Spring 設計 計算 公式 소개

資料提供：靑信産業(株)

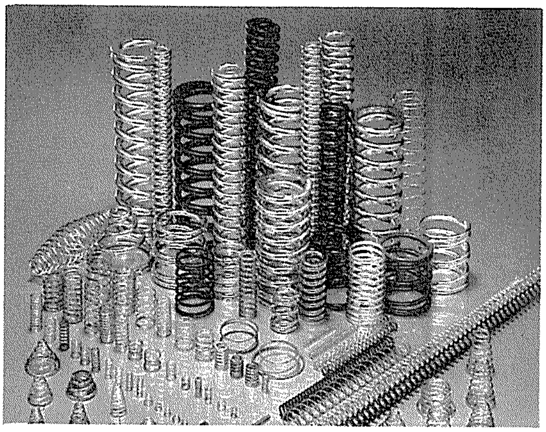
오늘날 Spring은 機械要素의 하나로서 勞動産業으로부터 尖端産業에 이르기까지 機能作用을 하는 물체에는 사용되지 않는 것이 없다. Spring은 사용하는 材料의 彈性, 또는 Energy를 흡수하는 능력을 極度로 이용하기 위하여 적당한 形狀으로 만든 것이다.

Spring 材料는 彈性體라면 어느 것이든 사용할 수 있으나 일반적인 機械要素로서의 Spring의 경우에는 彈性範囲가 좁은 材料를 사용하게 되면 작은 外力이나 變形에 의하여 彈性의 한계를 넘어 外力을 제외하더라도 變形이 남게 되어 Spring의 역할이 감소된다. 따라서 Spring材料는 彈性域이 넓은 즉, 彈性値가 높은 것이 요구되며 실질적으로 金屬材料를 많이 사용하게 된다.

Spring設計, Spring材料, 熱處理 등에 관한 모든 것을 記事化하는 것은 分量面에서 제한된 紙面으로서는 엄두를 낼 수가 없어서 그중에서도 표현하기가 간단하며 基礎가 되는 Spring 設計計算 公式만을 다루기로 했다.

電子工業 雄飛의 새 章을 연 1983年度에 이어 情報化社會의 1984年度를 맞이한 우리電子工業은 上半期中에 괄목할 만한 伸張을 이룩했고 高度尖端 産業에 挑戰하고 있으며 이는 實로 國家와 電子産業의 隆盛을 成就하려는 우리 業界의 結晶된 意志임에는 틀림없다.

高度尖端技術의 파도가 밀어닥치는 현실 속에서 微微하다고 인식되고 천시당하고 있는 Spring의 Image를 부각시켜 보려는 뜻은 超精密과 尖端技術間에는 같은 意味의 중요성이 內包



되어 強調되고 있기 때문이다.

電子産業의 급속한 成長과 병행하여 Spring의 需要가 급증하고 있는 것은 사실이나 아직까지 Spring에 관한 國內書籍은 찾을 길이 없으며 Spring도 다른 製品과 마찬가지로 設計로부터 시작된다.

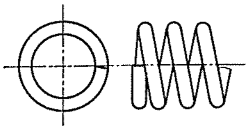
따라서 本誌는 Spring을 이해하고 설계하려는 독자를 위하여 Spring設計 計算 公式을 Spring의 종류별 사진과 함께 揭載한다.

記述된 내용이 단편적이고 이해하기 어려우며 틀리는 부분도 있을 것으로 믿으나 이러한 試圖를 거듭하면서 訂正補完해 나가는 노력이 超精密과 尖端技術을 발전시켜 나가는 지름길이 되리라고 굳게 확신하기 때문에 주저함이 없이 揭載함을 添言해 둔다. 끝으로 이 資料를 提供해 준 超精密 Spring 製造業體인 靑信産業株式會社의 관계자에게 感謝드린다.

