EJECTOR PIN • EJECTOR SLEEVE STRENGTH CALCULATION

■Ejector Pin・Ejector Sleeve Strength Calculation

Ejector pins and sleeves are subjected to compressive loads when the cavity is filled with molten plastic.
When long, thin objects are subjected to such compressive loads, buckling, bending of the pin, or breakage can occur. In order to prevent buckling, we recommend that you select an appropriate configuration by performing strength calculations beforehand.

(1) Computing buckling load P [kgf]:

Euler's formula is normally used to calculate the buckling strength of ejector pins.

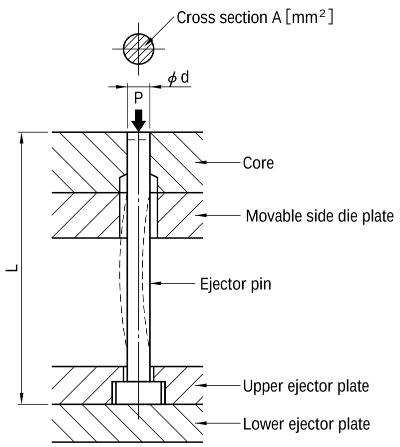
$$P = n\pi^2 AE\left(\frac{K}{L}\right)^2$$

(2) Computing compression load P_1 [kgf]:

Compression load refers to load that is applied to the ejector pin during filling and pressurization with molten plastic.

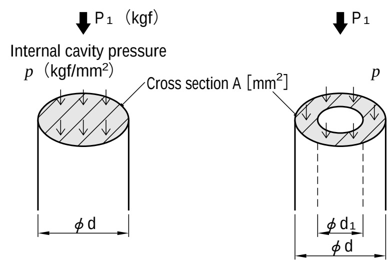
$$P_1 = p \times A$$

n: terminal condition constant	
For straight	n=4
For stepped	n=2.05
A: cross section [mm]	
For round	$\frac{\pi}{4}d^2$
For cylinder	$\frac{\pi}{4}(d^2 - d_1^2)$
E: modulus of longitudinal elasticity	21000 [kgf/mm²]
K: radius of gyration of area	$K = \sqrt{I/A}$ [mm]
For round	K=d/4
For cylinder	$K = \sqrt{d^2 + d_1^2/16}$
I: geometrical moment of inertia [mm⁴]	
For round	$I = \frac{\pi d^4}{4}$
For cylinder	$I = \frac{\pi}{64}(d^4 - d_1^4)$
p: Internal cavity pressure [kgf/mm²]	



(3) Computing safety factor:

$$S = \frac{P}{P_1}$$



《Considerations regarding safety factor values》: Safety factor (S) is affected by a wide variety of elements, including those listed below.

- Inaccuracy of load estimates・inconsistent strength of materials・effect of heat treatment,
- notch effect・finished surface roughness・abrasion and corrosion during use,
- expansion and contraction due to heat・fatigue・impact mold separation resistance during ejection of the molded object; etc.

In specific terms, we recommend that you decide in advance on an in-company design standard taking into consideration the empirical values of the various companies, and then use this to gauge the appropriateness of the computed results.

■Ejector Pin Strength Calculation Examples

《Example 1》 Straight Ejector Pin

We will examine buckling strength, where an internal cavity pressure of p=4 kgf/mm² is applied to a straight ejector pin with a tip diameter (d) of ϕ2mm, total length (L) of 100 mm

(1) From Euler's formula

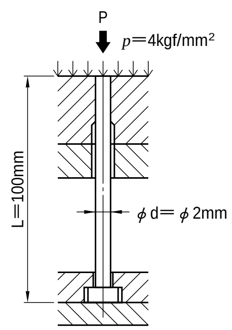
$$P = n\pi^2 AE\left(\frac{K}{L}\right)^2 = 4 \times \pi^2 \times \frac{\pi \times 2^2}{4} \times 21000 \times \left(\frac{2/4}{100}\right)^2 \fallingdotseq 65\ \text{(kgf)}$$

(2) The compression load P_1 exerted on the ejector pin is

$$P_1 = p \times A = p \times \frac{\pi d^2}{4} = 4 \times \frac{\pi \times 2^2}{4} \fallingdotseq 12.6\ \text{(kgf)}$$

(3) Therefore, the safety factor (S) is

$$S = \frac{P}{P_1} = \frac{65}{12.6} \fallingdotseq 5.2$$



<Straight Ejector Pin>

《Example 2》 Stepped Ejector Pin

We will examine buckling strength, where an internal cavity pressure of p=4 kgf/mm² is applied to a stepped ejector pin with a tip diameter (d) of ϕ1.2mm, total length (L) of 100 mm, and a tip section length (ℓ) of 40 mm.

(A) Buckling strength calculation for the tip section

(1) From Euler's formura

$$P = n\pi^2 AE\left(\frac{K}{\ell}\right)^2 = 2.05 \times \pi^2 \times \frac{\pi \times 1.2^2}{4} \times 21000 \times \left(\frac{1.2/4}{40}\right)^2 = 27.0\ \text{(kgf)}$$

(2) The compression load P_1 exerted on the ejector pin is

$$P_1 = p \times A = p \times \frac{\pi d^2}{4} = 4 \times \frac{\pi \times 1.2^2}{4} = 4.5\ \text{(kgf)}$$

(3) Therefore, the safety factor (S) is

$$S = \frac{P}{P_1} = \frac{27.0}{4.5} \fallingdotseq 6.0$$

(B) Buckling strength calculation for the shaft diameter section

As strength calculations for stepped ejector pins are extremely complex, we will make the calculation here assuming a straight ejector pin whose tip diameter is ϕd and length is L.

