# 1. Motor and Inertia Load

- The equation to calculate the toque that is required for the motor to make the inertia load start rotating is as follows.

$$T = J\alpha = J \cdot \frac{d\omega}{dt} = \frac{GD^2}{4g} \cdot \frac{d\omega}{dt} = \frac{2\pi}{60} \cdot \frac{GD^2}{4g} \cdot \frac{dn}{dt}$$

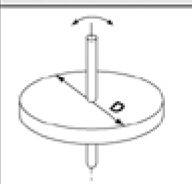
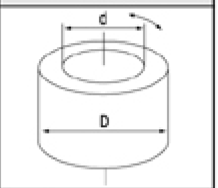
T : Torque
J : Inertia moment
ω : Angular velocity
t : Time
n : Rotational velocity
GD2 : Flywheel effect [GD2 = 4gl]
g : Gravitational acceleration (g = 9.8[m/sec2])
α : Angular acceleration

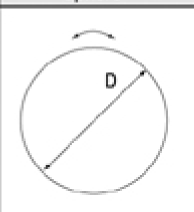
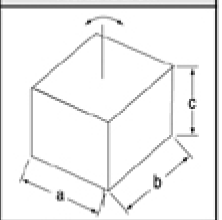
- In case of an induction motor, the starting torque would be changed by rotating speed.
- Thus, the average value of it that from the starting speed to the normal constant speed is called an average acceleration torque, a value commonly used in practice.
- The average acceleration torque TA required for the inertia load GD2 to be accelerated up to the speed n[r/min] within t[sec] is represented by the following equation.

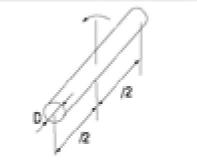
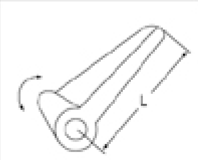
$$T_A = \frac{GD^2}{37500} \times \frac{n}{t} [kgf.cm]$$

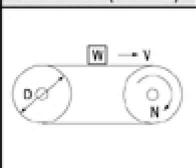
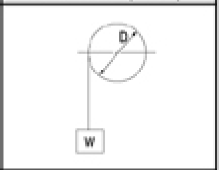
# 2. Calculation of Flywheel Effect [GD2]

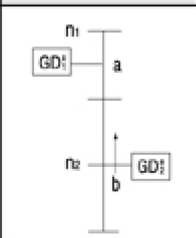
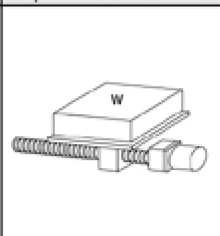
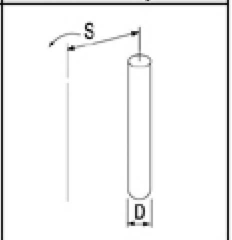
- In case that a load is acquired through the connection of a gearhead, the motor shaft component of the load inertia should be calculated to select the motor.
- Also, the calculation method of GD2 is different depending on the type of a load, and the following table provides GD2 calculation method for each shape.

| | Circular Disk | Hollow |
|---|---|---|
| Shape |  |  |
| $GD^2$ Equation | $GD^2 = \frac{1}{2} WD^2 [kgf \cdot Ucm^2]$<br>W : Mass[kgf]<br>D : Outer Diameter[cm] | $GD^2 = \frac{1}{2} W(D^2+d^2) [kgf \cdot Ucm^2]$<br>W : Mass[kgf] d : Inner Diameter[cm]<br>D : Outer Diameter[cm] |

| | Sphere | Hexahedron |
|---|---|---|
| Shape |  |  |
| $GD^2$ Equation | $GD^2 = \frac{2}{5} WD^2 [kgf \cdot cm^2]$<br>W : Mass[kgf]<br>D : Diameter[cm] | $GD^2 = \frac{1}{3} W(a^2+b^2) [kgf \cdot cm^2]$<br>W : Mass[kgf]<br>a, b : Length of Side [cm] |

