PROJECT ABSTRACT

Mechanisms of failure expansion and changes of strength properties of hybrid fibre titanium laminates previously subjected to impact

1. The aim of research / research hypothesis

The objective of this project is to analyse, interpret and describe the influence of low-velocity impacts applied to hybrid fibre-titanium laminates on the mechanisms of failure development and changes in laminate strength. Fibre-metal laminates based on glass- and carbon-epoxy composites, and titanium (as next-generation FMLs) will be assessed. Titanium-based laminates, particularly in combination with carbon fibres, represent a still under-researched area of materials engineering and provide significant prospects for use in the space, aviation, automotive and machine industries. The research conducted in the proposed scope will lead to identifying and analysing the mechanisms of degradation occurring in thin-walled hybrid FML, combined with assessing the changes in their carrying capacity as a result of low-velocity impacts. An attempt will be made to express the significant correlations between the material, impact, failure, carrying capacity and failure development (from the quantitative and qualitative perspectives).

An analysis of the state of the art has revealed that there have been no studies of this type. This could be related to the complexity and innovative nature of the subject of research. The analysis of literature data and the principal investigator own research formed the basis for a hypothesis that the type of laminate and the size of failure in its structure as a result of impacts have a significant influence on the future carrying capacity of laminates. There are indications that the loss of strength is not linear and the type and orientation of failure after impact have a major influence on it. The fact that the principal investigator can conduct such tests using their patent-pending original test stand is very important. Furthermore, the principal investigator is of the opinion that the carrying capacity understood as the threshold value of stress resulting in the complete failure of thin-walled fibre-titanium laminate sheets is strongly dependent on the type and scale of the failure following low-velocity impacts. The type of materials inside the FMLs and the no of layers and interphases inside are one the most features here and it will be tested and summarized by creation of material-load dependencies and numerical model.

2. The applied research method / methodology

The material for the experiment (fibre-titanium laminates) will be manufactured using the autoclave method (including the surface preparation of titanium used in aerospace). The impact experiment is planned to be conducted using a specialized measurement device (impact tower) dedicated to tests of composites and FMLs. Static load tests will be conducted using the INSTRON impact tester (100 kN). Both non-destructive and destructive methods will be used to evaluate failure at the respective stages of research: ultrasonic through transmission phased array, which will make it possible to describe the failure in quantitative terms. At each of the indicated stages, destructive analyses will be conducted on reference and tested samples.

3. Influence the expected results on the development of science, civilization and society

The expected results of the planned studies will contribute a number of new aspects to the discipline of materials engineering and mechanics of composite materials by using basic knowledge from the traditional disciplines of solid-state physics and dynamic mechanics of materials, which affect each other. The development of the discipline of materials engineering will effectively involve the possibility of optimising the manufacture of innovative hybrid composite materials to affect their as yet unknown or insufficient mechanical properties required in engineering applications. Modern materials engineering will most likely be expanded with specialist knowledge in the field of fundamental science relating to the quantitative and qualitative description of mechanical phenomena (static and dynamic) after damage-causing impacts and the static loads following them, which has been a known issue only for classic composite materials. The rapid development of composite materials has led to the emergence of an important research issue, which must be solved to effectively design fibre-metal laminates for the advanced applications required by contemporary technology. New guidelines for testing layered hybrid materials, which are currently considered some of the most prospective materials in engineering, will be prepared as a result of developing materials science.