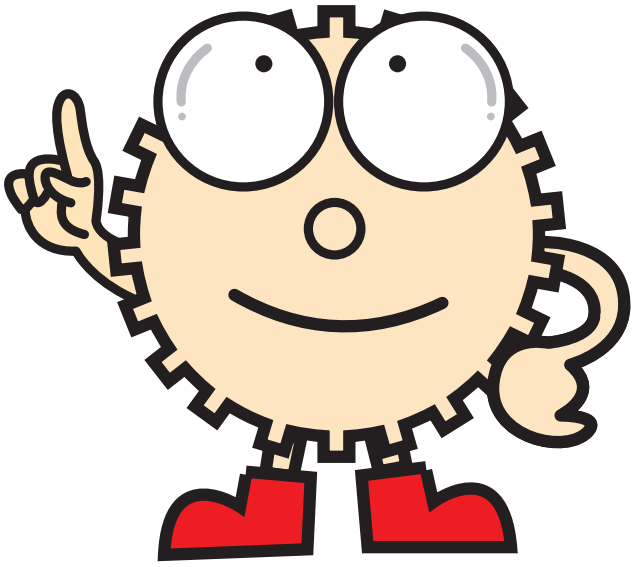
# Internal Gears

| SI<br>Steel Internal Gears | SIR<br>Internal Ring Gears |
|---|---|
|  |  |
| Material: S45C<br>*m*0.5~2.5 Page 210 | Material: S45C<br>*m*2~3 Page 212 |



## Catalog Number of KHK Stock Gears

The Catalog Number for KHK stock gears is based on the simple formula listed below. Please order KHK gears by specifying the Catalog Numbers.

(Example) Internal Gears

S I R 2 - 120

- 120 — No. of Teeth (120)
- 2 — Module (2)
- R — Other Products (Ring Shape)
- I — Type (Internal Gears)
- S — Material (S45C)

**Material**
S S45C

**Type**
I Internal Gears

**Other Information**
R Ring Gears

## Features

KHK stock internal gears are offered in modules 0.5 to 3 in 60 to 200 teeth. They can be used in many applications including planetary gear drives.

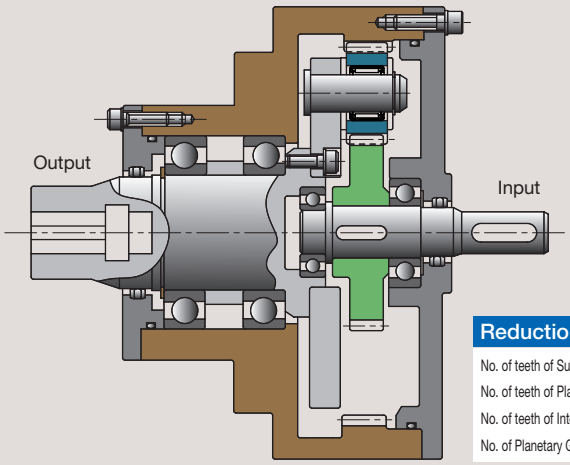
| Catalog Number | SI | SIR |
|---|---|---|
| Module | 0.5~2.5 | 2~3 |
| Material | S45C | S45C |
| Heat Treatment | — | — |
| Tooth Surface Finish | Cut | Cut |
| Precision JIS B 1702-1:1998 | N8 NOTE 1 | N9 |
| Secondary Operations | Possible | Possible |
| Features | A popular type of internal gear; Allows secondary operations. | They have a ring shape with a large number of teeth. Allows secondary operations. |

**[Note 1]** The product accuracy class having a module less than 0.8 corresponds to 'equivalent' as shown in the table.

## Application Examples

KHK stock internal gears are used to reduce the size of various equipment, such as reduction gears.

