MAC / MAD Sizing formulas & Examples

SHOCK ABSORBERS

Four parameters are required to precisely determine the dimension of shock absorbers

- Mass to be decelerated m (kg)
- Impact velocity v (m/s)
- Propelling or driving force F (N)
- Number of impact cycles per hour C (/hr)

Some useful calculation formulas

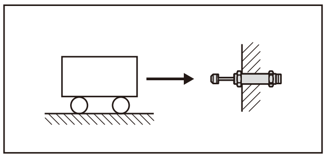
- Kinetic energy: $E_K = mv^2/2$
- Drive energy: $E_D = F \times S$
- Free fall velocity: $v = \sqrt{2g \times h}$
- Pneumatic or hydraulic cylinder driving forces.
  $F = 0.00785\ Pd^2$
- Maximum shock force (approximate).
  $Fm = 1.2\ E_T/S$
- Propelling force generated by electric motors.
  $F = 3000\ kW/v$
- Total energy absorbed per hour.
  $E_{TC} = E_T \times C$

Symbols	Unit	Description
μ		Coefficient of friction
α	(rad)	Angle of incline
θ	(rad)	Side load angle
ω	(rad/s)	Angular velocity
A	(m)	Width
B	(m)	Thickness
C	(/hr)	Impact cycles per hour
d	(mm)	Cylinder bore diameter
E_D	(Nm)	Drive energy per cycle
E_K	(Nm)	Kinetic energy per cycle
E_T	(Nm)	Total energy per cycle
E_{TC}	(Nm)	Total energy per hour
F	(N)	Propelling force
F_m	(N)	Maximum shock force
g	(m/s^2)	Acceleration due to gravity (9.81 m/s)
h	(m)	Height
HM		Arresting torque factor for motors (normally 2.5)
kW	(kW)	Electric motor power
m	(kg)	Mass to be decelerated
M_e	(kg)	Effective mass
P	(bar)	Operation pressure
R	(m)	Radius
R_s	(m)	Shock absorber mounting distance from rotation center
S	(m)	Stroke
T	(Nm)	Driving torque
t	(s)	Deceleration time
v	(m/s)	Velocity of impact mass
v_s	(m/s)	Impact velocity at shock absorber

Example 1. Horizontal impact

Application data

m = 300 kg
v = 1.0 m/s
S = 0.05 m
C = 300 /hr



Formulas and calculation

$$E_K = \frac{mv^2}{2} = \frac{300 \times 1.0^2}{2} = 150\ Nm$$

$$E_T = E_K = 150\ Nm$$

$$E_{TC} = E_T \times C = 150 \times 300 = 45000\ Nm/hr$$

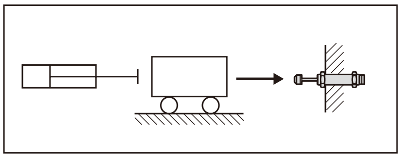
$$M_e = \frac{2E_T}{V^2} = \frac{2 \times 1.5}{1.0^2} = 300\ kg$$

Choose from calculation: MAD-3650 is adequate.

Example 2. Horizontal impact with propelling force

Application data

m = 300 kg
v = 1.2 m/s
S = 0.05 m
P = 40 N/cm^2
F = 1000 N
C = 500 /hr



Formulas and calculation

$$E_K = \frac{mv^2}{2} = \frac{300 \times 1.0^2}{2} = 216\ Nm$$

$$E_D = F \times S = 0.00785\ Pd^2 \times S$$

$$= 0.00785 \times 40 \times 100^2 \times 0.05 = 157\ Nm$$

$$E_T = E_K + E_D = 216+157 = 373\ Nm$$

$$E_{TC} = E_T \times C = 373 \times 300 = 111900\ Nm/hr$$

$$M_e = \frac{2E_T}{V^2} = \frac{2 \times 373}{1.2^2} = 518\ kg$$

Choose from calculation: MAD-4250 is adequate.

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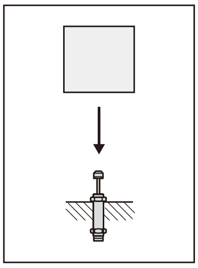
Example 3. Free fall impact

Application data

m = 40 kg
h = 0.4 m
S = 0.06 m
C = 200 /hr



Formulas and calculation

$$v = \sqrt{2g \times h} = \sqrt{2 \times 9.81 \times 0.4} = 2.8\ \text{m/sec}$$

$$E_K = \frac{mv^2}{2} = \frac{40 \times 2.8^2}{2} = 157\ \text{Nm}$$

$$E_D = F \times S = 40 \times 9.81 \times 0.06 = 23.5\ \text{Nm}$$

$$E_T = E_K + E_D = 157 + 23.5 = 180.5\ \text{Nm}$$

$$E_{TC} = E_T \times C = 180.5 \times 200 = 36100\ \text{Nm/hr}$$

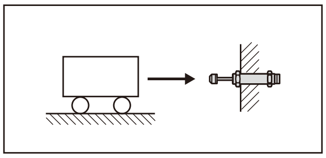
$$M_e = \frac{2E_T}{V^2} = \frac{2 \times 180.5}{2.8^2} = 46\ \text{kg}$$

Choose from calculation: MAC-3660-1 is adequate.