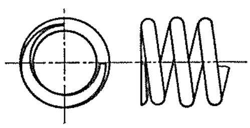
1. Compression Springs

● Shapes of Coil Ends of Compression Springs

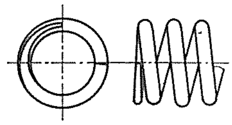
Closed End (unground)



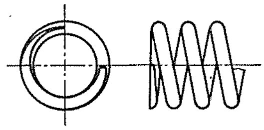
Closed End (ground)



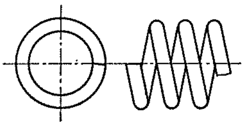
Closed End (tapered)



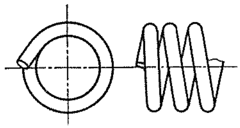
Open End (ground)



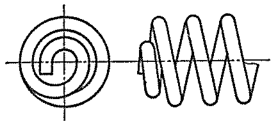
Open End (unground)



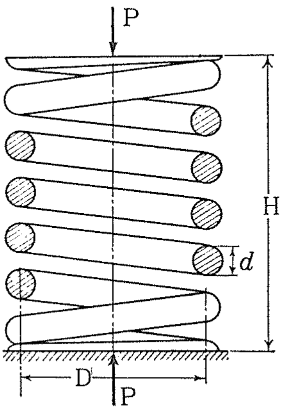
Tangent Tail



Pig Tail



● Calculation Formulas for Compression Springs



$$\delta = \frac{8NaD^3P}{Gd^4} \qquad Na = \frac{Gd^4\delta}{8D^3P}$$

$$K = \frac{P}{\delta} = \frac{Gd^4}{8NaD^3} \qquad U = \frac{P\delta}{2}$$

$$\tau_o = \frac{8DP}{\pi d_3}$$

$$\tau_o = \frac{Gd\delta}{\pi NaD^3}$$

$$\tau = k\tau_o$$

$$d = \sqrt[3]{\frac{8DP}{\pi\tau_o}} = \sqrt[3]{\frac{8kDP}{\pi\tau}}$$

d = Diameter of material ······················ mm
D = Coil average diameter ······················ mm
Na = Number of active turns
G = Modulus of transverse elasticity ··· kgf/mm^2
P = Load acting on spring ······················ kgf
δ = Deflection of spring ······················ mm
K = Spring constant ······················ kgf/mm
τ_o = Torsional stress ······················ kgf/mm^2
τ = Corrected torsional stress ········ kgf/mm^2
U = Energy stored in spring ················ kgf·m
k = Stress correction factor