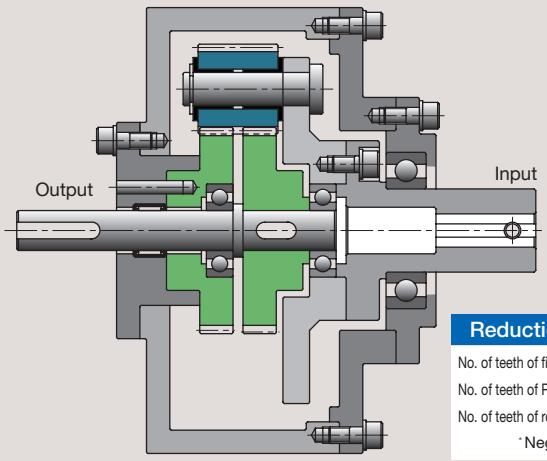
### ■ Design example of reduction gear (not a design for machinery or a device in actual use)




**Reduction Ratio 3**

No. of teeth of Sun Gear : 40
No. of teeth of Planetary Gears : 20
No. of teeth of Internal Gear : 80
No. of Planetary Gears : 3

Planetary Gear Mechanism used in a reduction gear




**Reduction Ratio 60**

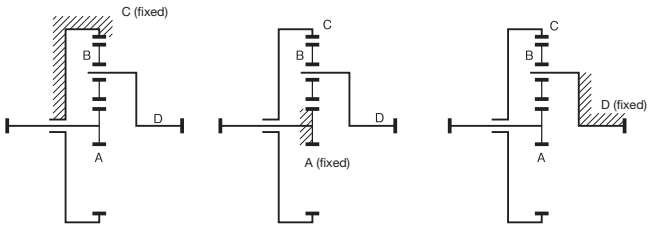
No. of teeth of fixed Sun Gear : 59
No. of teeth of Planetary Gears : 25
No. of teeth of rotating Sun Gear : 60*
*Negative dislocation

Mechanical Paradox Gear Mechanism used in a large reduction gear

### ■ Example of combinations

| No. of teeth of Internal Gear | No. of Planetary Gears | No. of teeth of sun gear | No. of teeth of Planetary Gears | Reduction ratio of planetary type | Reduction ratio of solar type | Reduction ratio of star type |
|---|---|---|---|---|---|---|
| 60 | 3 | 18 | 21 | 4.333 | 1.3 | -3.333 |
| 80 | 3 | 16 | 32 | 6 | 1.2 | -5 |
| 80 | 3 | 40 | 20 | 3 | 1.5 | -2 |
| 100 | 3 | 20 | 40 | 6 | 1.2 | -5 |
| 100 | 3 | 50 | 25 | 3 | 1.5 | -2 |

Types of Planetary Gear Mechanism




(a) Planetary type (b) Solar type (c) Star type

## Selection Hints

Please select the most suitable products by carefully considering the characteristics of items and contents of the product tables.

### 1. Caution in Selecting the Mating Gears

KHK stock internal gears can mate with any spur gears of the same module, however, there are cases of interference depending on the number of teeth of the mating gear. The table below contains the assumptions established for these products in order to compute gear strengths.

### ■ Interferences and the symptoms

| Type | SYMPTOMS | CAUSES |
|---|---|---|
| Involute interference | The tip of the internal gear digs into the root of the pinion. | Too few teeth on the pinion. |
| Trochoid interference | The exiting pinion tooth contacts the internal gear tooth. | Too little difference in number of teeth of the two gears. |
| Trimming interference | Pinion can slide in or out axially but cannot move radially. | Too little difference in number of teeth of the two gears. |

### ■ Allowable Mating Pinions and Number of Teeth

| No. of teeth of Internal Gear | No. of teeth of Allowable Mating Pinions | | |
|---|---|---|---|
| | Lower limit No. of teeth due to involute interference | Upper limit No. of teeth due to trochoid interference | Upper limit No. of teeth due to trimming interference |
| 60 | 21 | 51 | 43 |
| 80 | 20 | 72 | 64 |
| 100 | 19 | 92 | 84 |
| 120 | 19 | 112 | 104 |
| 160 | 19 | 152 | 144 |
| 200 | 18 | 192 | 184 |

