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Title

Thermal transfer effects on postbuckling behaviors of common bulkhead structures

Authors

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Abstract

The Knockdown factor is a buckling design criterion for the shell structures to consider the reduction of the buckling load due to the initial imperfection. In this study, the Knockdown factor of the hemispherical sandwich structure with foam core for a common bulkhead structure is derived for the design of launch vehicles. The thermal stresses and deformations may occur in the common bulkhead structure due to the heat transfer of the propellants, and these may cause the imperfection of the hemispherical sandwich structure with foam core. Therefore, it is necessary to derive the buckling design criterion considering the imperfection due to these thermal effects. A commercial finite element analysis program, ABAQUS, is used for modelings and numerical simulations. For thermal-structural analyses, it is assumed that heat conduction of liquid hydrogen appears in the upper part of the hemispherical sandwich structure with foam core (Fig. 1). In the lower part, the heat convection between liquid oxygen and ullage is considered. Post buckling analyses are performed for structure models under external pressure considering geometric imperfection caused by thermal effects. The buckling load of the hemispherical sandwich structure with foam core considering the thermal effects is about 29.02% lower than the buckling load of the structure not considering the thermal effects (Fig. 2). The Knockdown factor is derived as 0.71, which is 173.08% higher than the 0.26 by NASA SP-8032. Therefore, it is investigated that structural weight reduction is possible when the present Knockdown factor is used. (Fig. 3). In the full paper, by deriving the Knockdown factors considering other geometric initial imperfections, which can occur during manufacturing and operation as well as the deformation due to thermal effects, the possibility for lightweight design of the launch vehicles will be presented.

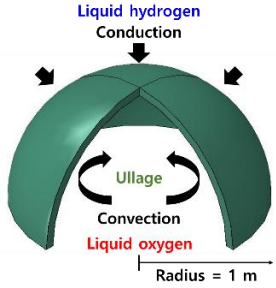

Fig. 1. Schematic diagram for common bulkhead

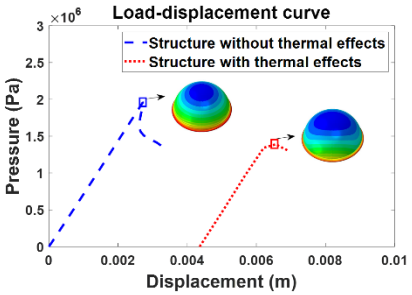

Fig. 2. Load-displacement curves

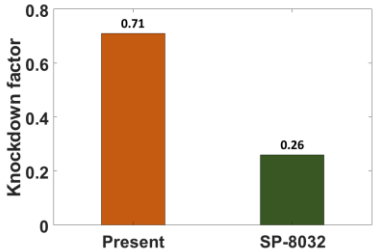

Fig. 3. Comparison for Knockdown factors