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Popular science project summary

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

Innovative fiber metal laminates based on titanium in combination with polymer matrix composites reinforced with glass and carbon fiber are the focus of attention of the world's major scientific bodies, although their manufacturing and essential properties are studied by few teams in this country and abroad.

From literature review follows that composite materials, mainly of polymer matrix composites reinforced with fibers are one of the most advanced and promising groups of materials. Particularly interesting and new group of composites materials are hybrid composites such as FML - Fibre Metal Laminates consisting of successively arranged (alternately) of the metal and polymer matrix composites layers. FML have high properties because of both metal and polymer composite properties and interactions between them. This combination give a new generation of hybrid materials with high strength and fatigue properties, chemical resistance, and corrosion and low density. Particularly laminates based on titanium and glass or carbon fibers are currently a focus of research, although due to the complexity of their manufacturing process and research capacity, they are unavailable to most scientific teams.

The objective of this project is to analyse, interpret and describe the influence of low-velocity impacts applied to hybrid fibre-metal laminates on the mechanisms of failure development and changes in laminate strength. Fibre-metal laminates based on glass- and carbon-epoxy composites, and titanium alloys (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 structures, 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).

The general study plan covers a number of tasks associated with the planned scope of work and subject of research. On the basis of the principal investigator previous experience and knowledge, an appropriate configuration and structure of fibre-metal laminates to be used in the research (titanium/epoxy-glass composite, titanium/epoxy-carbon composite) will be selected. The number of individual layers and the interfaces inside the laminate will be selected in such a way as to facilitate the assessment of the influence of those structural parameters on the mechanisms of failure development and the parameter of strength changes after impacts. Simulated impacts with the set and controlled parameters, such as impact energy etc. will be performed subsequently. After impacts, laminates will be subject to failure assessment with non-destructive methods, using ultrasonics testing techniques. Witness samples will also be created to assess failure using destructive methods (observation of cross-sections and electron microscopy). Following non-destructive evaluation of failure (specifying the size and orientation), the samples will be subjected to axial compression using the stand developed in house. Compression will be conducted at various levels of load, with the final one resulting in the complete destruction of the laminate. Quantitative and qualitative analyses of failure development will be conducted at specific load stages, In the last stage the quantitatively-expressed strength change parameter will be determined and the correlations between the material, impact, failure, carrying capacity and failure development will be conclusively expressed.

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 optimizing the manufacture of innovative hybrid composite materials to affect their as yet unknown or insufficient mechanical properties required in engineering applications.