## 2. Caution in Selecting Gears Based on Gear Strength

The gear strength values shown in the product pages were computed by assuming the application environment in the table below. Therefore, 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 | SI | SIR |
|---|---|---|
| Formula NOTE 1 | Formula of spur and helical gears on bending strength (JGMA401-01) | |
| No. of teeth of mating gears | 30 | |
| Rotational Speed | 100rpm | |
| Design Life (Durability) | Over $10^7$cycles | |
| Impact from motor | Uniform load | |
| Impact from load | Uniform load | |
| Direction of load | Bidirectional load (calculated with allowable bending stress of 2/3) | |
| Allowable bending stress at root $\sigma_{Flim}$ (kgf/mm$^2$) | 19 | |
| 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°C) |
| Gear support | Symmetric support by bearings |
| Allowable Hertz stress $\sigma_{Hlim}$ (kgf/mm$^2$) | 49 |
| Safety factor $S_H$ | 1.15 |

[NOTE 1] The gear strength formula is based on JGMA (Japanese Gear Manufacturers Association) specifications.
The units for the rotational speed (rpm) and the stress (kgf/mm$^2$) are adjusted to the units needed in the formula.

# Application Hints

In order to use KHK stock internal gears safely, read the Application Hints carefully before proceeding.
Please refer to Page 52 for “Cautions on Handling” and Page 53 for “Cautions on Starting”.
Please read “Cautions on Performing Secondary Operations” below when performing modifications and/or secondary operations for safety concerns.
Avoid performing secondary operations that narrow the tooth width, as it affects precision and strength.

## 1. Caution on Performing Secondary Operations

① If performing outer diameter machining, it is important to pay special attention to locating the center in order to avoid runout.
② Please exercise caution not to cause deformation when chucking the outer diameter. Gear precision may deteriorate and cause trouble.

## 2. Points of Caution during Assembly

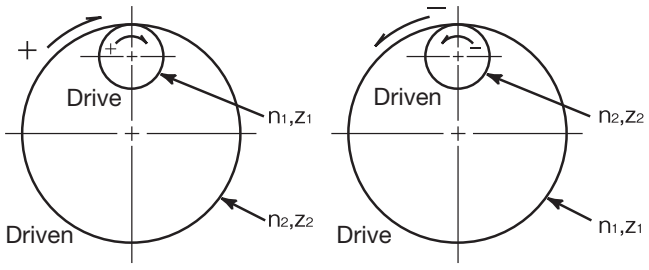
① KHK stock internal gears are designed to give the proper normal direction backlash when assembled using the center distance given by the formula below. The amount of backlash is given in the dimension table for each gear.

$$a = \frac{d_2 - d_1}{2}$$

Where
$a$ : Center distance
$d_1$ : Pitch diameter of pinion
$d_2$ : Pitch diameter of internal gear

② Refer to the figure below for the direction of rotation of internal gears.

### Gear Ratio and Direction of Rotation




Gear Ratio $i = \frac{z_2}{z_1} = \frac{n_1}{n_2}$

$z$ : No. of teeth
$n$ : Rotational speed

③ To use as a planetary gear drive, the following conditions must be satisfied.

### Gear tooth conditions for planetary gear mechanisms

● Condition 1: $z_c = z_a + 2z_b$

● Condition 2: $\frac{z_a + z_c}{N}$ = Integer

● Condition 3: $z_b + 2 < (z_a + z_b) \sin\frac{180°}{N}$

$z_a$ : No. of teeth of Sun Gear
$z_b$ : No. of teeth of Planetary Gears
$z_c$ : No. of teeth of Internal Gear
$N$ : No. of Planetary Gears