| | POLE | |
|---|---|---|
| Shape |  |  |
| $GD^2$ Equation | $GD^2 = W(\frac{D^2}{4} + \frac{\ell^2}{3})$ [kgf·Ucm²]<br>W: Mass[kgf] D:Outer Diameter[cm]<br>ℓ: Length [cm] | $GD^2 = \frac{4}{3} WL^2$[kgf·Ucm²]<br>W : Mass [kgf]<br>L : Length[cm] |

| | Linear Motion (Horizontal) | Linear Motion (Vertical) |
|---|---|---|
| Shape |  |  |
| $GD^2$ Equation | $GD^2 = WD^2$[kgf·cm²] $= \frac{WV^2}{N^2}$<br>V : CONVEYOR SPEED [cm/min]<br>N : DRUM ROTATIONALSPEED [rpm]<br>W : WEIGHT OVER CONVEYOR<br>D : DRUM OUTSIDE Diameter[cm]<br>(Not included $GD^2$ for belt and drum) | $GD^2 = WD^2$ [kgf·Ucm²]<br>W : Mass [kgf]<br>D : Diameter [cm] |

| | Gearhead | Operation of ball screw | $GD^2$of arbitrary shaft |
|---|---|---|---|
| Shape |  |  |  |
| $GD^2$ Equation | a axis component of total $GD^2$<br>$GD^2_a = GD^2_a + (\frac{n_2}{n_1})^2$<br>$GD^2_b$ [kgf·cm²]<br>$n_1$: Rotational speed of a-axis<br>$n_2$: Rotational speed of b-axis<br>Reduction ratio is $\frac{n_2}{n_1}$ (i > 1) | $GD^2_1 = GD^2 + \frac{WP^2}{\pi^2}$<br>$GD^2_1$ : $GD^2$ of BALL SCREW $GD^2$[kgf·cm²]<br>P : PITCH of BALL SCREW<br>W : Total weight of table and work | $GD^2 = GD^2 + 4WS^2$ [kgf·cm]<br>D : Diameter [cm]<br>W : Mass [kg]<br>S : Radius of Rotation [cm] |

- When the brake motor is used, the inertia moment of a load has a greater impact on stop time, overrun and stop precision. The relationship between the inertia moment J and the flywheel effect GD2 is expressed as the following equation.

$$GD^2 = 4\ J\ [kgf \cdot cm],$$

$GD^2$ : FAYWHEEL EFFECT
J : INERITA MOMENT

- When the deceleration is applied using a gearhead, the motor shaft component of GD2 is represented by 1/(gear ratio)² The equation is as follows.

$$GD^2 = \frac{1}{i^2} \times GD_L{}^2 [kgf \cdot cm^2]$$

$GD_M$ : MOTOR AXIS COMPONENT OF $GD^2$
$GD_L{}^2$ : ASSEMBLED LOAD OF $GD^2$ON GEARHEAD
i : REDUCTION RATIO OF A GEARHEAD

- For example, if a gearhead with a ratio of 1/18 is used and the inertia of a load (GDL2) is 1000[kgf.cm²], the component of the motor shaft is

$$GD_M{}^2 = \frac{1}{18^2} \times 1000 = 3.1 [kgf \cdot cm^2]$$

- If converted to SI units of the inertia moment, the inertia moment is expressed as I in SI units and this is represented as an equation below.

$$1 = \frac{GD^2}{4g} \; [kgf \cdot cm^2]$$

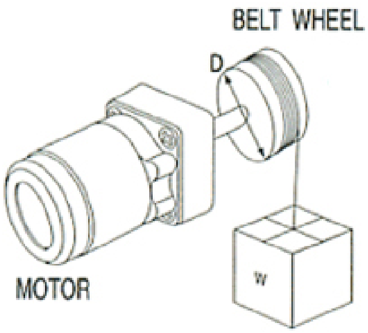
g : Gravitational acceleration 9.80665 [$m/sec^2$]

| SIZE | output | MOTOR |
| --- | --- | --- |
| | | $GD^2$ ($kgf \cdot cm^2$) |
| 60 | 3W | 0.19 |
| 60 | 6W | 0.25 |
| 70 | 15W | 0.57 |
| 80 | 15W,25W | 1.20 |
| 90 | 40W | 3.00 |
| 90 | 60W | 4.60 |
| 90 | 90W,120W,150W | 4.60 |
| 90 | 180W,200W | 6.00 |

## Explicit Calculation Method of Motor Capacity

- The following explanations describe how the required capacity for a motor can be calculated. We explained here is a basic equation in a general circumstance.
- Hence, when selecting a motor in reality, the following points should be taken into consideration. The acceleration at starting time, the power required for a instantaneously imposing large load, or the safety measures implemented at design and manufacturing levels, and the impact of changing voltage.

