Rotary actuator selection method

Select based on the following procedures

Step 1 Size (torque) selection
(1) Static load
(2) Resistance load
(3) Inertia load

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Step 2 Oscillating time confirmation

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STEP 3 Allowable energy confirmation

STEP 1 Size (torque) selection

Selection method is roughly categorized into three load.
In each case, the required torque must be calculated. If the load is a compound load, add each torque to calculate the required torque. Refer to the output table (effective torque table) and select the required torque size according to the working pressure.

(1) Static load (T_S)
When static pushing force is required for clamp, etc.

$T_S = F_S \times L$

T_S: Required torque (N·m)
F_S: Required force (N)
L : Length from center of rotation to pressure cone apex (m)

(2) Resistance load (T_R)
When force including frictional force, gravity or other external force is applied

$T_R = K \times F_R \times L$

T_R : Required torque (N·m)
K : Slack coefficient
When load does not fluctuate K=2
When load fluctuates K=5
F_R : Required force (N)
L : Length from center of rotation to pressure cone apex (m)

(3) Inertia load (T_A)
When the object is rotated

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

T_A: Required torque (N·m)
I : Moment of inertia ($kg \cdot m^2$)
$\dot{\omega}$: Angular acceleration (rad/s^2)
θ : Oscillating angle (rad)
t : Oscillating time (s)

Refer to the figure for moment of inertia calculation on page 1399 and calculate the moment of inertia.

Output table (effective torque)

Unit: N·m

Working pressure (MPa) / Model No.		0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Single vane	RV3S1	-	0.07	-0.10	0.12	0.15	0.18	-	-	-
	RV3S3	0.1	0.17	0.24	0.31	0.38	0.45	-	-	-
	RV3S10	0.35	0.56	0.75	0.98	1.2	1.39	-	-	-
	RV3S20	0.59	0.95	1.33	1.7	2.1	2.49	2.87	3.26	3.68
	RV3S30	1.1	1.8	2.5	3.19	4.1	4.8	5.8	6.5	7.2
	RV3S50	1.25	2.59	3.69	4.79	5.9	7	8.29	9.5	10.6
	RV3S150	5.5	8.5	11.5	15	18	21	24	27.3	30.5
	RV3S300	10.5	16.5	22.5	28.5	34.5	40.5	46	51.8	57.5
	RV3S800	37.8	59.1	81	102	123	144	166	186	205
Double vane	RV3D1	-	0.16	0.22	0.27	0.34	0.41	-	-	-
	RV3D3	0.25	0.39	0.54	0.71	0.86	1.01	-	-	-
	RV3D10	0.76	1.17	1.62	2.11	2.54	3.03	-	-	-
	RV3D20	1.4	2.22	3.06	3.88	4.17	5.53	6.38	7.17	8.07
	RV3D30	2.7	4.4	6	7.7	9.5	11.2	12.99	14.8	16.6
	RV3D50	3.3	5.79	8.29	10.4	12.8	15.1	17.6	20.1	22.5
	RV3D150	12.5	19	27	35	41.5	48	55	62	69
	RV3D300	25.5	39	54	68	83	97	110	124	137
	RV3D800	77.4	120	161	206	247	288	332	371	411

STEP 2 Oscillating time confirmation

If the oscillating time is set outside of the specified range, the actuator's operation may become unstable, or the actuator could be damaged. Always set the oscillating time within the specified oscillating time adjusting range.

Compact rotary actuator (s)

Model No.	Oscillating angle		
	90°	180°	270°
RV3 S/D 1	0.03 to 0.6	0.06 to 1.2	0.09 to 1.8
RV3 S/D 3	0.04 to 0.8	0.08 to 1.6	0.12 to 2.4
RV3 S/D 10	0.045 to 0.9	0.09 to 1.8	0.135 to 2.7
RV3 S/D 20	0.05 to 1.0	0.10 to 2	0.15 to 3
RV3 S/D 30	0.07 to 0.7	0.14 to 1.4	0.21 to 2.1

Large rotary actuator (s)