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

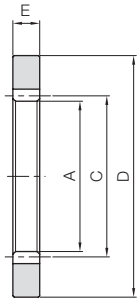
1. When using KHK products, follow relevant safety regulations (Occupational Safety and Health Regulations, etc.).
2. Pay attention to the following items when installing, removing, or performing maintenance and inspection of the product.
   ① Turn off the power switch.
   ② Do not reach or crawl under 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 ISO9001 quality management system; if you notice any malfunctions upon purchasing a product, please contact the supplier.

| Specifications | |
|---|---|
| Precision grade | JIS grade N8 (JIS B1702-1: 1998)* |
| Gear teeth | Standard full depth |
| Pressure angle | 20° |
| Material | S45C |
| Heat treatment | — |
| Tooth hardness | (less than 194HB) |
| Surface treatment | Black oxide coating |

* The precision grade of products with a module of less than 0.8 is equivalent to the value shown in the table.




T1

| Catalog Number | Module | No. of teeth | Shape | Outside dia. A | Pitch dia. C | Outside dia. D | Face width E | Allowable torque (N·m) Bending strength | Allowable torque (N·m) Surface durability | Allowable torque (kgf·m) Bending strength | Allowable torque (kgf·m) Surface durability | Backlash (mm) | Weight (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SI0.5-60** | ***m*0.5** | 60 | T1 | 29 | 30 | 50 | 5 | 3.75 | 0.67 | 0.38 | 0.068 | 0.04~0.15 | 0.049 |
| **SI0.5-80** | | 80 | | 39 | 40 | 60 | | 4.85 | 0.75 | 0.49 | 0.077 | | 0.062 |
| **SI0.5-100** | | 100 | | 49 | 50 | 70 | | 5.97 | 0.87 | 0.61 | 0.089 | | 0.074 |
| **SI0.8-60** | ***m*0.8** | 60 | | 46.4 | 48 | 75 | 8 | 15.4 | 2.87 | 1.57 | 0.29 | 0.05~0.16 | 0.16 |
| **SI0.8-80** | | 80 | | 62.4 | 64 | 90 | | 19.9 | 3.24 | 2.03 | 0.33 | | 0.20 |
| **SI0.8-100** | | 100 | | 78.4 | 80 | 105 | | 24.5 | 3.75 | 2.50 | 0.38 | | 0.23 |
| **SI1-60** | ***m*1** | 60 | | 58 | 60 | 90 | 10 | 30.0 | 5.95 | 3.06 | 0.61 | 0.09~0.21 | 0.28 |
| **SI1-80** | | 80 | | 78 | 80 | 110 | | 38.8 | 6.59 | 3.96 | 0.67 | | 0.35 |
| **SI1-100** | | 100 | | 98 | 100 | 130 | | 47.8 | 7.64 | 4.87 | 0.78 | | 0.43 |
| **SI1.5-60** | ***m*1.5** | 60 | | 87 | 90 | 130 | 15 | 101 | 20.6 | 10.3 | 2.10 | 0.11~0.25 | 0.81 |
| **SI1.5-80** | | 80 | | 117 | 120 | 160 | | 131 | 23.3 | 13.4 | 2.38 | | 1.04 |
| **SI1.5-100** | | 100 | | 147 | 150 | 190 | | 161 | 27.0 | 16.5 | 2.75 | | 1.26 |
| **SI2-60** | ***m*2** | 60 | | 116 | 120 | 170 | 20 | 240 | 50.5 | 24.5 | 5.15 | 0.12~0.28 | 1.79 |
| **SI2-80** | | 80 | | 156 | 160 | 210 | | 311 | 57.0 | 31.7 | 5.81 | | 2.28 |
| **SI2-100** | | 100 | | 196 | 200 | 250 | | 382 | 65.7 | 39.0 | 6.70 | | 2.77 |
| **SI2.5-60** | ***m*2.5** | 60 | | 145 | 150 | 210 | 25 | 469 | 101 | 47.8 | 10.3 | 0.14~0.31 | 3.33 |
| **SI2.5-80** | | 80 | | 195 | 200 | 260 | | 607 | 114 | 61.9 | 11.6 | | 4.25 |

[Caution on Product Characteristics] ① The backlash values shown in the table are the theoretical values for the normal direction for the internal ring in mesh with an SS spur gear.
② The allowable torques shown in the table are calculated values according to the assumed usage conditions. Please see Page 209 for more details.
③ Please check for the involute interference, trochoid interference and trimming interference prior to using internal gears.

