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GLOBAL OPTIMUM DESIGN OF EXTERNALLY PRESSURIZED ISOGRID STIFFENED CYLINDRICAL SHELLS WITH ADDED T-RINGS

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(This is an abridged version. See the full-length paper for more: panda2.papers/2002.isogrid.pdf)

ABSTRACT

PANDA2 is a code for the minimum-weight design of perfect and imperfect elastic stiffened panels and shells made of composite laminates and subjected to multiple sets of in-plane loads, edge moments, normal pressure, and temperature. The scope of PANDA2 is increased to include global optimization and the capability to handle isogrid stiffening. The enhanced program is used to find global optimum designs of internally T-isogrid and internally T-ring stiffened perfect and imperfect isotropic cylindrical shells under uniform external pressure. For the cases studied, it is found that for the perfect optimized shells the isogrid stiffening is important but the rings are not, whereas the opposite holds for the optimized shells with an initial general buckling modal imperfection of amplitude equal to one per cent of the shell radius.

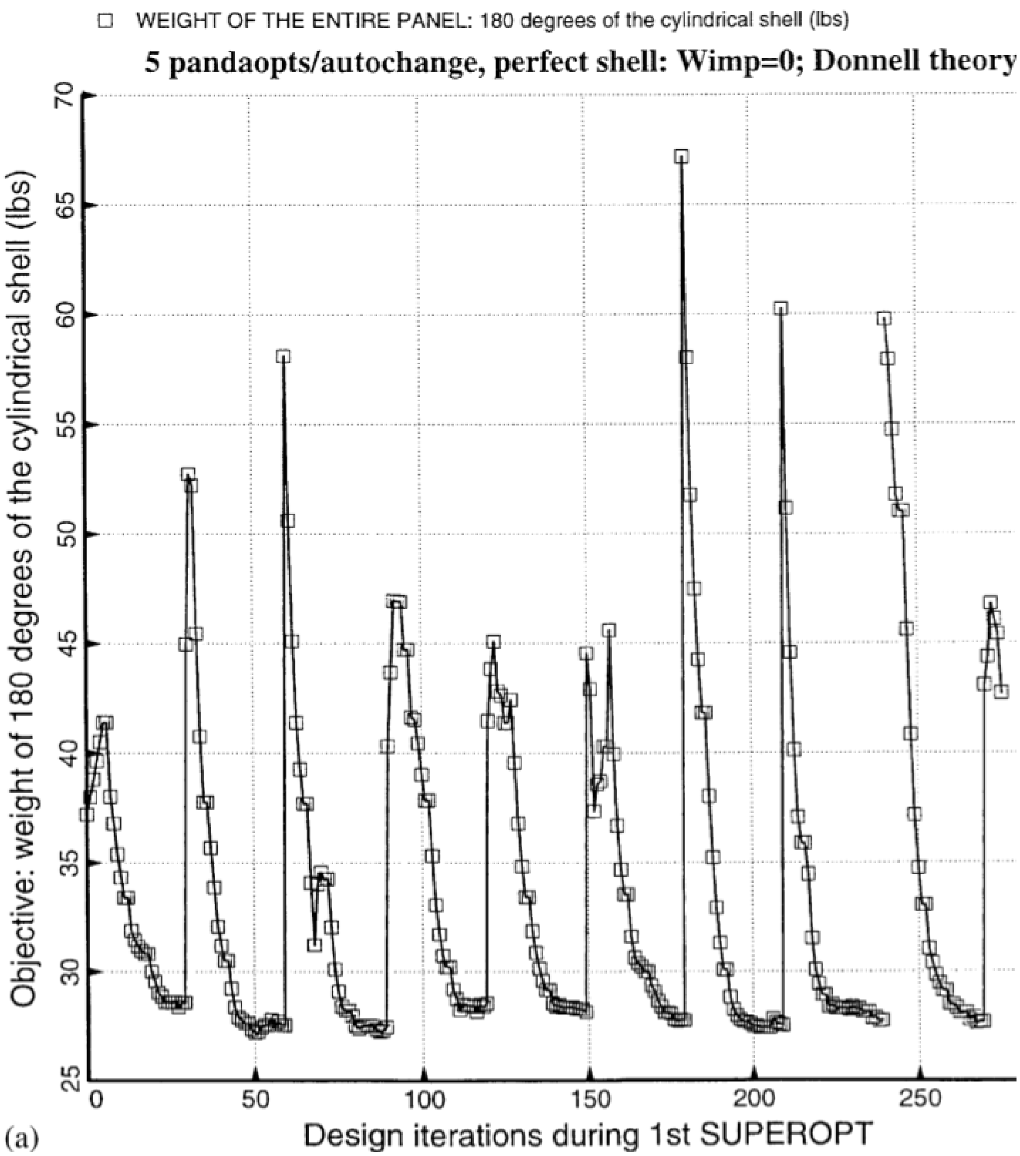
1. INTRODUCTION

This paper reports the use of the structural optimization code, PANDA2, to find minimum-weight designs of perfect and imperfect internally T-isogrid stiffened cylindrical shells with internal rings with T-shaped cross sections. An isogrid-stiffened skin has three sets of identical stiffeners that divide the skin into equilateral triangles [1]. In PANDA2 [2–11] there are two possible orientations of the isogrid stiffening pattern; Option 1: one of the three sets of stiffeners runs in the circumferential direction and Option 2: one of the three sets of stiffeners runs in the axial direction. In all of the examples presented here Option1 is used. The three sets of isogrid stiffeners are identified as “isogrd1, isogrd2, isogrd3”, with the stiffener axes oriented at +30 degrees, -30 degrees, and 90 degrees, respectively, relative to the axial coordinate, which is the generator of the cylindrical shell.