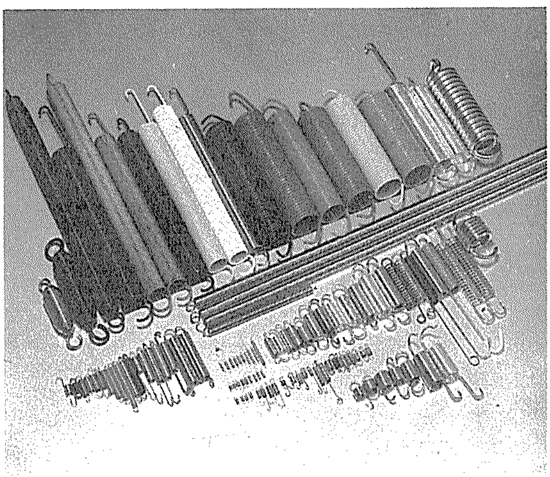


사진2

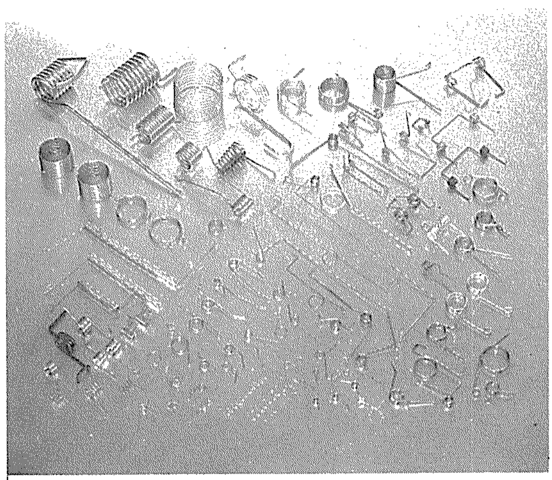
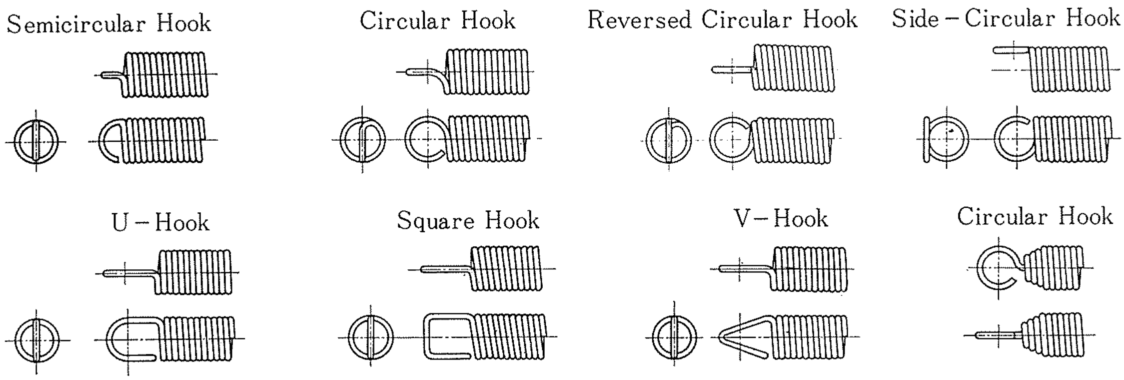


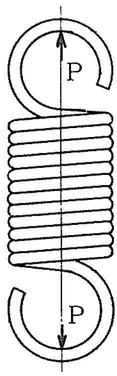
사진3

2. Tension Springs

● Shapes of Hooks of Tension Springs



● Calculation Formulas for Tension Springs



$$\delta = \frac{8NaD^3(P-Pi)}{Gd^4} \qquad Na = \frac{Gd^4\delta}{8D^3(P-Pi)}$$

$$K = \frac{P-Pi}{\delta} = \frac{Gd^4}{8NaD^3} \qquad U = \frac{(P+Pi)\delta}{2}$$

$$\tau_o = \frac{Gd^4}{\pi d^3}$$

$$\tau_o = \frac{Gd\delta}{\pi NaD^2} + \tau i$$

$$\tau = k\tau_o$$

$$d = \sqrt[3]{\frac{8DP}{\pi\tau_o}}$$

$$= \sqrt[3]{\frac{8kDP}{\pi\tau}}$$

d ＝Diameter of material ································mm
D ＝Coil average diameter ······························mm
Na ＝Number of active turns
Pi ＝Initial tension ··kgf
G ＝Modulus of transverse elasticity ·········kgf/mm²
P ＝Load acting on spring ·····························kgf
δ ＝Deflection of spring ·································mm
K ＝Spring constant ·································kgf/mm
τ_o ＝Torsional stress ·····························kgf/mm²
τ ＝Corrected torsional stress··················kgf/mm²
τi ＝Torsional stress due to initial tension····kgf/mm²
k ＝Stress correction factor
u ＝Energy stored in spring ·························kgf·m

