–	–	–	–
	T.C.E.	–	–	–	–	–	–	–	–	–	–	–	–

[NOTE] ① Since the pitch accuracy of racks may vary due to humidity, the precision grades are evaluated at the bottom surface of the product, at the temperature of 20℃ . The dimensions of the KHK KPR Plastic Racks may vary widely due to humidity. Therefore, the total composite error is assumed to be excluded from this accuracy standard.
Please refer in our separate technical reference book to "Design of Plastic Gears" (Page 100) for change in dimensions.
② For the accuracy of KCP Rack, convert KCP to *m* (module) when reference is made to the data in the table. (*m* =KCP/ π).

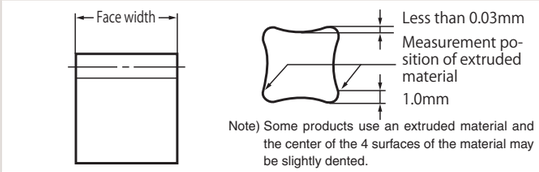
■ Pitch inspection and a sample report using Karl Zeiss UMC-550 Coordinate Measuring Machine. (KHK R 001 Grade 1)





② Precision of Rack Blanks

■ Tolerance on Face Width and Height



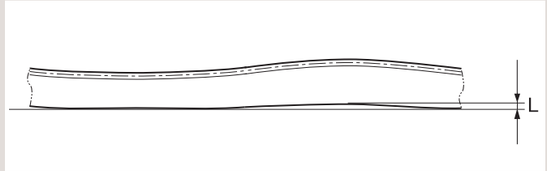
Note) Some products use an extruded material and the center of the 4 surfaces of the material may be slightly dented.

Unit: mm

Face width \ Precision grade (KHK R 001)	Grade 1	Grade 2	Grades 3 to 5*
6 or less	0 −0.05	0 −0.10	0 −0.18
7 to 10		0 −0.10	0 −0.22
11 to 18		0 −0.10	0 −0.27
19 to 30		0 −0.15	0 −0.33
31 to 50		0 −0.15	0 −0.39
51 to 90		0 −0.15	0 −0.46

[NOTE] Dimensional tolerance of hardened products is that prior to hardening. Dimensional tolerance for plastic racks is the value obtained when machining is performed, and may increase slightly due to aging.
* KBSR products are not applicable.

■ Maximum Curvature Values (Flatness Tolerance L)



Unit: mm

Length (nominal) \ Precision Grade (KHK R 001)	Grades 1 & 2	Grade 3	Grades 4 & 5
500	0.05	0.1	0.2
1000	0.1	0.2	0.3
1500	–	–	0.3
2000	–	–	0.4

[NOTE] The straightness tolerances of round racks are 0.15/500 mm and 0.2/1000 mm. Plastic racks change over time so are excluded from this precision standard.

■ Tolerance on Total Length **Unit: mm**

Product Type	Module	Dimensional Tolerance
F Type End Machined Product	*m*0.5	$\begin{pmatrix} -0.1 \\ -0.3 \end{pmatrix}$
	*m*0.8 (CP2.5)	$\begin{pmatrix} -0.1 \\ -0.5 \end{pmatrix}$
	*m*1 up to 2.5	$\begin{pmatrix} -0.2 \\ -0.6 \end{pmatrix}$
	*m*2.5 or more	$\begin{pmatrix} -0.2 \\ -0.8 \end{pmatrix}$
FRCP and DR Flexible Racks	Uniform	± 10
Products other than the above	Uniform	$\begin{matrix} +3 \\ -2 \end{matrix}$

[NOTE] For Type-F racks with machined ends, the dimensional tolerance is a calculated value according to assumed usage conditions, without consideration of pitch errors and aged deterioration.