1.1. Statement of the problem

All of the examples here pertain to a complete (360-degree) simply supported cylindrical shell of length 35 in and radius to the skin middle surface of 9.4 in. The stiffeners are internal. All stiffeners have T-shaped cross sections. The cross section dimensions of the isogrid members are different from those of the rings. The material is titanium and remains elastic. The cylindrical shell is loaded by uniform external pressure of 1500 psi. The optimization problem is completely set forth in Table 1. Optimum designs for several cases are listed in Table 2. Design margin definitions are listed in Table 3, and design margin values for several optimum designs are listed in Tables 4 and 5. The imperfect shells have an initial imperfection in the form of the general buckling mode with amplitude, Wimp = 0.094 inch. There are no additional inter-ring or local panel skin buckling modal imperfections.

In PANDA2 a complete (360-degree) cylindrical shell is modeled as a panel that spans 180 degrees [2,6,10]. Boundary conditions on all four edges of this panel are classical simple support (anti-symmetry) for buckling. The overall buckling behavior of a 180-degree panel simply supported along its two generators is identical to that of a complete (360-degree) cylindrical shell [2]. The optimum weights listed in Table 2, therefore, represent half (180 degrees) of the cylindrical shell.



(a)

Fig. 3a “Global” optimization of a perfect, internally isogrid and T-ring stiffened, hydrostatically compressed cylindrical shell. Each “spike” in the curve corresponds to a new “starting” design obtained randomly by the PANDA2 processor called AUTOCHANGE. Five PANDAOPTs per AUTOCHANGE were specified for the execution of SUPEROPT. (from International Journal of Non-Linear Mechanics 37 (2002) 801–831)