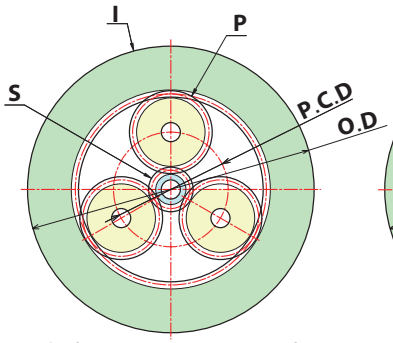
## Ground internal gears are available.



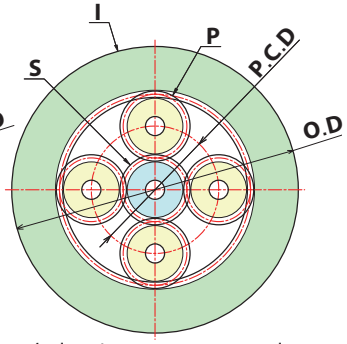

Klingelnberg Gear Grinding Machine VIPER 500W

| Internal ground gear machining range | |
|---|---|
| Maximum gear accuracy | JIS B 1702-1:1998 Grade N5 (former JIS Grade 1) |
| Maximum module | About m4 (DP6, CP12), special sizes available |
| Max. helix angle | 27°, right/left helix direction available |
| Maximum outer diameter | $\phi$ 500mm |
| Minimum inner diameter | $\phi$ 150mm |
| Maximum weight | 500 kgf (jig weight included) |

# Planetary Gear Systems created by using KHK Stock Gears



3 planetary gears are used



4 planetary gears are used

KHK's stock internal and spur gears working together will allow you to create planetary gear devices.
"In the table below, we introduce examples of planetary gear
The Speed ratio Note 1 are for planetary gear systems created with a stationary internal gear. When used as speed reducers, the input is the sun gear and the output is the carrier.
"Selection of the number of teeth also enables you to create various planetary gear devices with different transmission