③ Backlash of Rack Teeth

■ Backlash of Rack Teeth (Amount of Tooth Thinning) **Unit: mm**

Module (*m*) Pitch (CP) \ Precision grade (KHK R 001)	Grade 1 & 2	Grade 3	Grade 4		Grade 5		
			Excludes thermal refined racks	Includes thermal refined racks	Hardened Products	Stainless Steel/Helical Racks	Plastic Products
*m*0.5	–	0 to 0.07	0 to 0.08	–	–	–	–
*m*0.8, CP2.5	0 to 0.06	0 to 0.08	0 to 0.09	–	–	–	–
*m*1	0 to 0.06	0 to 0.10	0 to 0.11	–	–	0 to 0.13	0 to 0.20
*m*1.5, CP5	0 to 0.06	0 to 0.10	0.04 to 0.13	0.04 to 0.15	0.02 to 0.17	0.04 to 0.15	0 to 0.21
*m*2	0 to 0.06	0 to 0.10	0.05 to 0.14	0.05 to 0.16	0.03 to 0.18	0.05 to 0.16	0 to 0.22
*m*2.5	0 to 0.06	0 to 0.10	0.06 to 0.16	0.06 to 0.18	0.04 to 0.20	0.06 to 0.18	0 to 0.24
*m*3, CP10	0 to 0.06	0 to 0.10	0.07 to 0.18	0.07 to 0.20	0.05 to 0.22	0.07 to 0.20	0 to 0.27
*m*4	–	0 to 0.10	0.08 to 0.22	0.08 to 0.24	0.06 to 0.26	0.08 to 0.24	–
*m*5, CP15	–	0 to 0.10	0.09 to 0.24	0.09 to 0.26	0.07 to 0.28	0.09 to 0.26	–
*m*6, CP20	–	0 to 0.10	0.10 to 0.28	–	0.08 to 0.32	–	–
*m*8	–	–	0.13 to 0.32	–	–	–	–
*m*10	–	–	0.15 to 0.34	–	–	–	–

[NOTE] The values shown in the table are amount of tooth thinning. The theoretical backlash of assembled rack and pinion is given by:

Rack & pinion backlash = Amount of tooth thinning of the rack + Amount of tooth thinning of the pinion

Amount of tooth thinning of the rack : See above table
Amount of tooth thinning of the pinion : Take 1/2 of backlash given in the product table

Application Hints

In order to use KHK stock racks safely, carefully read the Application Hints before proceeding. If there are questions or you require clarifications, please contact our technical department or your nearest distributor.

TEL: 81-48-254-1744 FAX: 81-48-254-1765 E-mail: info@khkgears.net

1. Cautions on Handling

① KHK products are packaged one by one to prevent scratches and dents, but if you find issues such as rust, scratches, or dents when the product is removed from the box after purchase, please contact the supplier.

② Depending on the handling method, the product may become deformed or damaged. Long racks and resin racks deform particularly easily, so please handle with care.

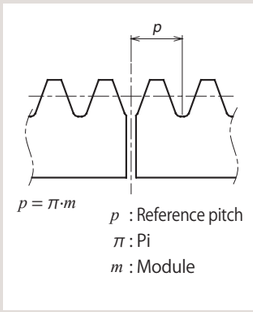
2. Cautions on Performing Secondary Operations

① Secondary operations can be performed on all KHK stock racks except for the racks with their gear teeth induction hardened. To avoid problems of gear precision, do not reduce the face width. The precision of ground racks and racks with mounting holes may drop if you do not exercise extreme caution during installation or while modifying.

② Pitch lines of racks are controlled by using the bottom surface as the reference datum and over-pin measurements on tooth thickness. If you machine the bottom surfaces, the precision of the racks may be affected.

③ When connecting two racks, the machining of the mating ends requires careful consideration in terms of the pitch (p) accuracy. The meshing will be poor if the pitch straddling the connection has a positive tolerance. We recommend a minus tolerance on pitch of at the connection.

The below is an indication of pitch tolerance for each module.



Unit: mm

Module	Pitch (p)	Tolerance
m0.5	1.57	− 0.05 − 0.15
m0.8	2.51	− 0.05 − 0.25
m1	3.14	− 0.1 − 0.3
m1.5	4.71	
m2	6.28	
m2.5	7.85	− 0.1 − 0.4
m3	9.42	
m4	12.57	
m5	15.71	
m6	18.85	
m8	25.13	
m10	31.42	

④ To use dowel pins to secure racks, attach the racks to the base and drill both simultaneously.

⑤ KHK stock racks made of S45C and SCM440 (except for ground racks) can be induction hardened. However, the precision of pitch is decreased.

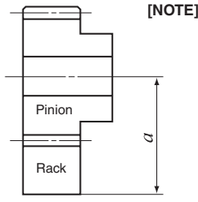
⑥ To be able to handle parts safely, all burrs and sharp corners should be removed after the secondary operations are done.

⑦ If you are going to modify the gear by gripping the teeth, please exercise caution not to crush the teeth by applying too much pressure. Any scarring will cause noise during operation.

3. Points of Caution during Assembly

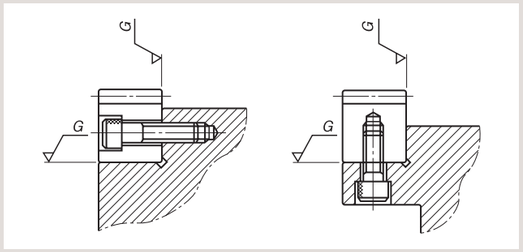
① KHK stock racks are designed to give the proper normal direction backlash when assembled using the mounting distance given by the formula below (mounting distance tolerance of H7 to H8 required). The backlash values are given in the table on Page 193. Make sure that the mounting distance stays constant for the length of the rack.