Model No.	Oscillating angle				
	90°	100°	180°	270°	280°
RV3 S/D 50	0.08 to 0.8	0.09 to 0.9	0.16 to 1.6	0.24 to 2.4	0.25 to 2.5
RV3 S/D 150	0.12 to 1.2	0.13 to 1.3	0.24 to 2.4	0.36 to 3.6	0.37 to 3.7
RV3 S/D 300	0.16 to 1.6	0.17 to 1.7	0.32 to 3.2	0.48 to 4.8	0.49 to 4.9
RV3*800	0.22 to 2.2	0.24 to 2.4	0.44 to 4.4	0.66 to 6.6	0.68 to 6.8

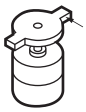
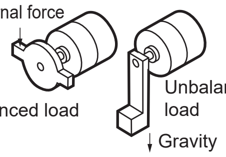
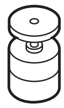
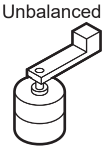
* Refer to page 1357 for the oscillating time of the angle variable.

STEP 3 Allowable energy confirmation

When using an inertial load, if the load's kinetic energy exceeds the allowable value at the oscillating end, the actuator could be damaged.
Calculate the energy with the following formula and set it so it is within the allowable value.
If the energy is too large, absorb the energy with a shock absorber, etc.

$$E = (1/2) \times I \times \omega_0^2 \times 10^3$$
$$\omega_0 \approx 1.2 \times \omega$$
$$\omega = \theta / t$$

E : Kinetic energy (mJ)
I : Moment of inertia ($kg \cdot m^2$)
ω_0 : Colliding angular speed (rad/s)
ω : Average angular speed (rad/s)
θ : Oscillating angle (rad)
t : Oscillating time (s)

Calculation of resistance torque	Horizontal load	Vertical load
Required	With resistance load  External force Balanced load Unbalanced load	With resistance load External force  Balanced load Unbalanced load Gravity
Not required	Without resistance load Balanced load  Unbalanced load 	Without resistance load  Balanced load

Refer to the figure for moment of inertia calculation on page 1399 and calculate the moment of inertia.

Selection method for shock absorber for rotary

STEP 1 Allowable energy confirmation

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STEP 2 Shock absorber performance confirmation

STEP 1 Allowable energy confirmation

Find the load's kinetic energy. If the value exceeds the rotary actuator with the vane mechanism's tolerable energy, install a shock absorber that complies with the rotary actuator.
Refer to STEP 3 of Rotary actuator selection method.

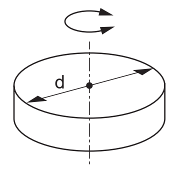
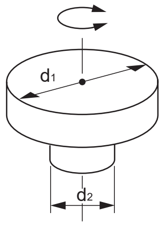
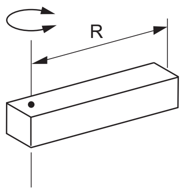
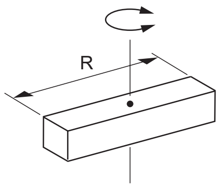
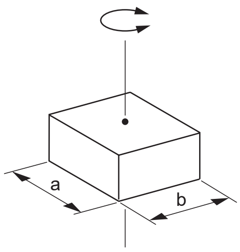
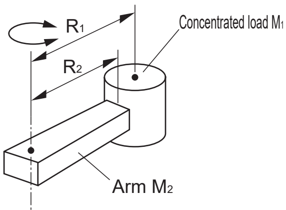
STEP 2 Shock absorber performance confirmation

If the load's collision energy exceeds the allowable value at the oscillating end, the shock absorber could be damaged.
Calculate the energy with the following formula and set it so it is within the allowable value.
If the energy is too large, consider using a separate shock absorber with large absorption performance.

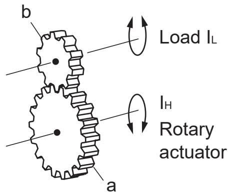
$$E = E_1 + E_2$$
$$E_1 = (1/2) \times I \times \omega_0^2$$
$$\omega_0 \approx 1.2 \times \omega$$
$$\omega = \theta / t$$
$$E_2 = (1/2) \times T \times \theta'$$
$$E_m = E \times n$$