Example 5. Horizontal impact with motor driving

Application data

m = 400 kg
v = 1.0 m/s
W = 1.5 kW
HM = 2.5
S = 0.075 m
C = 60 /hr



Formulas and calculation

$$E_K = \frac{mv^2}{2} = \frac{300 \times 1.0^2}{2} = 150\ \text{Nm}$$

$$E_D = F \times S = \frac{kW \times HM}{v} \times S = \frac{1500 \times 2.5}{1.0} \times 0.075 = 281\ \text{Nm}$$

$$E_T = E_K + E_D = 200 + 281 = 481\ \text{Nm}$$

$$E_{TC} = E_T \times C = 481 \times 60 = 25860\ \text{Nm/hr}$$

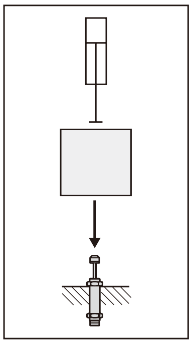
$$M_e = \frac{2E_T}{V^2} = \frac{2 \times 481}{1.0^2} = 962\ \text{kg}$$

Choose from calculation: MAD-4275 is adequate.

Example 4. Free fall impact with propelling

Application data

m = 40 kg
h = 0.3 m
S = 0.025 m
P = 5 bar
d = 50 mm
C = 200 /hr
v = 1.0 m/sec



Formulas and calculation

$$E_K = \frac{mv^2}{2} = \frac{40 \times 1.0^2}{2} = 20\ \text{Nm}$$

$$E_D = F \times S = (mg + 0.0785Pd^2) \times S$$

$$= (40 \times 9.81 + 0.0785 \times 5 \times 50^2) \times 0.025 = 34.3\ \text{Nm}$$

$$E_T = E_K + E_D = 20 + 34.3 = 54.3\ \text{Nm}$$

$$E_{TC} = E_T \times C = 54.3 \times 200 = 10860\ \text{Nm/hr}$$

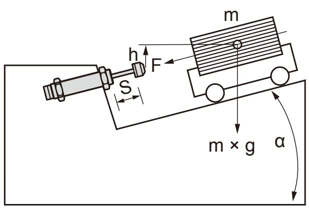
$$M_e = \frac{2E_T}{V^2} = \frac{2 \times 54.3}{1.0^2} = 108.6\ \text{kg}$$

Choose from calculation: MAD-2525 is adequate.

Example 6. Inclined impact

Application data

m = 150 kg
h = 0.3 m
S = 0.075 m
α = 30°
C = 200 /hr



Formulas and calculation

$$v = \sqrt{2g \times h} = \sqrt{2 \times 9.81 \times 0.3} = 2.43\ \text{m/sec}$$

$$E_K = \frac{mv^2}{2} = \frac{150 \times 2.43^2}{2} = 443\ \text{Nm}$$

$$E_D = F \times S = m \times g \times S \times \sin\alpha$$

$$= 50 \times 9.81 \times 0.075 \times \sin 30° = 55.2\ \text{Nm}$$

$$E_T = E_K + E_D = 433 + 55.2 = 498.2\ \text{Nm}$$

$$E_{TC} = E_T \times C = 498.2 \times 200 = 99640\ \text{Nm/hr}$$

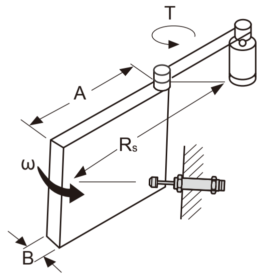
$$M_e = \frac{2E_T}{V^2} = \frac{2 \times 498.2}{2.43^2} = 168.7\ \text{kg}$$

Choose from calculation: MAD-4275 is adequate.

