Coil Spring Design for Spring Balancer of a Research Reactor

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1. Introduction

A spring balancer is installed between a hoist hook of a pool crane and a tool for a research reactor to detect abnormal loads. Battery-operated lamps and buzzers give an alarm to an operator when a certain unintended load occurs from the static balanced weight. In this study, coil spring equations are derived, and spring variables are considered for additional coil spring design for handling pool platform covers.

2. Methods and Results

Figure 1 shows free body diagram for a coil spring [1].

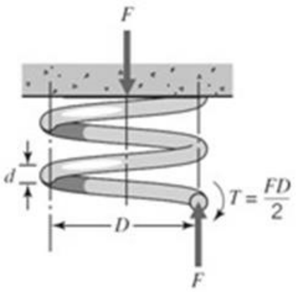

Fig. 1. Free body diagram for coil spring [1]

d = wire diameter, mm
D = spring mean diameter, mm
F = axial load, kgf
T = torsion, kgf·mm

The axial load F is derived from the following equations.

$$L = \pi D n \quad (1)$$

$$\delta = (D/2)\theta \quad (2)$$

$$T = (D/2)F \quad (3)$$

$$\theta = \frac{TL}{GJ} = \frac{32TL}{G\pi d^4} (\Leftarrow J = \frac{\pi}{32} d^4) \quad (4)$$

Substituting Eqs. (1) ~ (3) in (4) gives

$$F = \frac{Gd^4}{8nD^3}\delta (\Rightarrow K = \frac{Gd^4}{8nD^3}) \quad (5)$$

G = modulus of rigidity, kgf/mm^2
J = polar moment of inertia, mm^4
K = spring constant, kgf/mm
L = effective length of wire, mm
n = number of active coils
δ = deflection of spring, mm
θ = angle of deflection, radians

For the design of a spring balancer for a specific load range, the variables must be adjusted. In Eq. (5), the axial load F is proportional to G, d^4, δ and inversely proportional to n and D^3. To handle larger weights, the effects of d and D are large, but limited by the recommended Spring Index C (= D/d) and spring standards. The maximum load that can be handled is limited to when the spring is compressed to its maximum (about solid length), and is related to d and n. However, due to the pool and crane level in the research reactor, the maximum working load is limited by the specific value δ. G depends on the material, but there is a limit to the material that can be used in the pool of the research reactor. In addition, allowable shear stress, tolerances for loads, and pitch limitations, etc. should be considered.

3. Conclusions

In this study, the coil spring design for a spring balancer of a research reactor has been considered. The equations were derived to design the spring balancer for additional load ranges, and the effects of design variables and limitations in the research reactor were investigated. By applying these methods, spring balancers of several specific load ranges can be designed and manufactured.

ACKNOWLEDGEMENTS

This project is supported by the National Research Foundation of Korea (NRF) grant funded by the Government of Korea (MSIT: Ministry of Science and ICT) (No. 2020M2C1A1061043).

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