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

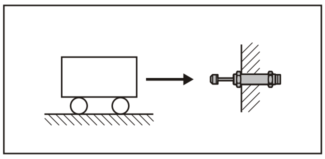
- Kinetic energy: $E_K = mv^2/2$
- Drive energy: $E_D = F \cdot S$
- Free fall velocity: $v = \sqrt{2g \cdot h}$
- Pneumatic or hydraulic cylinder driving forces: $F = 0.00785\ Pd^2$
- Maximum shock force (approximate): $Fm = 1.2\ E_T/S$
- Propelling force generated by electric motors: $F = 3000\ kW/v$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

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

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

$$E_T = E_K = 150\ Nm$$

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

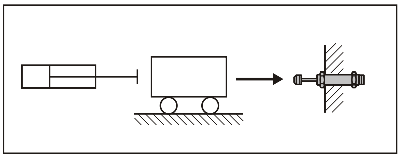
$$M_e = \frac{2E_T}{V^2} = \frac{2 \cdot 1.50}{1.0^2} = 300\ kg$$

Choose from sizing diagram: MDFC-3650 is adequate.

Example 2: Horizontal impact with propelling force

Application data

m = 50 kg
v = 1.0 m/s
S = 0.04 m
F = 1000 N
C = 500 /hr



Formulas and calculation

$$E_K = \frac{mv^2}{2} = \frac{50 \cdot 1.0^2}{2} = 25\ Nm$$

$$E_D = F \cdot S = 1000 \cdot 0.04 = 40\ Nm$$

$$E_T = E_K + E_D = 25+40 = 65\ Nm$$

$$E_{TC} = E_T \cdot C = 65 \cdot 500 = 32500\ Nm/hr$$

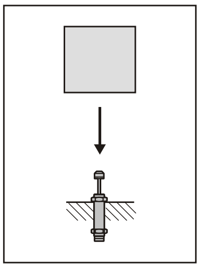
$$M_e = \frac{2E_T}{V^2} = \frac{2 \cdot 65}{1.0^2} = 130\ kg$$

Choose from sizing diagram: MDFC-2540 is adequate.

Example 3: Free fall impact

Application data

m = 30kg
h = 0.5m
S = 0.08m
C = 300/hr



Formulas and calculation

$$v = \sqrt{2g \cdot h} = \sqrt{2 \cdot 9.81 \cdot 0.5} = 3.1 \text{ m/sec}$$

$$E_K = mg \cdot h = 30 \cdot 9.81 \cdot 0.5 = 147 \text{ Nm}$$

$$E_D = mg \cdot s = 30 \cdot 9.81 \cdot 0.08 = 23.5 \text{ Nm}$$

$$E_T = E_K + E_D = 147 + 23.5 = 170.5 \text{ Nm}$$

$$E_{TC} = E_T \cdot C = 170.5 \cdot 300 = 51150 \text{ Nm/hr}$$

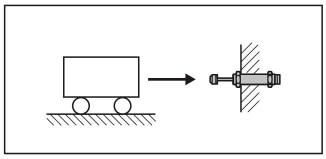
$$M_e = \frac{2E_T}{V^2} = \frac{2 \cdot 170.5}{3.1^2} = 35.5 \text{ kg}$$

Choose from sizing diagram: MDSC-2580-1 is adequate.

Example 5: Horizontal impact with motor driving

Application data

m = 50 kg
v = 1.5 m/s
kW = 2 kW
HM = 2.5
S = 0.06 m
C = 100 /hr



Formulas and calculation

$$E_K = \frac{mv^2}{2} = \frac{50 \cdot 1.5^2}{2} = 56.25 \text{ Nm}$$

$$E_D = F \cdot S = \frac{kW \cdot HM}{v} \cdot S = \frac{2000 \cdot 2.5}{1.5} \cdot 0.06 = 200 \text{ Nm}$$

$$E_T = E_K + E_D = 56.25 + 200 = 256.25 \text{ Nm}$$

$$E_{TC} = E_T \cdot C = 256.25 \cdot 100 = 25625 \text{ Nm/hr}$$

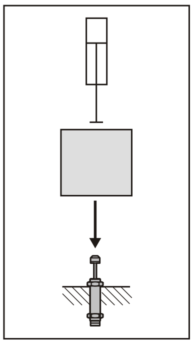
$$M_e = \frac{2E_T}{V^2} = \frac{2 \cdot 256.25}{1.5^2} = 227 \text{ kg}$$

Choose from sizing diagram: MDSC-3660-2 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

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

$$E_D = F \cdot S = (mg + 0.0785Pd^2) \cdot S$$
$$= (40 \cdot 9.81 + 0.0785 \cdot 5 \cdot 50^2) \cdot 0.025 = 34.3 \text{ Nm}$$

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

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

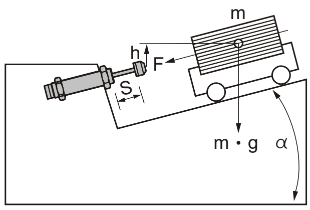
$$M_e = \frac{2E_T}{V^2} = \frac{2 \cdot 54.3}{1.0^2} = 108.6 \text{ kg}$$

Choose from sizing diagram: MDFC-2525 is adequate.

