Selection Method

Use the following procedure to select the model.

Step 1 Oscillating time confirmation

↓

Step 2 Size (torque) selection
(1) Static load
(2) Resistive load
(3) Inertial load

↓

Step 3 Allowable energy confirmation

↓

Step 4 Allowable load confirmation *
(1) Thrust load
(2) Radial load
(3) Momentum

* Consider SFRT only.

Step 1 Oscillating time confirmation

If the oscillating time is set outside the range stipulated in the specifications, actuator operation will be unstable, possibly resulting in actuator damage. Always operate within the oscillating time adjustment range stipulated in the specifications.

Step 2 Size (torque) selection

Models are categorized largely into three sizes based on the load type.
Calculate the required torque in each case. In the case of combined loads, calculate the required torque based on the combined total torque.
Select a size which satisfies the required torque from the execution torque drawing based on the pressure used.

(1) Static load (T_S)
If a static pressing force such as a clamp is required

$$T_S = F_S \times L$$

T_S : Required torque (N·m)
F_S : Required force (N)
L : Length from rotation center to point of action (m)

(2) Resistive load (T_R)
If an external force such as frictional force or gravity is applied (* See drawing on right)

$$T_R = K \times F_R \times L$$

T_R : Required torque (N·m)
K : Margin coefficient [No load variation : K = 2; Load variation : K = 5
F_R : Required force (N)
L : Length from rotation center to point of action (m)

(3) Inertial load (TA)
If rotating the body

$$T_A = 5 \times I \times \dot{\omega}$$
$$\dot{\omega} = \frac{2\theta}{t^2}$$

T_A : Required torque (N·m)
I : Inertial moment (kg/m^2)
$\dot{\omega}$: Max. angular acceleration (rad/s^2)
θ : Oscillating angle (rad)
t : Oscillating time (s)

Calculate inertial moment using the inertial moment and swing time adjustment range (page 1), or the inertial moment calculation drawings (pages 19, 20), etc.

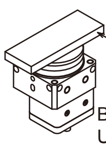
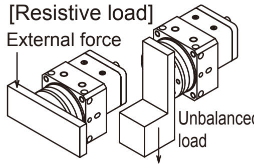
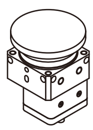
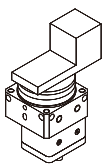
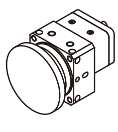
Step 3 Allowable energy confirmation

In the case of an inertial load, the actuator may be damaged if the load kinetic energy at the oscillation end exceeds the allowable value. Select the model based on the specifications to ensure that the kinetic energy lies within the allowable value.
If the energy is too great, use an external shock canceller, etc. to reduce the load.

$$E = \frac{1}{2} \times I \times \omega^2$$
$$\omega = \frac{2\theta}{t}$$

E : Kinetic energy (J)
I : Inertial moment (kg/m^2)
ω : Angular speed (rad/s) at oscillation end
θ : Oscillating angle (rad)
t : Oscillating time (s)

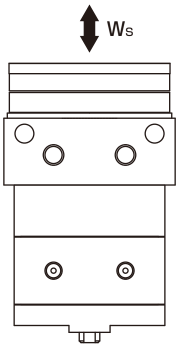
Calculate inertial moment using the inertial moment and oscillating time adjustment range (page 1), or the inertial moment calculation drawings (pages 19, 20), etc.

Resistance torque calculation	Horizontal load	Vertical load
Required	[Resistive load]  External force, Balanced load, Unbalanced load	[Resistive load]  External force, Unbalanced load, Balanced load, Gravity
Not required	[No resistive load] Balanced load  Unbalanced load 	[No resistive load]  Balanced load

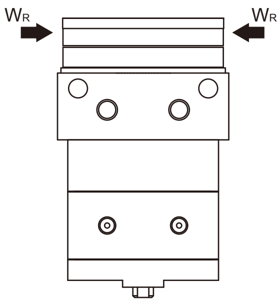
Selection Method

Step 4 Allowable load confirmation

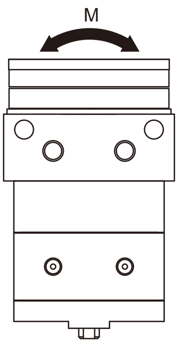
If a load is applied to the shaft or table directly, ensure that it lies within the allowable value indicated in the specifications.
And in the case of combined loads, ensure that the total ratio with respect to allowable value for each load is 1.0 or less.
Loads are categorized into the three following types.
(1) Thrust load (shaft direction load)



(2) Radial load (lateral direction load)



(3) Momentum



After calculating each load, substitute each value into the following equation to confirm.