E : Colliding energy (J)
E_1 : Kinetic energy (J)
E_2 : Thrust energy (J)
ω_0 : Colliding angular speed (rad/s)
ω : Average angular speed (rad/s)
I : Moment of inertia ($kg \cdot m^2$)
θ : Oscillating angle (rad)
θ' : Absorbing angle of shock absorber (rad)
t : Oscillating time (s)
T : Torque of rotary actuator ($N \cdot m$)
E_m : Energy per minute (J/min)
n : Operating frequency (time/min)

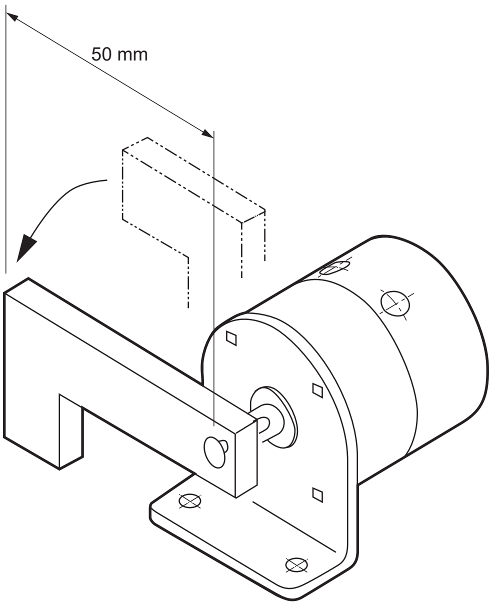
Calculating moment of inertia

Shape	Sketch	Requirements	Moment of inertia I kg·m²	Radius of rotation K_1^2	Remarks
Dial plate		● Diameter d(m) ● Weight M(kg)	$I=\frac{Md^2}{8}$	$\frac{d^2}{8}$	● No mounting direction ● For sliding use, contact CKD.
Circular stepped plate		● Diameter d_1(m) d_2(m) ● Weight d_1 section M_1(kg) d_2 section M_2(kg)	$I=\frac{1}{8}(M_1d_1^2+M_2d_2^2)$	$\frac{d_1^2+d_2^2}{8}$	● Ignore when the d_2 section is extremely small compared to the d_1 section
Bar (center of rotation at end)		● Bar length R(m) ● Weight M(kg)	$I=\frac{MR^2}{3}$	$\frac{R^2}{3}$	● Mounting direction is horizontal ● Oscillating time changes when the mounting direction is vertical
Bar (center of rotation at CG)		● Bar length R(m) ● Weight M(kg)	$I=\frac{MR^2}{12}$	$\frac{R^2}{12}$	● No mounting direction
Rectangular parallelepiped		● Side length a(m) b(m) ● Weight M(kg)	$I=\frac{M}{12}(a^2+b^2)$	$\frac{a^2+b^2}{12}$	● No mounting direction ● For sliding use, contact CKD.
Concentrated load		● Shape of concentrated load ● Length to center of gravity of concentrated load R_1 ● Arm length R_2(m) ● Concentrated load weight M_1(kg) ● Arm weight M_2(kg)	$I=M_1(R_1^2+K_1^2)+\frac{M_2R_2^2}{3}$	Calculate K_1^2 according to shape of concentrated load	● Mounting direction is horizontal ● When M_2 is extremely small compared to M_1, it may be calculated as $M_2=0$

How to convert load J_L to rotary actuator shaft rotation when using with gear

Gear		• Gear - Rotary actuator side (tooth number) a Load side (tooth number) b • Load inertia moment N·m	Load moment of inertia for the rotary actuator's shaft rotation $I_H=\left(\frac{a}{b}\right)^2 I_L$		● When gear shape is larger, gear moment of inertia should be considered.

Selection example 1 Clamp



[Operation conditions]

Pressure	0.5 MPa
Oscillating angle	90°
Oscillating time	0.3 s
Clamp lever weight	0.1 kg
Clamping force	20 N
Clamp position	50 mm

STEP 1 Size (torque) selection

Calculate the torque required for the static torque.

F_S = clamping force: 20 N
R = clamp position: 0.050 m

$T_S = 20 \times 0.05 = 1.0$ N·m

RV3S20-90 temporarily selected from required torque

STEP 2 Oscillating time confirmation

Make sure that the oscillating time in the working conditions is within the specified value.

If the operation time is 0.3 seconds for 90°,
it is OK since the RV3S20-90 oscillating time
adjusting range is 0.05 to 1.0.
Proceed to the next step.