Example 6: Inclined impact

Application data

m = 30 kg
h = 0.25 m
S = 0.04 m
α = 30°
C = 250 /hr



Formulas and calculation

$$v = \sqrt{2g \cdot h} = \sqrt{2 \cdot 9.81 \cdot 0.25} = 2.2 \text{ m/sec}$$

$$E_K = \frac{mv^2}{2} = \frac{30 \cdot 2.2^2}{2} = 72.6 \text{ Nm}$$

$$E_D = F \cdot S = m \cdot g \cdot S \cdot \sin\alpha$$
$$= 30 \cdot 9.81 \cdot 0.04 \cdot \sin 30^\circ = 5.9 \text{ Nm}$$

$$E_T = E_K + E_D = 72.6 + 5.9 = 78.5 \text{ Nm}$$

$$E_{TC} = E_T \cdot C = 78.5 \cdot 250 = 19625 \text{ Nm/hr}$$

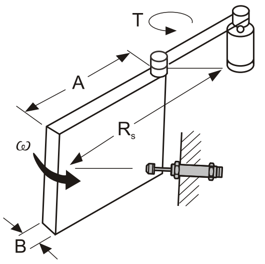
$$M_e = \frac{2E_T}{V^2} = \frac{2 \cdot 78.5}{2.2^2} = 32 \text{kg}$$

Choose from sizing diagram: MDSC-2540-1 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

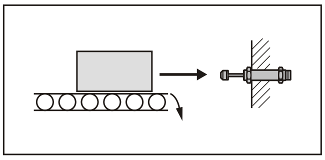
I	=	$\frac{m(4A^2+B^2)}{12}$	= $\frac{20(4 \cdot 1.0^2+0.05^2)}{12}$	= 6.67 kg · m²
E_K	=	$\frac{I\omega^2}{2}$	= $\frac{6.67 \cdot 2.0^2}{2}$	= 13.34 Nm
θ	=	$\frac{s}{R_S}$	= $\frac{0.04}{0.8}$	= 0.05 rad
E_D	=	$T \cdot \theta$	= 20 · 0.05	= 1.0 Nm
E_T	=	E_K+E_D	= 13.34+1.0	= 14.34 Nm
E_{TC}	=	$E_T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

Choose from sizing diagram: MDFC-2016 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

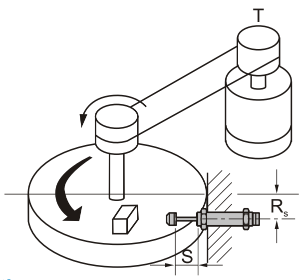
E_K	=	$\frac{mv^2}{2}$	= $\frac{150 \cdot 0.5^2}{2}$	= 18.75 Nm
E_D	=	$F \cdot S = mg\mu \cdot S$	= 150 · 9.81 · 0.25 · 0.02	= 7.35 Nm
E_T	=	E_K+E_D	= 18.73+7.35	= 26.1 Nm
E_{TC}	=	$E_T \cdot C$	= 26.1 · 120	= 3132 Nm/hr
M_e	=	$\frac{2E_T}{V^2}$	= $\frac{2 \cdot 26.1}{0.5^2}$	= 208.8 kg

Choose from sizing diagram: MDSC-2020-3 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

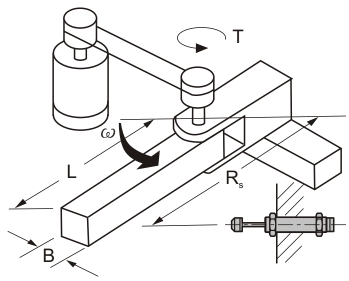
I	=	$\frac{mR^2}{2}$	= $\frac{200 \cdot 0.5^2}{2}$	= 25 kg · m²
E_K	=	$\frac{I\omega^2}{2}$	= $\frac{25 \cdot 1.0^2}{2}$	= 12.5 Nm
θ	=	$\frac{s}{R_S}$	= $\frac{0.04}{0.4}$	= 0.1 rad
E_D	=	$T \cdot \theta$	= 100 · 0.1	= 10 Nm
E_T	=	E_K+E_D	= 12.5+10	= 22.5 Nm
E_{TC}	=	$E_T \cdot C$	= 22.5 · 50	= 1125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

Choose from sizing diagram: MDFC-2540 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	=	$\frac{m(4A^2+B^2)}{12}$	= $\frac{40(4 \cdot 0.5^2+0.05^2)}{12}$	= 3.34 kg · m²
E_K	=	$\frac{I\omega^2}{2}$	= $\frac{3.34 \cdot 2.0^2}{2}$	= 6.7 Nm
θ	=	$\frac{s}{R_S}$	= $\frac{0.05}{0.4}$	= 0.125 rad
E_D	=	$T \cdot \theta$	= 10 · 0.125	= 1.25 Nm
E_T	=	E_K+E_D	= 6.7+1.25	= 8 Nm
E_{TC}	=	$E_T \cdot C$	= 8 · 50	= 400 Nm/hr
v	=	$\omega \cdot R_S$	= 2.0 · 0.4	= 0.8 m/s
M_e	=	$\frac{2E_T}{V^2}$	= $\frac{2 \cdot 8}{0.8^2}$	= 25 kg

Choose from sizing diagram: MDFC-2050 is adequate.