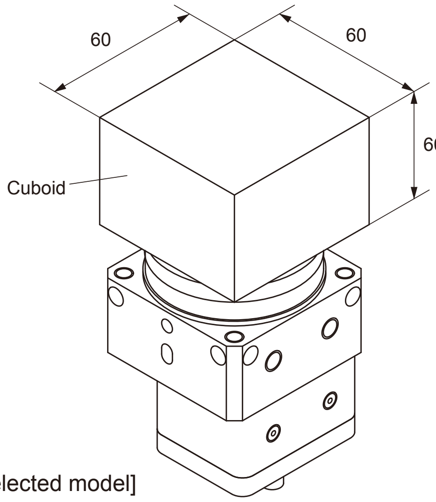
$$\frac{W_S}{W_{Smax}} + \frac{W_R}{W_{Rmax}} + \frac{M}{M_{max}} \leqq 1.0$$

W_S : Thrust load (N)
W_R : Radial load (N)
M : Momentum (N·m)
W_{Smax} : Allowable thrust load (N)
W_{Rmax} : Allowable radial load (N)
M_{max} : Allowable momentum (N·m)

* For SFR, consider a method of usage that does not involve directly applying loads to the shaft.

Selection Example (1)

If there is a cuboid load



[Selected model]
SFRT
[Operating conditions]
Pressure : 0.5(MPa)
Oscillating angle : 90°
Oscillating time : 0.6 (s)
Load (Cuboid) : 0.5 (kg), (aluminum alloy)

Step 1 Oscillating time confirmation

The oscillating time from the operating conditions is 0.6 (s/90°). As this is within the oscillating time adjustment range of 0.07 to 1.5 (s/90°), proceed to the next step.

Step 2 Size (torque) selection

As the load involved is an inertial load, first calculate the inertial moment (I).
[Cuboid]

$$I = 0.5 \times \frac{0.06^2}{6} = 3\times10^{-4}\ (kg\cdot m^2) \quad ......(1)$$

Next, calculate the maximum angular acceleration ($\dot{\omega}$).

From the conditions, $\theta = 90° = \frac{\pi}{2}$ (rad), t=0.6(s)

Consequently,

$$\dot{\omega} = \frac{2\theta}{t^2} = \frac{\pi}{0.6^2} = 8.73(rad/s^2) \quad ......(2)$$

Thus, the inertial load (T_A) from (1) and (2) is,

$T_A = 5 \times 3 \times 10^{-4} \times 8.37$
$= 0.0131$ (N·m) ....(3)

From the value in (3) and operating conditions, as well as the torque when the pressure is 0.5(MPa),

SFRT - 3 - 90 ....(A)

can be selected.

Step 3 Allowable energy confirmation

Calculate kinetic energy, and ensure that it is within the kinetic energy value.
Calculate angular speed ω at the swing end.

From the conditions, $\theta = 90° = \frac{\pi}{2}$ (rad), t=0.6(s)
Consequently,

$$\omega = \frac{2\theta}{t} = \frac{\pi}{0.6} = 5.24(rad/s)$$

Thus, kinetic energy (E) is,

$$E = \frac{1}{2} \times 3\times10^{-4} \times 5.24^2 \times 10^3$$
$$= 4.12(mJ) \quad ....(4)$$

From (A) selected at (4) and Step 2,

SFRT-10-90 ....(B)

can be selected.