| Speed ratio Note 1 | Stock gears used in the system | | | | | | | | | | Allowable transmission torque (kgf·m) | | | | Total weight (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Internal gears ( I ) | | | Planetary gears ( P ) | | | | | Sun gear ( S ) | | Sun gear_$T_1$ | | Planetary carrier _$T_2$ | | |
| | OD(mm) | Catalog Number | No. of teeth | Catalog Number | No. of teeth | Quantity | P.C.D(mm) | Equal angles | Catalog Number | No. of teeth | Bending strength | Surface durability | Bending strength | Surface durability | |
| 6 | 90 | SI1-60 | 60 | SSA1-24 | 24 | 3 | 36 | 120° | SSS1-12 | 12 | 0.58 | 0.0023 | 3.47 | 0.11 | 0.48 |
| | 130 | SI1.5-60 | | SSA1.5-24 | | | 54 | | SS1.5-12 | | 1.77 | 0.0081 | 10.7 | 0.40 | 1.20 |
| | 170 | SI2-60 | | SSA2-24 | | | 72 | | SS2-12 | | 4.21 | 0.020 | 25.2 | 0.99 | 2.66 |
| | 210 | SI2.5-60 | | SSA2.5-24 | | | 90 | | SS2.5-12 | | 8.21 | 0.040 | 49.3 | 1.98 | 5.03 |
| | 110 | SI1-80 | 80 | SSA1-32 | 32 | 3 | 48 | 120° | SS1-16 | 16 | 0.99 | 0.0047 | 5.96 | 0.24 | 0.57 |
| | 160 | SI1.5-80 | | SSA1.5-32 | | | 72 | | SS1.5-16 | | 3.35 | 0.026 | 20.1 | 1.32 | 1.72 |
| | 210 | SI2-80 | | SSA2-32 | | | 96 | | SS2-16 | | 7.95 | 0.064 | 47.7 | 3.22 | 3.85 |
| | 260 | SI2.5-80 | | SSA2.5-32 | | | 120 | | SS2.5-16 | | 15.5 | 0.13 | 93.2 | 6.45 | 7.33 |
| | 105 | SI0.8-100 | 100 | SS0.8-40A | 40 | 4 | 48 | 90° | SS0.8-20A | 20 | 0.95 | 0.0082 | 5.68 | 0.41 | 0.59 |
| | 130 | SI1-100 | | SSA1-40 | | | 60 | | SS1-20 | | 1.85 | 0.016 | 11.1 | 0.82 | 0.84 |
| | 190 | SI1.5-100 | | SSA1.5-40 | | | 90 | | SS1.5-20 | | 6.24 | 0.058 | 37.5 | 2.90 | 2.62 |
| | 250 | SI2-100 | | SSA2-40 | | | 120 | | SS2-20 | | 14.8 | 0.14 | 88.8 | 7.09 | 6.01 |
| 5 | 60 | SI0.5-80 | 80 | SS0.5-30B | 30 | 4 | 25 | 90° | SS0.5-20A | 20 | 0.23 | 0.0012 | 1.13 | 0.070 | 0.12 |
| | 90 | SI0.8-80 | | SS0.8-30C | | | 40 | | SS0.8-20A | | 0.93 | 0.0050 | 4.65 | 0.30 | 0.40 |
| | 110 | SI1-80 | | SSA1-30 | | | 50 | | SS1-20 | | 1.82 | 0.010 | 9.08 | 0.60 | 0.59 |
| | 160 | SI1.5-80 | | SSA1.5-30 | | | 75 | | SS1.5-20 | | 6.13 | 0.035 | 30.63 | 2.13 | 1.86 |
| | 210 | SI2-80 | | SSA2-30 | | | 100 | | SS2-20 | | 14.5 | 0.087 | 72.6 | 5.21 | 4.18 |
| | 260 | SI2.5-80 | | SSA2.5-30 | | | 125 | | SS2.5-20 | | 28.4 | 0.17 | 142 | 10.4 | 7.97 |
| 3 | 60 | SI0.5-80 | 80 | SS0.5-20A | 20 | 4 | 30 | 90° | Ⓜ SSG0.5-40B | 40 | 0.46 | 0.0016 | 1.39 | 0.10 | 0.13 |
| | 90 | SI0.8-80 | | SS0.8-20A | | | 48 | | SS0.8-40A | | 1.89 | 0.0068 | 5.68 | 0.41 | 0.35 |
| | 110 | SI1-80 | | SSA1-20 | | | 60 | | SS1-40 | | 3.70 | 0.014 | 11.1 | 0.82 | 0.60 |
| | 160 | SI1.5-80 | | SSA1.5-20 | | | 90 | | SS1.5-40 | | 12.5 | 0.048 | 37.5 | 2.91 | 1.77 |
| | 210 | SI2-80 | | SSA2-20 | | | 120 | | SS2-40 | | 29.6 | 0.12 | 88.8 | 7.12 | 3.93 |
| | 260 | SI2.5-80 | | SSA2.5-20 | | | 150 | | SS2.5-40 | | 57.8 | 0.24 | 173 | 14.3 | 7.47 |
| | 70 | SI0.5-100 | 100 | SS0.5-25B | 25 | 3 | 37.5 | 120° | SS0.5-50B | 50 | 0.47 | 0.0020 | 1.42 | 0.12 | 0.16 |
| | 130 | SI1-100 | | SSA1-25 | | | 75 | | SS1-50 | | 3.79 | 0.017 | 11.4 | 1.01 | 0.75 |
| | 190 | SI1.5-100 | | SSA1.5-25 | | | 112.5 | | SS1.5-50 | | 12.8 | 0.060 | 38.4 | 3.58 | 2.24 |
| | 250 | SI2-100 | | SSA2-25 | | | 150 | | SS2-50 | | 30.4 | 0.15 | 91.1 | 8.79 | 5.02 |

