FUTURE DESIGN OF COMPOSITE LAUNCHER STRUCTURES

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Introduction

The Space industry demand for lighter and cheaper launcher transport systems. The running EU project DESICOS (New Robust DESIgn Guideline for Imperfection Sensitive COmposite Launcher Structures, cf. [1]), which started in February 2012, contributes to these aims by a new design procedure for imperfection sensitive composite launcher structures, exploiting the worst imperfection approach efficiently by implementation of the Single Perturbation Load Approach [2]. Currently, imperfection sensitive shell structures prone to buckling are commonly designed according the NASA SP 8007 guideline using the conservative lower bound curve. The guideline dates from 1968, and the structural behaviour of composite material is not considered appropriately, in particular since buckling load and imperfection sensitivity of shells made from such materials substantially depend on the lay-up design. This is not considered in the NASA SP 8007, which allows designing only so called "black metal" structures. Here is a high need for a new precise and efficient design approach for imperfection sensitive composite structures which allows significant reduction of structural weight and design cost. For most relevant architectures of cylindrical and conical launcher structures (monolithic, sandwich - without and with holes) DESICOS will investigate a combined methodology from the Single Perturbation Load Approach and a Specific Stochastic Approach which guarantees an effective and robust design. A recent investigation demonstrated, that an axially loaded unstiffened cylinder, which is disturbed by a large enough single perturbation load, is leading directly to the design buckling load 45% higher compared with the respective NASA SP 8007 design [3]. Within DESICOS the new methods will be further developed, validated by tests and summarized in a handbook for the design of imperfection sensitive composite structures. The potential will be demonstrated within different industrially driven use cases. This paper deals with the objectives of the DESICOS project, describes the line of actions of the new approach, and specifies the theoretical and experimental work to be carried out in order to meet the objectives.

DESICOS project

The main objectives of DESICOS is realised by the implementation of the *Single Perturbation Load Approach* (SPLA) for buckling of imperfection sensitive structures. This approach considers the ‘traditional’ imperfections like the geometric and implicitly also the loading ones. In order to guarantee a robust design, the approach is combined with a specific stochastic procedure, which considers the ‘non-traditional’ imperfections like variations of thickness, material properties, etc. The outcome of the single perturbation load approach is the knock down factor ρ_1 and the outcome of the stochastic approach under consideration of specific aspects of composites (stacking, etc.) leads to the knock down factor ρ_2. Both factors are combined together in order to define the design load. This concept promises to exploit the full potential of composite structures in an efficient way.

Figure 1 compares the NASA SP 8007 guideline as current design scenario using the conservative lower bound curve for the knock-down factor ρ_{NASA} with the new approach to be developed in DESICOS which combines the knock-down factor ρ_1 from the Single Perturbation Load Approach and the knock-down factor ρ_2 from a stochastic approach. First results of a composite cylinder show possible reduction of structural weight of 20% (cf. [3]).

Expected results

To reach the main objective, improved design methods, experimental data bases as well as design guidelines for imperfection sensitive structures are needed. The experimental data bases are indispensable for validation of the analytically developed methods. Reliable fast methods will allow for an economic design process. Industry brings in experience with the design and manufacture of real shells; research contributes knowledge on testing and on development of design methods. Design guidelines are defined in common, and the developed methods are validated by industry.

The results of DESICOS comprise:

- Material properties
- Method for the design of buckling critical fibre composite launcher structures, based on the combined SPLA and stochastic procedures, validated by experiments
- Experimental results of buckling tests including measured imperfections, buckling and postbuckling deformations, load shortening curves, buckling loads
- Guidelines how to design composite cylindrical shells to resist buckling
- Reliable procedure how to apply the Vibration Correlation Technique (VCT) in order to predict buckling loads non-destructively by experiments
- Handbook including all the results
- Demonstration of the potential with different industrially driven use cases.

Summary

The main objective of the upcoming DESICOS project is the future design scenario for imperfection sensitive CFRP structures. The results comprise extended experimental data bases, improved design methods as well as design guidelines. More details can be found at www.desicos.de.

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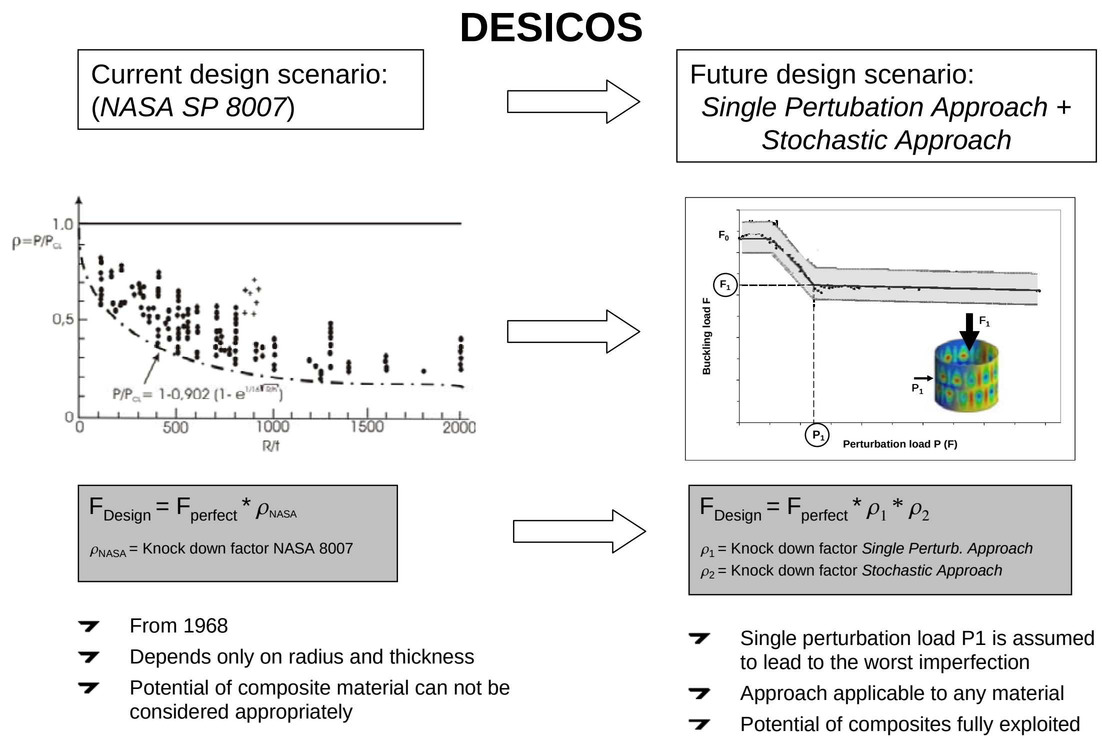

Fig. 1 Future design scenario for composite launcher structures