Step 4 Permissible load confirmation

Finally, calculate the load value applied to the table, and ensure that it lies within the allowable load value.
[Thrust load]
Thrust load (Ws) is,
$W_{RS} = 0.5 \times 9.8 = 4.9$ (N) ....(5)
[Radial load]
As no radial load is applied,
$W_R = 0$ (N) ....(6)
[Momentum]
As no momentum is applied,
M = 0 (N·m) ....(7)
From (5), (6), (7), and (B),

$$\frac{W_s}{W_{smax}} + \frac{W_R}{W_{Rmax}} + \frac{M}{M_{max}}$$
$$= \frac{4.9}{60} + \frac{0}{50} + \frac{0}{0.9} = 0.082 \leqq 1.0 \quad ......(C)$$

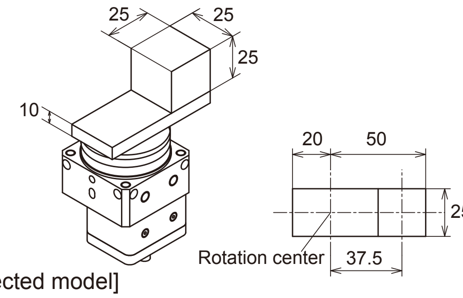
From (B) and (C), as the total load is within the allowable load value,

SFRT-10-90

can be selected.

Selection Example (2)

If there is a cuboid load on the rectangular plate



[Selected model]
SFRT
[Operating conditions]
Pressure : 0.5(MPa)
Oscillating angle: 90°
Oscillating time: 0.4 (s)
Load 1 (Rectangular plate on left side of rotation center) : 0.04 (kg), (steel)
Load 2 (Rectangular plate on right side of rotation center) : 0.1 (kg), (steel)
Load 3 (Cuboid) : 0.12 (kg), (steel)

Step 1 Oscillating time confirmation

The oscillating time from the operating conditions is 0.4 (s/90°). As this is within the oscillating time adjustment range of 0.07 to 1.5 (s/90°), proceed to the next step.

Step 2 Size (torque) selection

As the load involved is an inertial load, first calculate the inertial moment (I).
[Rectangular plate]

$$I_1=0.1\times\frac{4\times0.05^2+0.025^2}{12}+0.04\times\frac{4\times0.02^2+0.025^2}{12}=9.60\times10^{-5}(kg\cdot m^2)$$

[Cube]

$$I_2=0.12\times\frac{0.025^2}{6}+0.12\times0.0375^2=1.81\times10^{-4}(kg\cdot m^2)$$

Consequently, the overall inertial moment (I) will be as follows.
$I = I1 + I2 = 2.77 \times 10^{-4}$ (kg/m^2) ....(1)
Next, calculate the maximum angular acceleration ($\dot{\omega}$).
From the conditions, $\theta=90°=\frac{\pi}{2}(rad)$, $t=0.4(s)$
Consequently,

$$\dot{\omega}=\frac{2\theta}{t^2}=\frac{\pi}{0.4^2}=19.63(rad/s^2)$$ ....(2)

Thus, the inertial load (T_A) from (1) and (2) is,
$T_A = 5 \times 2.77 \times 10^{-4} \times 19.63$
$= 0.027$ (N·m) ....(3)
Based on the value in (3) and operating conditions, from the torque when the pressure is 0.5(MPa),

| SFRT - 3 - 90 | ....(A)

can be selected.

Step 3 Allowable energy confirmation

Calculate kinetic energy, and ensure that it is within the kinetic energy value.
Calculate angular speed ω at the oscillation end.
From the conditions, $\theta=90°=\frac{\pi}{2}(rad)$, $t=0.4(s)$
Consequently,

$$\omega=\frac{2\theta}{t}=\frac{\pi}{0.4}=7.85(rad/s)$$

Thus, kinetic energy (E) is,

$$E=\frac{1}{2}\times2.77\times10^{-4}\times7.85^2\times10^3$$
$$=8.53(mJ)$$ ....(4)

From (A) selected at (4) and Step 2,

| SFRT - 20 - 90 | ....(B)

can be selected.

Step 4 Allowable load confirmation

Finally, calculate the load value applied to the table, and ensure that it lies within the allowable load value.
[Thrust load]
The total weight is,
0.04 + 0.1 + 0.12 = 0.26 (kg)
Consequently, the thrust load (Ws) is,
Ws = 0.26 × 9.8 = 2.55 (N) ....(5)
[Radial load]
As no radial load is applied,
W_R = 0 (N) ....(6)
[Momentum]
The moment load (M_1) due to the rectangular plate is,
0.1 × 9.8 = 0.98 (N)
0.04 × 9.8 = 0.39 (N)
Consequently,
M_1 = 0.98 × 0.025 + 0.39 × 0.01
= 0.0284 (N·m)
The moment load (M_2) due to the cuboid is,
0.12 × 9.8 = 1.18 (N)
Consequently,
M_2 = 1.18 × 0.0375 + 0.044 (N·m)
Thus, the sum of M_1 and M_2 is,
M = 0.044 + 0.0284 = 0.0725 (N·m) ......(7)
From (5), (6), (7), and (B),

$$\frac{W_s}{W_{smax}}+\frac{W_R}{W_{Rmax}}+\frac{M}{M_{max}}$$
$$=\frac{2.55}{80}+\frac{0}{60}+\frac{0.0725}{2.9}=0.057>1.0$$

