3 Load and Stress Calculations of Dish Spring (Reference data: JIS B 2706)

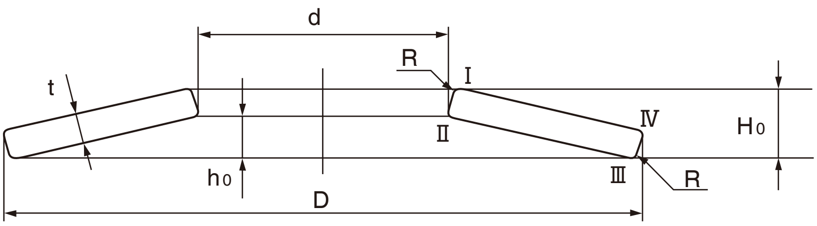

Fig. 3 Dish Spring

- D: Diameter of outer periphery (mm)
- d: Diameter of inner periphery (mm)
- t: Plate thickness (mm)
- H_0: Free height (mm)
- h_0: Total amount of deflection (H_0 - t) (mm)
- E: Longitudinal elastic modulus (N/mm²) (Table 1)
- ν: Poisson's ratio of material (0.3)
- P: Load (N)
- δ: Amount of deflection (mm)
- k: Load rate (N/mm)
- R: Chamfer radius of corner (mm)
- σⅠ: Stress on position Ⅰ (N/mm²)
- σⅡ: Stress on position Ⅱ (N/mm²)
- σⅢ: Stress on position Ⅲ (N/mm²)
- σⅣ: Stress on position Ⅳ (N/mm²)

The coefficients used for calculation are as follows:

$$\alpha = \frac{D}{d}$$

$$C_1 = \frac{1}{\pi} \cdot \frac{\left(\frac{\alpha - 1}{\alpha}\right)^2}{\frac{\alpha + 1}{\alpha - 1} - \frac{2}{\ln \alpha}}$$

$$C_2 = \frac{1}{\pi} \cdot \frac{6}{\ln \alpha} \cdot \left(\frac{\alpha - 1}{\ln \alpha} - 1\right)$$

$$C_3 = \frac{3}{\pi} \cdot \frac{\alpha - 1}{\ln \alpha}$$

Including the correction item $\left(\frac{D - d}{(D - d) - 3R}\right)$ that allows for round chamfering of the corner presents the load P by the following formula:

$$P = \frac{D - d}{(D - d) - 3R} \cdot \frac{4E}{1 - \nu^2} \cdot \frac{t^3}{C_1 D^2} \cdot \delta \cdot \left[\left(\frac{h_0}{t} - \frac{\delta}{t}\right) \cdot \left(\frac{h_0}{t} - \frac{\delta}{2t}\right) + 1\right]$$

The stresses on the positions Ⅰ, Ⅱ, Ⅲ and Ⅳ can be calculated according to the formulas given below. A positive value indicates tensile stress while a negative value indicates compression stress.

$$\sigma_{I} = \frac{4E}{1 - \nu^2} \cdot \frac{t}{C_1 D^2} \cdot \delta \cdot \left[- C_2 \cdot \left(\frac{h_0}{t} - \frac{\delta}{2t}\right) - C_3\right]$$

$$\sigma_{II} = \frac{4E}{1 - \nu^2} \cdot \frac{t}{C_1 D^2} \cdot \delta \cdot \left[- C_2 \cdot \left(\frac{h_0}{t} - \frac{\delta}{2t}\right) - C_3\right]$$

$$\sigma_{III} = \frac{4E}{1 - \nu^2} \cdot \frac{t}{\alpha C_1 D^2} \cdot \delta \cdot \left[(2C_3 - C_2) \cdot \left(\frac{h_0}{t} - \frac{\delta}{2t}\right) + C_3\right]$$

$$\sigma_{IV} = \frac{4E}{1 - \nu^2} \cdot \frac{t}{\alpha C_1 D^2} \cdot \delta \cdot \left[(2C_3 - C_2) \cdot \left(\frac{h_0}{t} - \frac{\delta}{2t}\right) - C_3\right]$$

The load rate of the spring is non-linear and can be calculated according to the following equation.

$$k = \frac{dP}{d\delta} = \frac{D - d}{(D - d) - 3R} \cdot \frac{4E}{1 - \nu^2} \cdot \frac{t^3}{C_1 D^2} \cdot \left[\left(\frac{h_0}{t}\right)^2 - 3\frac{h_0}{t} \cdot \frac{\delta}{t} + \frac{3}{2}\left(\frac{\delta}{t}\right)^2 + 1\right]$$