Mounting distance a = Height of pitch line of rack + Pitch radius of pinion



[NOTE] Pinions are assumed to be standard stock spur gears (x=0).

② KKRG type of KHK stock ground racks have four surfaces ground parallel with high precision. To maintain true angle, they should be mounted on high precision bases (within 10μm recommended) as shown below. It is even possible to correct for the angular errors of racks by compensating the mounting base. With recent increases in the requirement for zero backlash linear drives, such accurate assembly as shown is becoming more important.

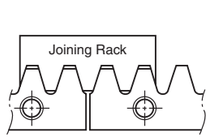


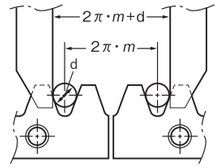
③ If the racks are not secured properly to the base, they could shift during operation and cause unexpected problems. It is very important to insure firm mounting by the use of dowel pins or similar devices.

④ Machined end type racks such as KSRF and KSRFD series have the pitch tolerance of -0.05 to -0.4mm at the end face. If you try to connect the racks without any space, the pitch at the connection will be too small and will cause problems. Please follow the following diagrams for assembly.

⑤ With KSRFD etc., if using more than 10 racks connected together to form a rack with mounting holes machined along a length of 1 meter, the pitch precision and machining precision may cause the rack and base mount-ing holes to deviate, leading to set screw interference with the counterbored hole and preventing mounting. When using a rack for long lengths such as 10 meters or 20 meters, have the mounting holes additionally ma-chined into long holes.

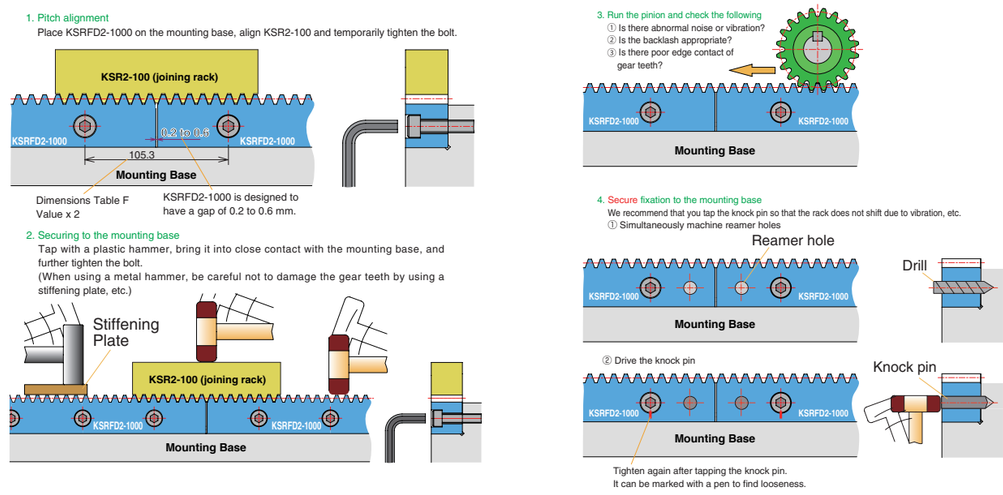
As an example of Rack Joining, we recommend the following method.





[NOTE] Joining gauge racks for helical racks must have the opposite hand from the racks. Please use 100 mm long racks as a joining gauge rack, or alternatively the rack of the same specifications on hand.

How to mount racks on a mounting base (For KSRFD2-1000)



4. Cautions on Starting

① Check the following items before starting.
- Are the gears installed securely?
- Is there uneven tooth contact?
- Is there adequate backlash?
  Be sure to avoid zero-backlash.
- Has proper lubrication been supplied?

② If gears are exposed, be sure to attach a safety cover to ensure safety. Also, be careful not to touch rotating gears.

③ Gears can be lubricated with the "grease lubrication method", "splash lubrication method (oil bath method)", or "forced lubrication method (circulation lubrication method)".

For initial operation, the lubricant may deteriorate markedly, so check the condition of the lubricant after starting.
For more technical information, please see the section "Gear Lubrication" (Page 112) of our technical reference book.

