Experimental Investigation of the Buckling Process of a Cylindrical Composite Shell under Static Axial Loading

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Abstract:

The buckling of cylindrical launch vehicle structures under axial load occurs similar to the behaviour of unstiffened cylindrical shells. The design of those structures is still burdened by high knock down factors, because of their strong sensitivity to various kinds of imperfections and the specific behaviour under dynamic loads. So, the better understanding of the buckling process on unstiffened cylindrical shells can be a helpful contribution on the dimensioning of those structures.
The experimental investigation on the buckling of unstiffened circular shells under axial compression load still needs some further understanding on the initiation of the buckling process. In widely published experimental tests the results comprise load-displacement-curves, strain development or pictures from the state of the post-buckling pattern after the load suddenly decreased. Only few publications are known that show the buckling process in its development, especially under the quasi-static axial loading. The initiation of a first instable buckle is shown in some observations, but the reason for its appearance at this location is not explained. Furthermore, most of those publications treat the buckling of shells with isotropic material. The buckling phenomena under dynamic loads as well as the interaction of vibration and stability require the knowledge of the buckling process under quasi-static loading. In addition, the understanding of buckling deformation is seen to be necessary for further methods like vibration-correlation-technique (VCT) or perturbation load experiments. Hence, the author suggests to have a closer look on how buckling evolves on a cylindrical shell and under which condition it is initiated.
This presentation shows the results of experimental tests in a buckling test machine on a composite cylindrical shell. At first, results of repeated experimental tests demonstrate the reproducibility of the shell behaviour. The use of digital image correlation (DIC) in combination with standard sensors for load, displacement and strain leads to a more detailed explanation on buckling of thin composite cylindrical shells and its phenomena. The sequence of buckling deformation of a cylindrical composite shell is presented and described in detail. Results of some complementary numerical simulations support the assessment of the experimental data. So, the results of the numerical simulation and the investigation of the experimental data help to understand the ongoing process of buckling. The presentation concludes with the proposal to use these observations for further investigations, especially for experimental buckling analysis under dynamic pulse loads, perturbation experiments or potentially in addition to VCT tests.