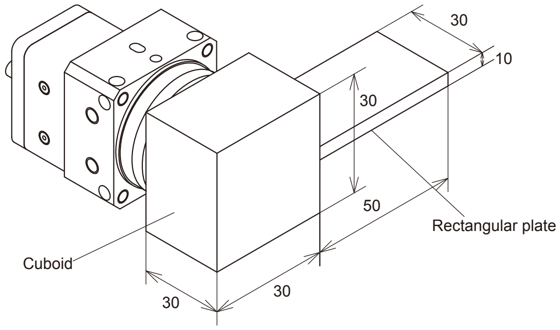
From (C), as the total load is within the allowable load value,

| SFRT - 20 - 90 |

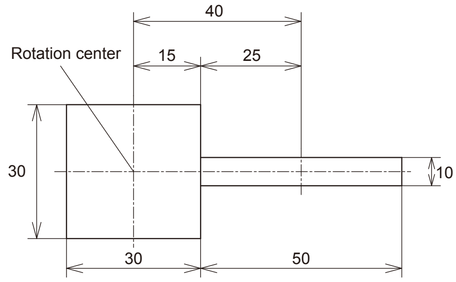
can be selected.

Selection Example (3)

If the rotary axis is horizontal, and the load is a rectangular plate



Load details



[Selected model]
SFRT
[Operating conditions]
Pressure : 0.5(MPa)
Oscillating angle: 180°
Oscillating time: 0.8 (s)
Load 1 (Rectangular plate) : 0.11 (kg), (steel)
Load 2 (Cuboid) : 0.21 (kg), (steel)

Step 1 Oscillating time confirmation

The oscillating time from the operating conditions is 0.8 (s/180°). As this is within the oscillating time adjustment range of 0.07 to 1.5 (s/180°), proceed to the next step.

Step 2 Size (torque) selection

As the loads involved are a resistive load generated by gravity, and an inertial load, calculate the resistive load (T_R) and inertial moment (I).

[Resistive load]
The resistive load varies as the table rotates.
F_R = 0.11 × 9.8 = 1.08 (N)
R = 0.04 (M)
Consequently,
T_R = 5 × 1.08 × 0.04 = 0.216 (N·m) ......(1)

[Inertial load]
[Rectangular plate]

$$I_1=\frac{0.11}{12}\times(0.01^2+0.05^2)+0.11\times0.04^2$$
$$=2.00\times10^{-4}(kg\cdot m^2)$$

[Cuboid section]

$$I_2=0.21\times\frac{0.03^2}{6}=3.15\times10^{-5}(kg\cdot m^2)$$

Consequently, the overall inertial moment (I) will be as follows.
I = I1 + I2 = 2.31×10^{-4} (kg/m^2) ....(2)
Next, calculate the maximum angular acceleration ($\dot{\omega}$).
From the conditions, θ = 180° = π (rad), t = 0.8 (s)
Consequently,

$$\dot{\omega}=\frac{2\theta}{t^2}=\frac{2\pi}{0.8^2}=9.81(rad/s^2) \quad ....(3)$$

Thus, the inertial load (T_A) from (2) and (3) is,
$T_A = 5 \times 2.31 \times 10^{-4} \times 9.81$
= 0.011 (N·m) ....(4)
The total torque (T) from (1) and (4) is,
T = 0.216 + 0.011 = 0.227 (N·m) ....(5)
Based on the value in (5) and operating conditions, from the torque when the pressure is 0.5(MPa),

SFR - 3 - 180	............................(A)

can be selected.