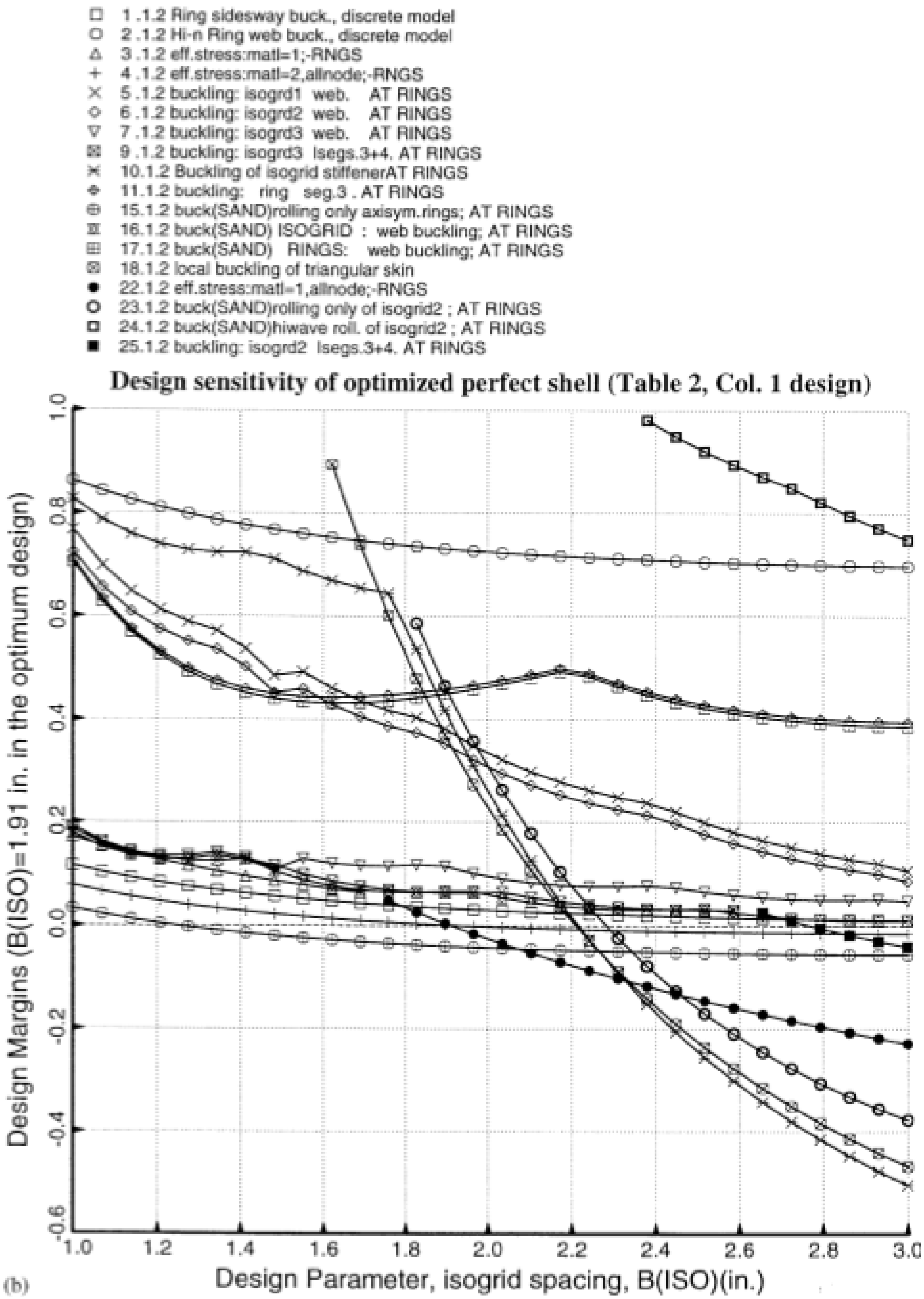


Fig. 8b Design sensitivity of an optimized, hydrostatically compressed, perfect, internally isogrid-stiffened cylindrical shell with added internal T-shaped rings. B(ISO) is the spacing of the isogrid. (from International Journal of Non-Linear Mechanics 37 (2002) 801–831)