STEP 3 Allowable energy confirmation

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

Calculate the moment of inertia I for the clamp lever.
[Bar (center of rotation at end)]
$I = M \times R^2/3 = 0.1 \times 0.05^2/3$
$= 0.0000833$ kg·m^2
Calculate colliding angular speed ω_0.
$\theta = 90° = \pi/2$ (rad)
$t = 0.3$ s
$\omega = \theta/t = (\pi/2)/0.3 = 5.236$ (rad/s)
$\omega_0 = 1.2 \times \omega = 6.283$ (rad/s)

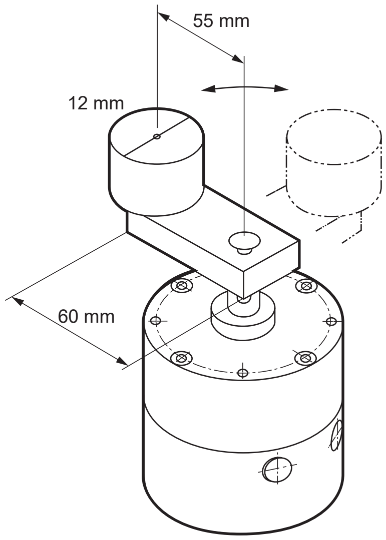
Therefore, kinetic energy (E) is

$E = (1/2) \times 8.33 \times 10^{-5} \times 6.283^2 \times 10^3$
$= 1.64$ (mJ)

The allowable energy is satisfied, so the RV3S20-90 can be selected.

LCM
LCR
LCG
LCW
LCX
STM
STG
STS/STL
STR2
UCA2
ULK*
JSK/M2
JSG
JSC3/JSC4
USSD
UFCD
USC
UB
JSB3
LMB
LML
HCM
HCA
LBC
CAC4
UCAC2
CAC-N
UCAC-N
RCS2
RCC2
PCC
SHC
MCP
GLC
MFC
BBS
RRC
GRC
RV3*
NHS
HRL
LN
Hand
Chuk
MecHnd/Chuk
ShkAbs
FJ
FK
SpdContr
Ending

Selection example 2 When there is a disc-shaped load at end of bar



[Operation conditions]

Pressure	0.5 MPa
Oscillating angle	90°
Oscillating time	0.2 s
Bar length	60 mm
Bar weight	0.1 kg
Distance to dial plate	55 mm
Diameter of dial plate	12 mm
Dial plate weight	0.12 kg

STEP 1 Size (torque) selection

Since this is an inertial load, calculate the moment of inertia.

$I = M_1(R_1^2 + K_1^2) + M_2 R_2^2/3$
$= 0.12x(0.055^2 + (0.012^2/8))$
$+ 0.1x0.06^2/3$
$= 4.85x10^{-4}$

Then calculate the angular speed $\dot{\omega}$.
From conditions
$\theta = 90° = \pi/2(rad)$
$t = 0.2$ s
$\dot{\omega} = \theta/t^2 = (\pi/2)/0.2^2$
$= 39.27$ (rad/s^2)
Thus, the inertial torque (T_A) is,
$T_A = 5x4.85x10^{-4}x39.27$
$= 0.095$ (N·m)

RV3S3-90 temporarily selected from inertial torque

STEP 2 Oscillating time confirmation

Make sure that the oscillating time in the working conditions is within the specified value.

If the operation time is 0.2 seconds for 90°,
it is OK since the RV3S3-90 oscillating time
adjusting range is 0.04 to 0.8.
Proceed to the next step.