④ If there is any abnormality such as noise or vibration during startup, check the gears and assembly condition. "High gear accuracy", "smooth gear teeth surface" and "correct tooth contact" are some of the measures against gear noise. For more technical information, please see the section "Gear Noise and Countermeasures" (Page 119) of our technical reference book.

KHK considers safety a priority in the use of our products.
When handling, adding secondary operations, assembling, and operating KHK products, please be aware of the following issues in order to prevent accidents.

⚠ Warning: Precautions for preventing physical and property damage

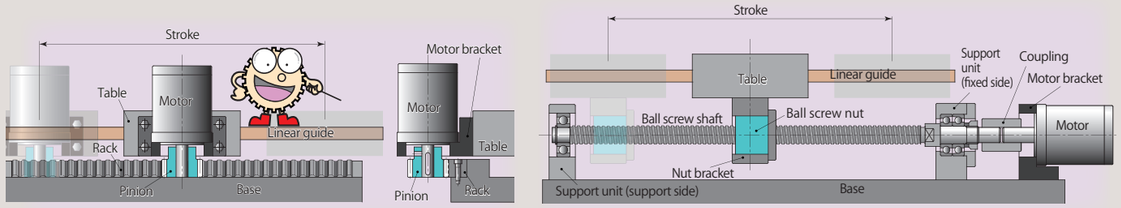
1. When using KHK products, follow relevant safety regulations (Occupational Safety and Health Regulations, etc.).
2. Pay attention to the following items when installing, removing, or performing maintenance and inspection of the product.
   ① Turn off the power switch.
   ② Do not reach or crawl under the product.
   ③ Wear appropriate clothing and protective equipment for the work.

⚠ Caution Cautions in Preventing Accidents

1. Before using a KHK product, read the precautions in the catalog carefully in order to use it correctly.
2. Avoid use in environments that may adversely affect the product.
3. Our products are manufactured under a superior quality control system based on the ISO9000 quality management system; if you notice any malfunctions upon purchasing a product, please contact the supplier.

Comparison of Racks & Pinions and Ball Screws

Since racks are a simple mechanism, the material, hardening, strength and precision can be designed according to the environment.
They are also inexpensive, with parts that can be purchased separately for replacement.
In the designing process, please refer to Features of Racks & Pinions and Ball Screws in the table below.



● Features of Racks & Pinions

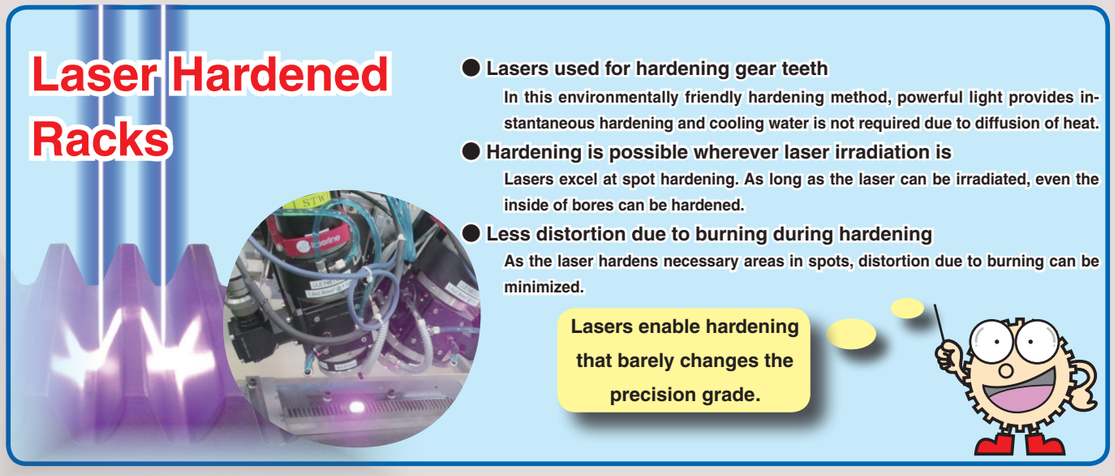
Advantages	Details
Few component parts	Since it does not have parts such as balls and retainers, there is less risk of accidentally falling apart during assembly and disassembly.
Supports heavy loads	Racks with large module can be used for heavy loads.
Compact products can be manufactured	Since it can be made smaller than products with ball screws, it can be used compactly for light loads.
High transmission efficiency	High transmission efficiency of about 98% (excluding lubrication oil stirring resistance and bearing resistance).
High feed speed	If the pinion diameter is large, it supports high-speed feeding.
No length limit	Screws can only be up to about 2 m to avoid excessive bending, but racks can be joined together and used at greater lengths.
Flexible production is available	Materials, hardening, shapes and the like can be designed flexibly, allowing easy adjustment to the machine.
High-precision products can be manufactured	Gear grinding can be provided to minimize pitch error.
Can be used for food-related machinery	MC nylon and stainless steel products can be manufactured.

