Buckling Analysis for the Shape of the Thin-tube Support of Radioisotope Thermoelectric Generator to investigate structure integrity

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1. Introduction

RTG(Radioisotope Thermoelectric Generator) is thermoelectric generator using the decay heat of the radioisotope. RTG produce power with a limited heat source, so the thin tube is positioned on and under heat source to increase the efficiency of generation[1-2]. The thin tube is unstable because of the buckling, so that's structure integrity is investigated using the buckling analysis. The theoretical prediction for thick column is possible easily, but the theoretical prediction for thin tube is difficult, so the FEM(finite element method) is required to verify the structure integrity[3-6].

In this study, the buckling analysis was conducted to investigate the structural integrity of RTG's thin tube using ANASYS™ which is FEM program.

2. Methods and Results

2.1 FEM model and boundary condition

Buckling analysis for shape of RTG support was conducted by using ANSYS™

Fig. 1 shows that the analysis models. Fig. 1 (a) is circle tube, (b) is hexagon tube, (c) square tube, (d) triangle tube. The material of tube is SUS304 because of low thermal conductivity and high strength. The height of tube is 53 mm, the thickness of tube is 0.3 mm,

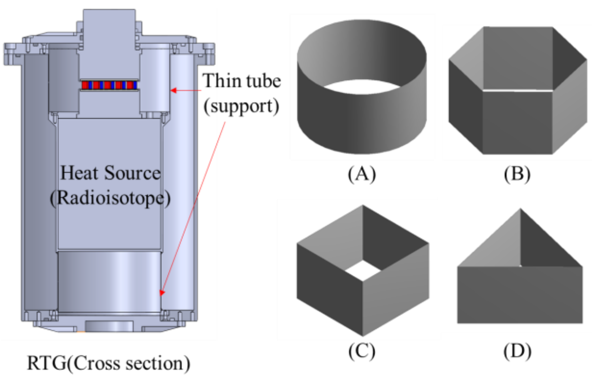

Fig. 1 Analysis model for shape of a tube: (a) circular tube, (b) hexagonal tube, (c) square tube and (d) triangular tube

The result of buckling analysis is changed according to the initial imperfection value, so the initial imperfection value was obtained by comparing the buckling theoretical formula for cylinder and results of buckling analysis in order to ensure the reliability of FEM results. The theoretical formula is (1) and (2) below[7].

$$\frac{KL}{r} \geq \left(\frac{KL}{r}\right)_c, \quad \sigma_{max} = \left[\frac{(KL/r)_c^2}{2(KL/r)^2}\right] \cdot \sigma_Y \qquad (1)$$

$$\frac{KL}{r} \leq \left(\frac{KL}{r}\right)_c, \quad \sigma_{max} = \left[1 - \frac{(KL/r)_c^2}{2(KL/r)^2}\right] \cdot \sigma_Y \qquad (2)$$

K is a constant that depends on the restraints of the two ends of the column, L is denotes the length of the component, r is the radius of gyration, KL/r is the effective slenderness ratio σ_Y is yield strength. Eq. (1) is used when the slenderness ratio of the column is more than the effective slenderness ratio, Eq. (2) is used when the slenderness ratio of the column is less than the effective slenderness ratio.

Fig. 2 shows that the result of the theory and analysis. As you can see that the analysis value is distributed in the theory area.

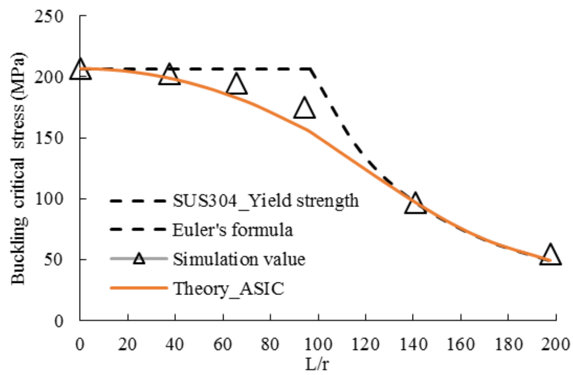

Fig. 2 Comparison of the result of simulation and theory

2.2 Buckling analysis

The buckling analysis for thin tube was conducted with the obtained initial imperfection value

Fig. 3 shows that the buckling stress for the thin-tube shape. The buckling stress of circular tube is 177 MPa, hexagonal tube is 89, rectangular tube is 62 and triangular tube is 49. According to the buckling theory for cylinder, the triangular shape is the most stable. But in case of the thin tube, the circular shape is the most stable. This reason was predicted that because the thickness of the tube is very thin.

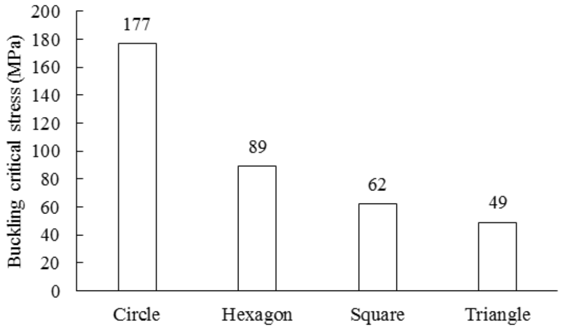

Fig. 3 Comparison of the result for shape of tube

3. Conclusions

The buckling analysis was conducted in this study to investigate the buckling stress for shape of thin-tube support. As a result, the circle-tube is the most appropriate structure for supporting inside of RTG.

In the future, we will conduct the thermal-structure analysis to investigate that the decay heat of heat source(radioisotope) affect on the structure integrity of thin-tube support.

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