Mechanical micro-drilling of glass and carbon fibre reinforced polymer (GFRP and CFRP) composites

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Considering that minimising resources and materials are key priorities of the circular economy encouraged by the EU, the miniaturisation of geometric features in high-strength fibre-reinforced polymer (FRP) composites will come to the fore. In addition, micro-holes are beneficial in various FRP applications such as in the miniaturised polymeric composites in microelectronic systems, biomedical filters, composite panel absorbers, to improve aerodynamic properties, micro-perforated panels in FRPs to improve acoustic absorption and noise control, etc. Although the macro-machineability of FRPs is becoming known thanks to the extensive research in this area, these experiences cannot be directly adopted to the micro-scale. The micro-machining of FRPs combines the challenges of macro-machining of FRPs (abrasive tool wear, delamination and burr formation, fibre dependency, etc.) and micro-machining (size-effect, tool deflection, size limitations, etc.), making the technology planning even more difficult.

We collected and systematised our own experience and others' published expertise on the micro-drilling of glass and carbon fibre-reinforced polymer composites for critical review. We reviewed chip removal mechanisms of micro-drilling of FRPs and compared them to conventional-sized technologies. Furthermore, the micro-drilling-induced geometrical defects and the cutting energetics are also discussed. Moreover, the future aspects and research directions are highlighted. The following aspects were addressed as room for improvement and development in the future: machine tools and equipment, peck cycles, cooling, chip removal and ultrasonic vibration assistance; advanced cutting tool geometries should be implemented in micro-scales; develop specific FRP testing regime for micro-drilled holes to analyse effects of multiple micro-holes on mechanical performance; and further exploration of machine tool, tool geometry, tool coating, cutting parameters and cooling.

References

[1] https://doi.org/10.1016/j.compositesb.2023.110589

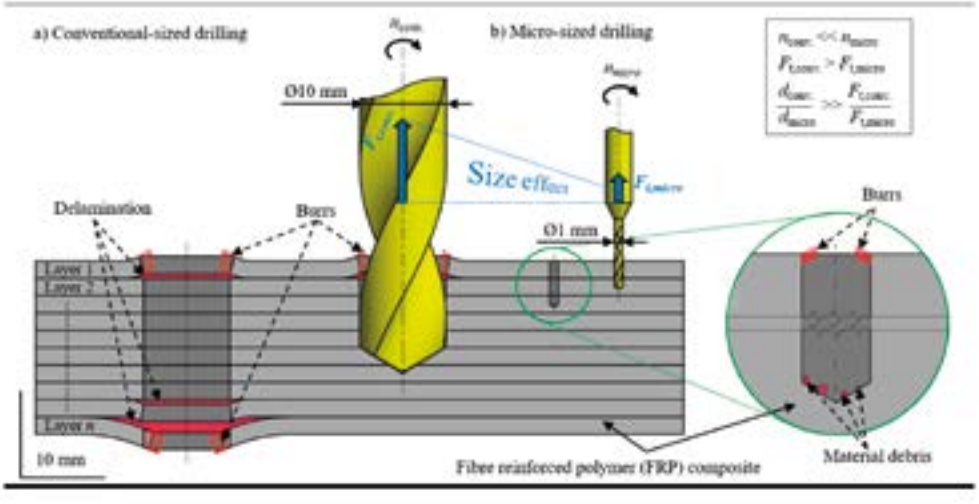

FIGURE 1
A schematic illustration of macro and micro-drilling of FRPs [1]: (a) conventional-sized and (b) micro-sized drilling, where n denotes the spindle speed, F_t is the thrust force, and d denotes the hole diameter.