Disadvantages	Details
Backlash is present	Backlash is required for smooth rotation. Backlash may become a problem in forward/reverse rotation positioning.
Lubrication is required	Metal racks require lubrication. Plastic racks do not require lubrication at light loads, but their precision is lower.

● Features of Ball Screws

Advantages	Details
High transmission efficiency	Transmission efficiency of 90% or higher.
High-precision products can be manufactured	High-precision ball screws can be manufactured by grinding.
High feed speed	High-speed feed is possible with high-lead ball screws.
No backlash	The use of pressure eliminates backlash.

Disadvantages	Details
Length is limited	Since the screw deflects, about 2 meters is the practical limit.
Hard to manufacture special products	Since it is hard to manufacture special products, machines must be adjusted to the shape of the ball screw.

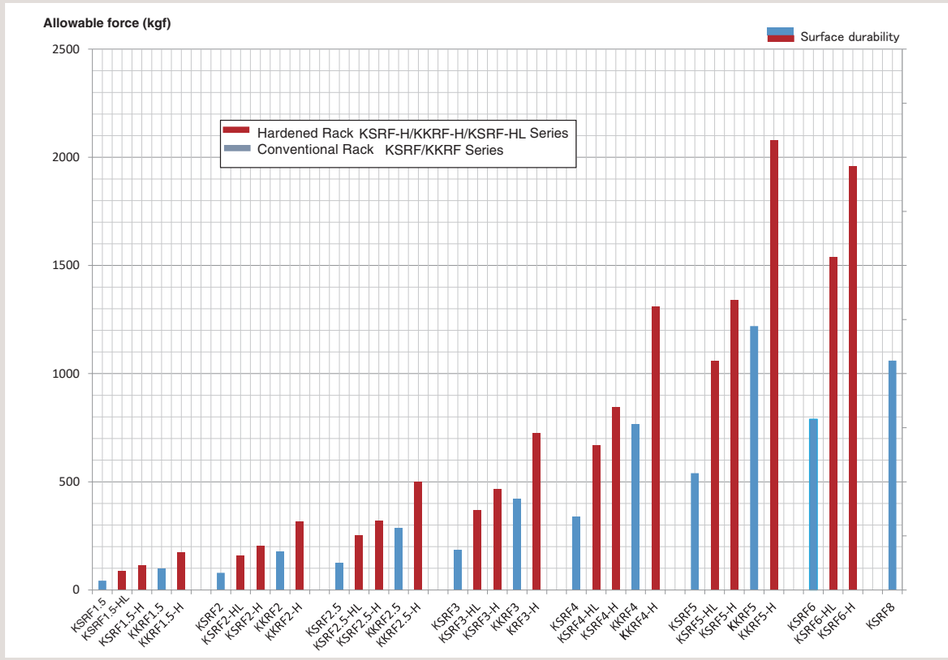


Rack downsizing

The H Series, KHK stock racks with induction hardened gear teeth, and the KHL Series, with laser hardening, are available.

The graph below simulates the downsizing of KHK stock racks. It is possible to reduce the module (size) with equivalent transmission power, or to reduce the price likewise. Please select a product that fits your needs.

■ Comparison table of permissible transmission force of hardened racks



Comparison table per series (module 3, rack length: 1,000 mm)

Catalog Numbers (Comparison Example)	Material	Heat Treatment	Allowable force kgf		Precision	Series nominal total length mm
			Bending strength	Surface durability	KHK R 001	
KSRF3-1000	S45C	None (raw material)	879	186	Grade 4	300,500,1000,1500,2000
KKRF3-1000	SCM440	Thermal refined	1410	421	Grade 4	500,1000
KSRF3-1000HL	S45C	Laser hardened	879	407	Grade 4	1000,1500,2000
KSRF3-1000H	S45C	Induction hardened	799	468	Grade 5	1000
KKRF3-1000H	SCM440	Thermal refined / induction hardened	1280	725	Grade 5	1000
KMRGF 3-500 (2 units)	SCM415	Carburized	2070	1900	Grade 1	500

■ Example of rack downsizing

The surface durability can be increased by hardening the gear teeth. By increasing the strength thus, the angular dimensions of modules and racks can be re-duced. This helps reduce the cost.

Increased strength leads to smaller size	
KSRF8-1000	39.7kg
KKRF4-1000H	12.9kg
Mass reduced ⇒	26.8 kg