On the buckling mechanism of imperfection sensitive monolithic thin-walled unstiffened composite cylinders – physical observations to support less conservative knock-down factors

Saullo G. P. Castro[(1)], Mariano A. Arbelo[(1)], Rolf Zimmermann[(2)], Richard Degenhardt[(2)]

[1] Private University of Applied Sciences – PFH, Airbus-Straße, 6. 21684, Stade, Germany.

[2] German Aerospace Center – DLR, Institute of Composite Structures and Adaptive Systems, Lilienthalplatz 7, 38108, Braunschweig, Germany.

Abstract:

The need to take the imperfection sensitivity of thin-walled unstiffened cylinders into account during the early design phases motivated the development of the NASA SP-8007 guideline, which brings an empirically based lower-bound curve that gives the knock-down factor (KDF) as a function of the cylinder's radius and thickness. This guideline is still used also for composites, using correction. The conservativeness of these guidelines has been proved both stochastically by Arbocz, Starnes Jr., Hilburger, et al.; and deterministically by Geier, Hühne, Degenhardt, et al. A deterministic method: single perturbation load approach; developed by Hühne, showed that after some radial load (called P1) the imperfection sensitivity decreases, i.e. the buckling load remains nearly constant even increasing the radial load. Such physical benefit is not taken into account by the NASA SP-8007 guideline. This study, in the context of DESICOS, investigates the buckling mechanism of composite benchmark cylinder, developed by Zimmermann, being extreme-case laminates with high and low imperfection sensitivity. The explanation why the buckling load is constant after P1 is given and a physical meaning for the P1 value is proposed. These findings pave the way for the development of semi-analytical approaches for calculating P1. By applying the P1 value in the analysis, one can obtain less conservative KDFs which have shown to be closer to test results, allowing cost savings for the space industry.