Step 3 Allowable energy confirmation

Calculate kinetic energy, and ensure that it is within the kinetic energy value.
Calculate angular speed ω at the oscillation end.
From the conditions, θ = 180° = π (rad), t = 8 (s)
Consequently,

$$\omega=\frac{2\theta}{t}=\frac{2\pi}{0.8}=7.85(rad/s)$$

Thus, kinetic energy (E) is

$$E=\frac{1}{2}\times2.31\times10^{-4}\times7.85^2\times10^3 \quad ....(6)$$
$$=7.13(mJ)$$

From A selected at (6) and Step 2,

SFR - 20 - 180	....................................(B)

can be selected.

Step 4 Allowable load confirmation

Finally, calculate the load value applied to the table, and ensure that it lies within the allowable load value.
[Thrust load]
As no thrust load is applied, thrust load (Ws) is,
W_S = 0 (N) ....(7)
[Radial load]
The total weight is,
0.11 + 0.21 = 0.32 (kg)
Consequently,
W_R = 0.32 × 9.8 = 3.14 (N) ....(8)
[Momentum]
Momentum (M) is,
M = 0.015 × (0.11 + 0.21) × 9.8
= 0.047 (N·m) ....(9)
From (7), (8), (9), and (B),

$$\frac{W_S}{W_{Smax}}+\frac{W_R}{W_{Rmax}}+\frac{M}{M_{max}}$$
$$=\frac{0}{80}+\frac{3.14}{60}+\frac{0.047}{2.9}=0.068\leqq1.0 \quad ......(C)$$

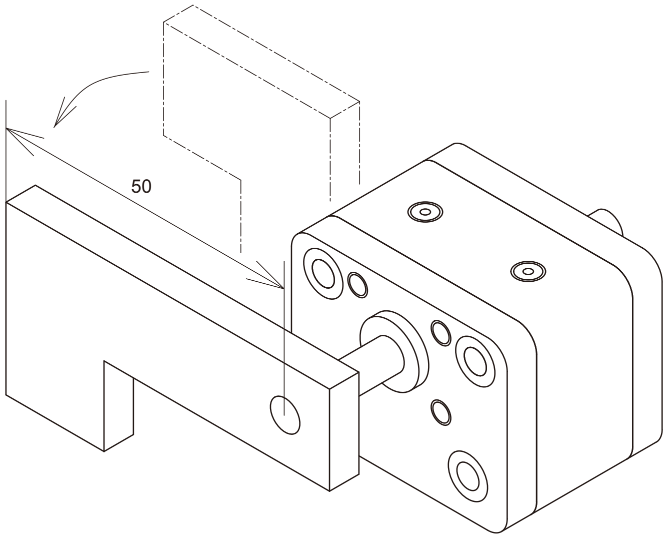
From (B) and (C), as the total load is within the allowable load value,

SFRT - 20 - 180

can be selected.

Selection Example (4)

If clamp



[Selected model]
SFR
[Operating conditions]

Pressure	0.5MPa
Oscillating angle	90°
Oscillating time	0.6s
Clamp lever weight	0.1kg
Clamp force	20N
Clamp position	50mm

Step 1 Oscillating time confirmation

The operation time based on the operating conditions is 0.6 (s/90°). As this is within the oscillating time adjustment range of 0.07 to 1.5 (s/90°), proceed to the next step.

Step 2 Size (torque) selection

As this is a static load, calculate the required torque.

F_S = Clamp force: 20 N
L = Clamp position: 0.050 m

$T_S = 20 \times 0.05 = 1.0\ N \cdot m$

Select SFR-10-90 based on the required torque.

Step 3 Allowable energy confirmation

Calculate kinetic energy, and ensure that it is within the allowable energy value.

Calculate the inertial moment I for the clamp lever.
[Rod (end is rotation center)]

$$I = M \times \frac{L^2}{3} = 0.1 \times \frac{0.05^2}{3}$$

$$= 0.0000833\ kg \cdot m^2$$

Calculate angular speed ω at the oscillation end.

$$\theta = 90° = \frac{\pi}{2}\ (rad)$$

$$t = 0.6s$$

$$\omega = \frac{2\theta}{t} = \frac{2\pi}{2 \times 0.6} = 5.236\ (rad/s)$$

Thus, kinetic energy (E) is,

$$E = \frac{1}{2} \times 8.33 \times 10^{-5} \times 5.236^2 \times 10^3$$

$$= 1.14\ (mJ)$$

Allowable energy is satisfied, and therefore SFR-10-90 can be selected.