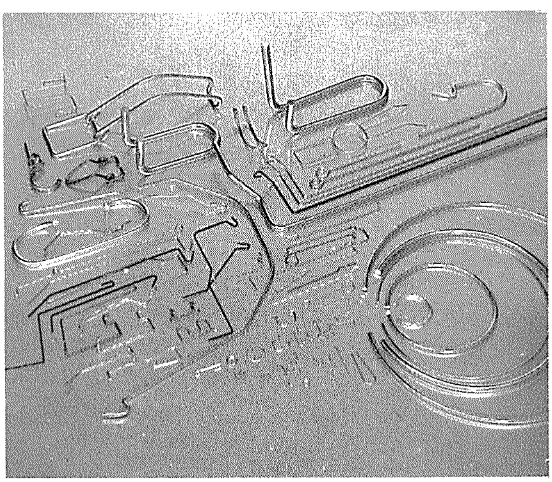


사진4

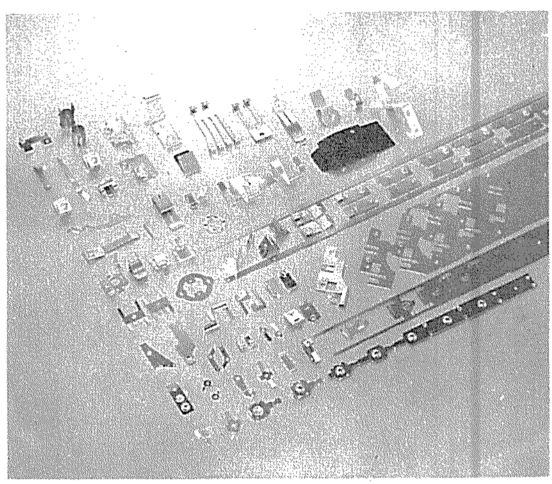
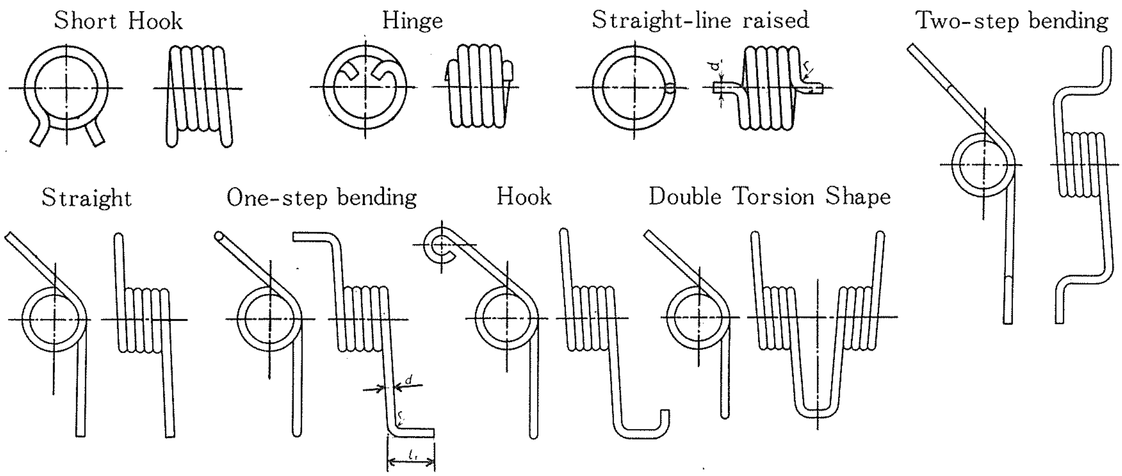


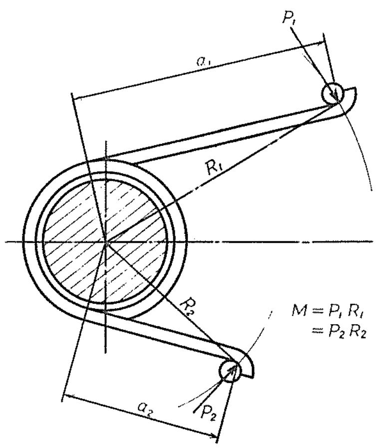
사진5

3. Torsion Springs

● Shapes of Torsion Springs



● Calculation Formulas for Torsion Springs



$$L \fallingdotseq \pi DN + \frac{1}{3}(a_1 + a_2)$$

$$\phi = \frac{64M}{E\pi d^4}\left[\pi DN + \frac{1}{3}(a_1 + a_2)\right]$$

$$k_T = \frac{E\pi d^4}{64\left[\pi DN + \frac{1}{3}(a_1 + a_2)\right]}$$

$$\phi_d = \frac{64M}{E\pi d^4}\left[\pi DN + \frac{1}{3}(a_1 + a_2)\right] \cdot \frac{180}{\pi}$$

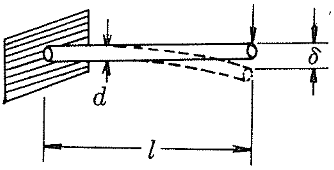
$$k_{Td} = \frac{E\pi d^4}{64\left[\pi DN + \frac{1}{3}(a_1 + a_2)\right]} \cdot \frac{\pi}{180}$$

$$\sigma = \frac{Ed\phi_4}{360DN}$$

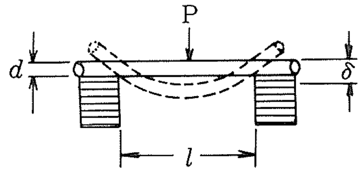
d	= Diameter of material ························ mm
D	= Coil average diameter························ mm
N	= Number of turns
E	= Modulus of longitudinal elasticity ······ kgf/mm^2
$P(P_1, P_2)$	= Load exerted on spring ······················ kgf
M	= Torsional moment acting on spring ···kgf·mm
a_1, a_2	= Length of arm ································ mm
L	= Expanded wire length of active portion····· mm
$k_T(k_{Td})$	= Spring constant···kgf·mm/rad (kgf·mm/deg)
$\phi(\phi_d)$	= Torsion angle of spring ········· rad (degree,°)
σ	= Bending stress··························· kgf/mm^2