(1) From Euler's formula

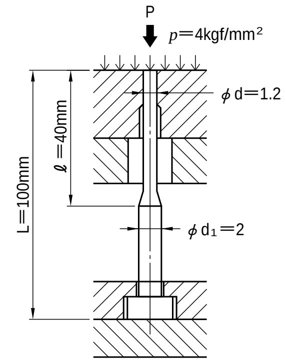
$$P = n\pi^2 AE\left(\frac{K}{L}\right)^2 = 4 \times \pi^2 \times \frac{\pi \times 1.2^2}{4} \times 21000 \times \left(\frac{1.2/4}{100}\right)^2 = 8.42\ \text{(kgf)}$$

(2) The compression load P_1 exerted on the ejector pin is

$$P_1 = p \times A = p \times \frac{\pi d^2}{4} = 4 \times \frac{\pi \times 1.2^2}{4} = 4.52\ \text{(kgf)}$$

(3) Therefore, the safety factor (S) is

$$S = \frac{P}{P_1} = \frac{8.42}{4.52} \fallingdotseq 1.9$$



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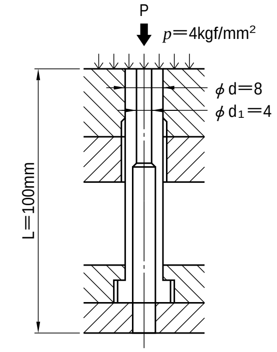


<Straight Ejector Sleeve>

■Ejector Sleeve Strength Calculation Examples

《Example 3》 Straight Ejector Sleeve

We will examine buckling strength, where an internal cavity pressure of p=4 kgf/mm is applied to the straight ejector sleeve shown in the diagram.

(1) From Euler's formula

$$P = n\pi^2 AE\left(\frac{K}{L}\right)^2 \quad * K = \sqrt{\frac{d^2 + d_1^2}{16}}$$

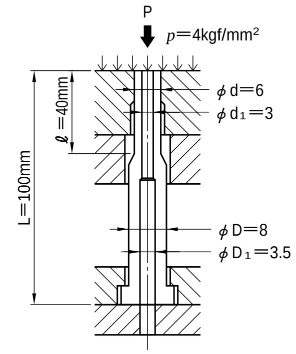
$$= 4 \times \pi^2 \times \frac{\pi(8^2 - 4^2)}{4} \times 21000 \times \left(\frac{\sqrt{(8^2+4^2)/16}}{100}\right)^2 = 15600\ \text{(kgf)}$$

(2) The compression load P_1 exerted on the ejector pin is

$$P_1 = p \times A = p \times \frac{\pi(d^2 - d_1^2)}{4} = 4 \times \frac{\pi \times (8^2 - 4^2)}{4} = 151\ \text{(kgf)}$$

(3) Therefore, the safety factor (S) is

$$S = \frac{P}{P_1} = \frac{15600}{151} \fallingdotseq 103$$



<Stepped Ejector Sleeve>

《Example 4》 Stepped Ejector Sleeve

We will examine buckling strength, where an internal cavity pressure of p=4 kgf/mm is applied to a stepped ejector sleeve with a tip diameter (d) of ϕ6mm, hole diameter (d₁) of ϕ3 mm, total length (L) of 100 mm, tip section ength (ℓ) of 40 mm, shaft diameter (D) of ϕ3 mm, and recessed hole diameter (D₁) of ϕ3.5 mm.

(A) Buckling strength calculation for the tip section

(1) From Euler's formula

$$P = n\pi^2 AE\left(\frac{K}{R}\right)^2 \quad * K = \sqrt{\frac{(d^2 + d_1^2)}{16}}$$

$$= 2.05 \times \pi^2 \times \frac{\pi(6^2 - 3^2)}{4} \times 21000 \times \left(\frac{\sqrt{(6^2+3^2)/16}}{40}\right)^2 = 15810\ \text{(kgf)}$$

(2) The compression load P_1 exerted on the ejector pin is

$$P_1 = p \times A = p \times \frac{\pi(d^2 - d_1^2)}{4} = 4 \times \frac{Q \times (6^2 - 3^2)}{4} = 84.8\ \text{(kgf)}$$

(3) Therefore, the safety factor (S) is

$$S = \frac{P}{P_1} = \frac{15810}{84.8} \fallingdotseq 186$$

(B) Buckling strength calculation for the shaft diameter section

As strength calculations for stepped ejector sleeves are extremely complex, we will make the calculation here assuming a straight ejector sleeve with tip diameters of d and d₁.

(1) From Euler's formula

$$P = n\pi^2 AE\left(\frac{K}{L}\right)^2 = 4 \times \pi^2 \times \frac{\pi(6^2 - 3^2)}{4} \times 21000 \times \left(\frac{\sqrt{(6^2+3^2)/16}}{100}\right)^2 = 4940\ \text{(kgf)}$$

(2) The compression load P_1 exerted on the ejector pin is

$$P_1 = p \times A = p \times \frac{\pi(d^2 - d_1^2)}{4} = 4 \times \frac{\pi \times (6^2 - 3^2)}{4} = 84.7\ \text{(kgf)}$$

(3) Therefore, the safety factor (S) is

$$S = \frac{P}{P_1} = \frac{4940}{84.7} \fallingdotseq 58.3$$