Study on superior mechanical properties of thermoplastic woven composites made of opened carbon fiber yarns

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Abstract: Carbon fiber woven laminates composed of opened thin-layer prepreg sheets have better impregnation and static mechanical properties than conventional woven laminates reinforced with unopened carbon fiber yarns and comparable mechanical properties to those of orthogonal laminates composed of thin-layer prepreg sheets. On the other hand, from the viewpoint of impact energy absorption, the unrolled woven fabric laminates can absorb a large amount of impact energy due to the easy formation of interlaminar separation, and are superior in applications where performance is demonstrated at impact failure. In order to develop thermoplastic CFRP for structural components, it is important to consider the mechanical properties under both static and dynamic loads in product design.

Keywords: *carbon fiber, Nylon, textile, CFRTP.*

Experiment: Carbon fibers and resins used in the study are listed in Table 1. Figure 1 shows how the thin-layer carbon fiber prepregs were made.

Table 1 Table type styles

Matrix resin (grade, supplier)	PA 6 (DIAMIRON®, Mitsubishi Chemical)
Reinforced fiber (grade, supplier)	Carbon Fiber (TORAYCA™ T700SC-12000 60E, Toray
Form of prepreg	Unidirectional fiber reinforced thermoplastic sheet
Designed thickness	40 μm
Designed volume fraction of reinforcement	50 %

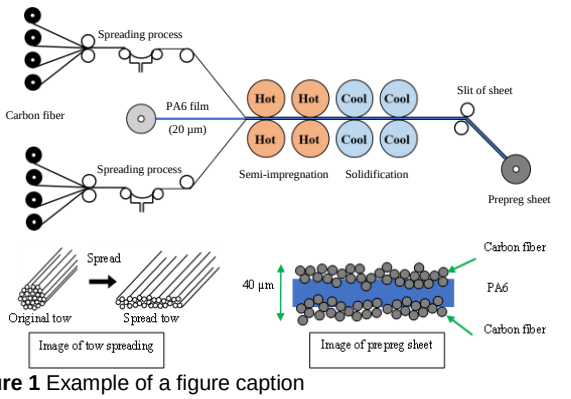

Figure 1 Example of a figure caption

Result and discussion: Woven fabrics made of thin-layer prepreg sheets have a much lower crimp ratio than conventional CF fabrics without the fiber opening process, and have excellent impregnation properties of matrix resin. In order to understand the basic properties of the materials, such as tensile properties and fracture behavior, tensile tests were conducted, and it was found that the S-S curves were linear up to the maximum tensile stress, and that there was no difference in the behavior of the S-S curves within the range of the difference in the crimp ratio in the present study. In addition, the woven laminates with thin-layer prepreg sheets show the same strength and modulus of elasticity as the orthogonal laminates, and higher strength and modulus of elasticity than those of the normal woven laminates. Furthermore, the thin-layer prepreg laminates exhibit the thin-layer effect reported for thermoset CFRP, and the thin-layer prepreg laminates exhibit a fracture mode in which interlaminar exfoliation is suppressed. When thermoplastic CFRP is applied to structural members, one of the expected performances is excellent impact resistance due to its thermoplasticity. In the drop-weight impact test, in which an impact is applied to a flat surface from the out-of-plane direction, it was found that the thin-layer prepreg laminates exhibit a fracture behavior in which interlaminar peeling is suppressed at the striker penetrations and surrounding areas due to the thin-layer effect. On the other hand, the unopened woven fabric laminate exhibits a fracture phase in which numerous interlaminar peels occur, and absorbs more impact energy than the thin-layer prepreg laminate. It is clear that interlaminar exfoliation, which is conventionally considered as a fracture to be avoided, is an effective fracture mode from the viewpoint of impact energy absorption.

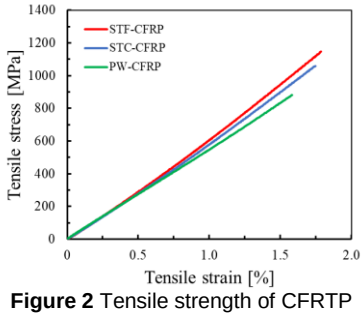

Figure 2 Tensile strength of CFRTP

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