Example 7. Horizontal rotating door

Application data

m = 20 kg
ω = 2.0 rad/s
T = 20 Nm
R_S= 0.8 m
A = 1.0 m
B = 0.05 m
S = 0.016 m
C = 100 /hr



Formulas and calculation

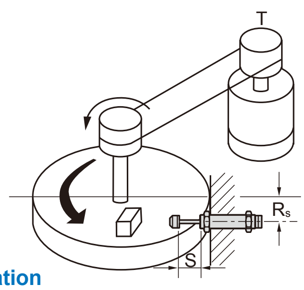
I	=	$\frac{m(4A^2+B^2)}{12}$	=	$\frac{20(4 \times 1.0^2+0.05^2)}{12}$	= 6.67 kg.m²
E_K	=	$\frac{I\omega^2}{2}$	=	$\frac{6.67 \times 2.0^2}{2}$	= 13.34 Nm
θ	=	$\frac{s}{R_S}$	=	$\frac{0.04}{0.8}$	= 0.05 rad
E_D	=	T × θ	=	20 × 0.05	= 1.0 Nm
E_T	=	E_K+E_D	=	13.34+1.0	= 14.34 Nm
E_{TC}	=	E_T × C	=	14.34 × 100	= 1434 Nm/hr
v	=	ω × R_S	=	2.0 × 0.8	= 1.6 m/s
M_e	=	$\frac{2E_T}{V^2}$	=	$\frac{2 \times 14.34}{1.6^2}$	= 11.20 kg

Choose from calculation: MAD-2016 is adequate.

Example 8. Rotary index table with propelling force

Application data

m = 200 kg
ω = 1.0 rad/s
T = 100 Nm
R = 0.5 m
R_S= 0.4 m
S = 0.04 m
C = 100 /hr



Formulas and calculation

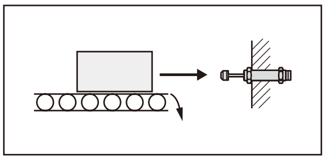
I	=	$\frac{mR^2}{2}$	=	$\frac{200 \times 0.5^2}{2}$	= 25 kg.m²
E_K	=	$\frac{I\omega^2}{2}$	=	$\frac{25 \times 1.0^2}{2}$	= 12.5 Nm
θ	=	$\frac{s}{R_S}$	=	$\frac{0.04}{0.4}$	= 0.1 rad
E_D	=	T × θ	=	100 × 0.1	= 10 Nm
E_T	=	E_K+E_D	=	12.5+10	= 22.5 Nm
E_{TC}	=	E_T × C	=	22.5 × 50	= 1125 Nm/hr
v	=	ω × R_S	=	1.0 × 0.4	= 0.4 m/s
M_e	=	$\frac{2E_T}{V^2}$	=	$\frac{2 \times 22.5}{0.4^2}$	= 281 kg

Choose from calculation: MAD-2540 is adequate.

Example 9. Horizontal mass on driven rollers

Application data

m = 150 kg
v = 0.5 m/s
μ = 0.25
S = 0.02 m
C = 120 /hr



Formulas and calculation

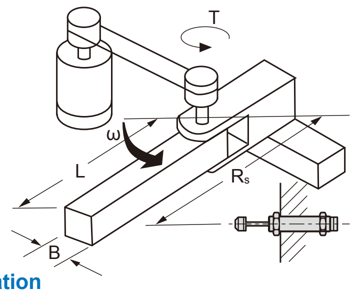
E_K	=	$\frac{mv^2}{2}$	=	$\frac{150 \times 0.5^2}{2}$	= 18.75 Nm
E_D	=	F × S = mgμ × S = 150 × 9.81 × 0.25 × 0.02 = 7.35 Nm			
E_T	=	E_K+E_D =		18.73+7.35	= 26.1 Nm
E_{TC}	=	E_T × C =		26.1 × 120	= 3132 Nm/hr
M_e	=	$\frac{2E_T}{V^2}$	=	$\frac{2 \times 26.1}{0.5^2}$	= 208.8 kg

Choose from calculation: MAC-2020-3 is adequate.

Example 10. Rotating beam with driving force

Application data

m = 40 kg
A = 0.5 m
B = 0.05 m
ω = 2.0 rad/s
T = 10 Nm
R_S= 0.4 m
S = 0.05 m
C = 50 /hr



Formulas and calculation

I	=	$\frac{m(4A^2+B^2)}{12}$	=	$\frac{40(4 \times 0.5^2+0.05^2)}{12}$	= 3.34 kg.m²
E_K	=	$\frac{I\omega^2}{2}$	=	$\frac{3.34 \times 2.0^2}{2}$	= 6.7 Nm
θ	=	$\frac{s}{R_S}$	=	$\frac{0.05}{0.4}$	= 0.125 rad
E_D	=	T × θ	=	10 × 0.125	= 1.25 Nm
E_T	=	E_K+E_D	=	6.7+1.25	= 8 Nm
E_{TC}	=	E_T × C	=	8 × 50	= 400 Nm/hr
v	=	ω × R_S	=	2.0 × 0.4	= 0.8 m/s
M_e	=	$\frac{2E_T}{V^2}$	=	$\frac{2 \times 8.05}{0.8^2}$	= 25 kg

Choose from calculation: MAD-1416-2 is adequate.