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Title

Derivation of Buckling Knockdown Factors for Hemispherical Shells with Foam Core

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Abstract

The buckling loads of the thin-walled shell structures are significantly reduced by the initial imperfection compared to the linear buckling load of the perfect cylinder without the initial imperfection. Therefore, this load reduction should be considered in the preliminary design of thin-walled shell structures subjected to axial compression. The buckling knockdown factor (KDF) is expressed as the ratio between the global buckling loads of the thin-walled shell structures with and without the initial imperfection to consider the load reduction due to the initial imperfection in the preliminary design. The previous NASA buckling design criteria [1] were established using the test results of the hemispherical shell structures in the 1930s to 1960s. Thus, the previous buckling design criteria [1] cannot consider the modern structural material and manufacturing techniques, such as the foam core sandwich used in the common bulkhead of launch vehicle's propellant tanks. Therefore, in this study, the KDFs of the hemispherical shells with foam core (Fig. 1(a)) under external pressure are derived numerically using ABAQUS. The numerical modeling method (Fig. 1(b)) of the initial imperfection is used to represent the initial imperfection. The nonlinear postbuckling analyses using Riks method (Fig. 1(c)) are conducted for the hemispherical shells with the initial imperfection modeling the under external pressure. The numerical KDFs of the present model are derived from the global buckling load results of the postbuckling analyses. The global buckling load with the initial imperfection (5.39 MPa) is 82.04% lower than that the result without the initial imperfection (30.01 MPa). The KDF in this work is predicted to be 0.18, which is 14.04% lower than the previous buckling design criteria ([1], 0.21). These results show that the buckling design criteria for the hemispherical shells with foam core should be re-derived for the robust preliminary design that can prevent buckling failure.

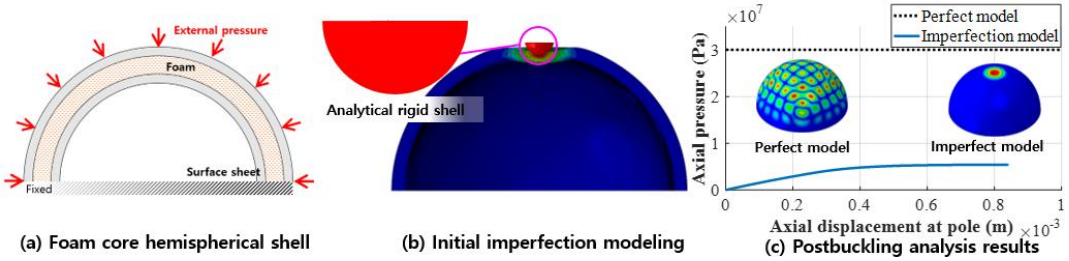

Figure 1. Postbuckling analysis for hemispherical shells under external pressure

References

[1] Weingarten, V. I. and Seide, P., "Buckling of thin-walled doubly curved shells," NASA SP-8032, 1969.