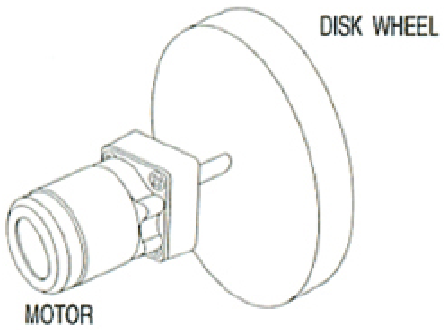
(1) In case of rolling up load




$$T = \frac{1}{2} D \cdot W \; [kgf \cdot m]$$

D : Drum [m]
W : Weight [kgf]

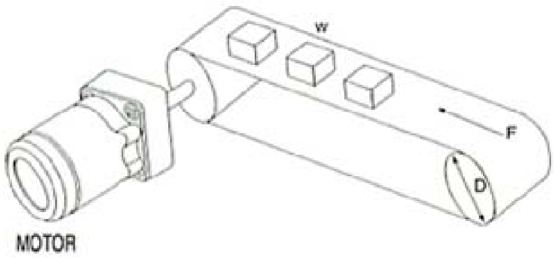
(2) In case of opration inertia mass




$$T = \frac{GD^2}{37500} \times \frac{N}{t} \; [kgf \cdot cm]$$

N : Revolutions per minute [m]
GD : Disk wheel effect [$kgf \cdot cm^2$]
t : Time [sec]

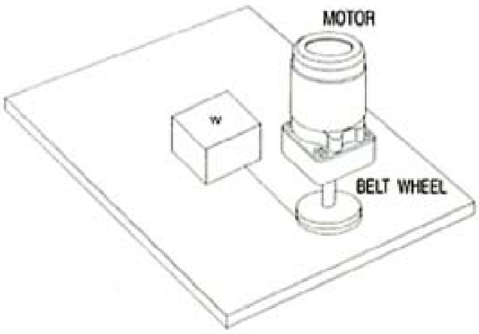
### (3) In case of belt conveyor




$$T = \frac{1}{2} D(F+\mu W)\ [kgf \cdot m]$$

D : Drum [m]
W : Mass of belt in unit length [kgf/m]
$\mu$ : Coefficient of triction
F : [kgf]

### (4) A case of moving an object horizontally on the surface

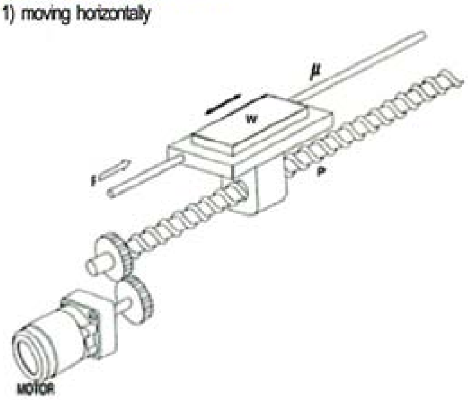



$$T = \frac{1}{2} D \cdot \mu W\ [kgf \cdot m]$$

W : Weight [kgf]
$\mu$ : Coefficient of triction
F : WHEEL

### (5) In case of driving a ball screw

1) moving horizontally




$$T = \frac{1}{2\pi} P(F+\mu W)\ [kgf \cdot m]$$

F : Cutting force [kgf]
W : Work Mass + Table Mass [kgf]
$\mu$ : Coefficient of sliding friction in the slide guide surface [0.01]
P : BALL SCREW LEAD [m]