The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Javane Karami**

The public defense will take place on **Thursday 18th December 2025 at 4 pm** in room **D.2.01** (Building D, VUB Main Campus)

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EXPERMENTAL INVESTIGATION OF THE FRACTURE BEHAVIOR OF THERMOPLASTIC COMPOSITES AND OVERMOLDED PARTS

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Abstract of the PhD research

Fiber Reinforced Polymer (FRP) composites are increasingly used in the aerospace and automotive industries for their high strength-to-weight ratio, mechanical properties, and design flexibility, which in turn lead to reduced fuel consumption and CO_2 emissions. Thermoplastic-based FRP composites offer additional advantages over thermosets, including shorter cycle times, higher damage tolerance, recyclability, and weldability, enabling the design of lighter structures with fewer mechanical fasteners. However, they remain susceptible to various damage mechanisms, particularly delamination, which significantly reduces the load-bearing capacity of composite structures. Understanding these mechanisms under service conditions is essential for developing reliable, damage-tolerant designs. Accordingly, the current study addresses two critical aspects of structural integrity: delamination in composite laminates and bonding quality at the compound-insert interface in injection overmolded parts.

1st part: This concerns the delamination fracture characterization of PEKK-FC, commercially known as APC, a high-performance thermoplastic composite material with potential applications in aerospace structures. Delamination experiments are performed under different in-plane loading modes while employing Acoustic Emission (AE) and Digital Image correlation (DIC) techniques for real-time damage monitoring. Given the importance of mode mixity in determining the criticality of a crack, and thus the structural integrity of composite structures, the AE data is utilized to develop a machine learning-based methodology for estimating the mode mixity in mixed-mode delamination experiments.

2nd part: The same APC material is employed in producing injection overmolded (OM) components, combining the high mechanical performance of FRP composites with the design versatility offered by injection molding. At the compound-insert interface, due to mismatch in mechanical properties, the interface is prone to cracking. To address this issue, it is crucial to choose the correct processing window using experimental and numerical approaches. To do so, two different specimen geometries, i.e., T-pull and Double Cantilever Beam (DCB) specimens, have been considered to study the effects of insert temperature and insert top-ply fiber orientation on the apparent pull-off strength and fracture behavior of OM parts. Furthermore, the fracture morphologies of DCB specimens are successfully compared with a thermal transient finite element model to link the observed fracture trends to the temperature evolution during the overmolding process and the employed processing parameters. Such models are important, as they help explore the design space and potentially reduce the number of experimental trials.