STEP 3 Allowable energy confirmation

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

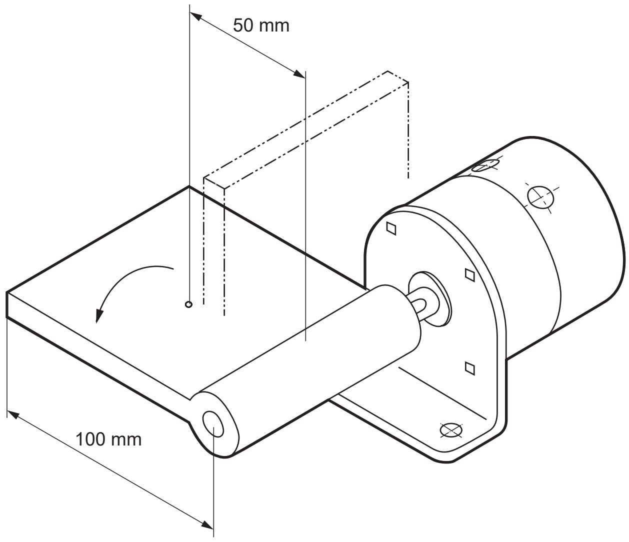
Calculate colliding angular speed ω_0 according to the conditions.
$\theta = 90° = \pi/2(rad)$
$t = 0.2$ s
$\omega = \theta/t = (\pi/2)/0.2$
$= 7.854$ (rad/s)
$\omega_0 = 1.2 \times \omega = 1.2 \times 7.854 = 9.425$ (rad/s)

Therefore, kinetic energy (E) is

$E = (1/2)x4.85x10^{-4}x9.425^2x10^3$
$= 21.54$ (mJ)

The allowable energy is exceeded, so select the RV3S50 or install an external shock absorber.

Selection example 3 When plate-shaped load is applied with rotary shaft horizontal



[Operation conditions]

Pressure	0.5 MPa
Oscillating angle	90°
Oscillating time	0.15 s
Plate length	100 mm
Plate weight	1.5 kg
Distance to center of gravity	50 mm
Operating frequency	5 cycle/min.

STEP 1 Size (torque) selection

This is a gravitational resistance load and inertial load, so calculate the resistance torque (TR) and inertial torque (TA).

[Resistance torque]
Since the resistance torque varies according to the rotation, calculate the max. value.
F_R = gravity = 1.5 x 9.8 = 14.7 N
R = distance to the center of gravity: 0.050 mm

T_R = 5 x 14.7 x 0.05 = 3.675 N·m ...(1)

[Inertial torque]
Bar (center of rotation at end)
I = $1.5 \times 0.1^2 / 3 = 0.005$ (kg·m^2)
From conditions
θ =90°=π/2(rad)
t =0.15 s
$\dot{\omega}$ $=\theta/t^2=(\pi/2)/0.15s^2$
=69.8 (rad/s2)
Thus, the inertial torque (T_A) is,
T_A =5x0.005x109.1
= 1.745 (N·m) ......(2)
When the resistance torque and inertial torque are added,
T = $T_R + T_A$ = 3.675 + 1.745 = 5.420 (N·m)

RV3S150-90 temporarily selected from required torque

STEP 2 Oscillating time confirmation

Make sure that the oscillating time in the working conditions is within the specified value.

If the operation time is 0.15 seconds for 90°,
it is OK since the RV3S150-90 oscillating time adjusting range is 0.12 to 1.2.
Proceed to the next step.

STEP 3 Allowable energy confirmation

Calculate the kinetic energy, and confirm that it is within the allowable energy value.
Calculate colliding angular speed according to the conditions.
θ =90°=π/2(rad)
t =0.15s
ω =θ/t=(π/2)/0.15
=10.47 (rad/s)
ω_0 = 1.2 x ω = 1.2 x 10.47 = 12.57 (rad/s)
Therefore, kinetic energy (E) is
E =(1/2)x0.005x12.57^2x10^3
=395 (mJ)
Since the allowable energy is exceeded, consider a shock absorber

Shock absorber review

Shock absorber STEP 1 Allowable energy confirmation

Since the rotary actuator’s allowable energy is exceeded, confirm the shock absorber’s capability in the next step.

Shock absorber STEP 2 Confirmation of shock absorber performance

Colliding angular speed
ω_0 =12.6 (rad/S)
Kinetic energy
E1 =(1/2)x0.005x12.6^2=0.395(J)
Torque at 0.5 MPa of RV3S150: 14.7 (N·m)
Absorbing angle of shock absorber: 0.2 (rad)
Thrust energy
E2 =(1/2)x14.7x0.2=1.47(J)
Thus, the collision energy (E) is
E = E1 + E2 = 0.395 + 1.47 ≈ 1.86 (J)

Energy per minute (Em)
Em =1.86x5=9.32(J)

Since all the shock absorber’s specification values are satisfied, the RV3S150 with shock absorber can be selected.