4. Wire Forms

● Calculation Formulas For Wire Forms

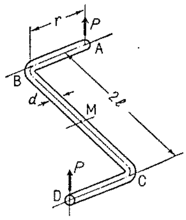


$$\delta=\frac{64Pl^3}{3\pi Ed^4} \qquad \sigma=\frac{32Pl}{\pi d^3}$$



$$\delta=\frac{4Pl^3}{3\pi Ed^4} \qquad \sigma=\frac{8Pl}{\pi d^3}$$

d = Diameter of wire ························ mm
σ = Bending stress ························ kgf/mm^2
E = Modulus of longitudinal elastiaty····· kg/mm^2
δ = Deflection amount························ mm
P = Load ························ kg
l = Active length of spring························ mm
τ = Torsional stress ························ kgf/mm^2
G = Modulus of transverse elasticity····kgf/mm^2



When a load "P" is imposed on A and D normally to the spring plane, when AB and CD function for bending moment, and when BC Functions for torsional moment,

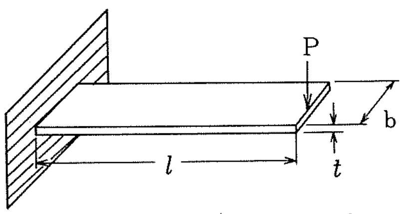
the deflection amount at point "D" is:

$$\delta=\frac{32Pr^2}{\pi d^4}\left(\frac{l}{G}+\frac{2r}{3E}\right) \qquad \tau=\frac{16Pr}{\pi d^3} \qquad \sigma=\frac{32Pr}{\pi d^3} \qquad \tau\max=\sqrt{\frac{\sigma^2}{4}+\tau^2}=1.414\tau=22.6\frac{Pr}{\pi d^3}$$

where AB = CD = r, BC = $2l$.

5. Thin Plate Springs

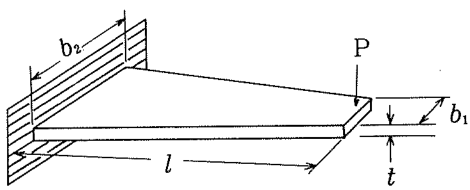
● Calculation Formulas For Plate Springs



$$\delta=\frac{Pl^3}{3IE}=\frac{4Pl^3}{bh^3E}\left(I=\frac{bh^3}{12}\right)$$

$$k=\frac{P}{\delta}=\frac{3IE}{l^3}=\frac{bh^3E}{4l^3}$$

$$\sigma=\frac{Pl}{Z}=\frac{6Pl}{bh^2}\left(Z=\frac{bh^2}{6}\right)$$



$$\delta=\frac{Pl^3}{3IE}=K_1\frac{4Pl^3}{b_2h^3E}\left(I=\frac{b_2h^3}{12}\right)$$

$$k=\frac{P}{\delta}=\frac{3IE}{l^3}=\frac{1}{K_1}\cdot\frac{b_2h^3E}{4l^3}$$

$$\sigma=\frac{Pl}{Z}=\frac{6Pl}{b_2h^3}\left(Z=\frac{b_2h^2}{6}\right)$$

h = Thickness of spring plate ························ mm
b_1,b_2 = Width of spring plate ························ mm
L = Length of spring plate························ mm
k = Spring constant························ kg/mm
K_1 = Shape correction factor
E = Modulus of longitudinal elasticity···· kg/mm^2
P = Load ························ kg
σ = Stress at maximum deflection ······ kg/mm^2
δ = Deflection························ mm
I = Cross-sectional moment of inertia ······ mm^4
Z = Cross-section factor ························ mm^3