Ⓜ ··· Made to Order

## Calculation of Allowable Transmission Torque

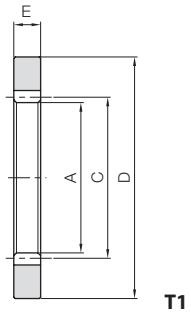
One advantage of a planetary gear system is that they share load burdens by grouping multiple planetary gears.
This enables high torque capacity transmission.
The following formula is the calculation method for T1 (Allowable transmission torque of Sun Gear) and T2 (Allowable transmission torque of Planetary Carrier), shown in the table.

$T1=Ts \cdot Zp \cdot \eta$ (kgf·m) ····· ( 1 )
$T2=Ts \cdot Zp \cdot u \cdot \eta$ (kgf·m) ····· ( 2 )

Here,

Ts : Allowable transmission torque for a Sun gear (kgf·m) on a meshed pair of sun gear and planetary gear.
For a sun gear meshed with a planetary gear, the number of revolutions is set to 100rpm.
Zp : Number of planetary gears used in the system
u : Speed ratio
$\eta$ : Contact efficiency for torque transmission
In consideration of machining accuracy, variation in tooth thickness or other factors on the planetary carrier, the contact efficiency is set to 75%.

| Specifications | |
|---|---|
| Precision grade | JIS grade N9 (JIS B1702-1: 1998) |
| Gear teeth | Standard full depth |
| Pressure angle | 20° |
| Material | S45C |
| Heat treatment | — |
| Tooth hardness | (less than 194HB) |
| Surface treatment | Black oxide coating |



T1

| Catalog Number | Module | No. of teeth | Shape | Outside dia. A | Pitch dia. C | Outside dia. D | Face width E | Allowable torque (N·m) Bending strength | Allowable torque (N·m) Surface durability | Allowable torque (kgf·m) Bending strength | Allowable torque (kgf·m) Surface durability | Backlash (mm) | Weight (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SIR2-120** | ***m*2** | 120 | T1 | 236 | 240 | 286 | 20 | 413 | 68.8 | 42.1 | 7.02 | 0.12~0.28 | 2.98 |
| **SIR2-200** | | 200 | | 396 | 400 | 446 | | 677 | 110 | 69.0 | 11.2 | | 4.80 |
| **SIR2.5-120** | ***m*2.5** | 120 | | 295 | 300 | 355 | 25 | 807 | 138 | 82.3 | 14.0 | 0.14~0.31 | 5.55 |
| **SIR2.5-200** | | 200 | | 495 | 500 | 555 | | 1320 | 220 | 135 | 22.5 | | 8.94 |
| **SIR3-120** | ***m*3** | 120 | | 354 | 360 | 424 | 30 | 1390 | 244 | 142 | 24.9 | 0.15~0.35 | 9.28 |
| **SIR3-160** | | 160 | | 474 | 480 | 544 | | 1840 | 315 | 188 | 32.1 | | 12.1 |

[Caution on Product Characteristics] ① The backlash values shown in the table are the theoretical values for the normal direction for the internal ring in mesh with an SS spur gear.
② The allowable torques shown in the table are calculated values according to the assumed usage conditions. Please see Page 209 for more details.
③ Please check for the involute interference, trochoid interference and trimming interference prior to using internal gears.

## Established equipment and technology Custom gears are also available.

Module 0.5~4, Tooth diameter ϕ150mm or more
Outside diameter ϕ700mm or less, weight 40kg or less

Gear cutting by CNC Gear Shaper