Improvement of bolted joining in fibre-reinforced composites

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Abstract:

Despite many new methods of joining developed recently, bolted joining is still widely acknowledged as a method of joining fibre-reinforced plastic (FRP) composites. However, bolted joining requires machining a hole in the composite and this process brings about certain problems. Firstly, the hole itself breaks the fibres and thus disrupts load-carrying paths in the composite. Secondly, the machining process causes the appearance of damages such as delaminations, fibre and matrix cracking, and burrs. As the process of drilling holes for bolted joining is responsible for 60% rejections of composite parts and the drilling process is the last stage of the manufacturing composite part, it brings about significant costs. Therefore, the elimination of the drilling holes would improve both cost- and time-effectiveness of the composite part manufacturing process and improve the load-bearing behaviour of bolted joints due to the preservation of fibre continuity in the composite. This can be achieved by employing so-called moulded holes. The moulded holes are manufactured along with the composite part. A special mould with pins embedded in the locations of the holes has to be used and plies of uncured composite are stuck by the pins during the manufacturing of the composite. Thus, moulded holes are an integral part of the composite element and no further machining is needed. Moreover, as fibres of the composite are not damaged, because they align around the holes, the load-carrying paths are disturbed to a lesser degree than in the case of drilled holes. However, the available results indicate that the increase in the strength of bolted joints with moulded holes compared to joints with drilled holes is less significant than could have been expected taking into account the indisputable advantages of the moulded holes. Therefore, the present research concerns the method of improvement of moulded hole performance. The first step necessary to achieve this goal was to understand the load-carrying mechanisms around the moulded hole. Therefore, a numerical model of the moulded hole was developed and its results were validated against experimental results. The validated model allowed the understanding of the behaviour of the moulded hole and, therefore, constitutes a useful tool for future development and improvement of the idea of the moulded holes. Based on the model the behaviour of the moulded holes will be explained.