RELATION BETWEEN FLUCTUATION IN FIBER ORIENTATION AND TENSILE PROPERTIES OF GREEN COMPOSITES

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Summary. This paper describes effects of fiber orientation angle and fluctuation on Young’s modulus and tensile strength of the so-called fully green composites. The composites were fabricated with slivers of high-strength natural fibers extracted from curaua plants.

1 INTRODUCTION

Plant-based natural fibers attract attention as alternative material of glass fibers to reduce negative effects on the environment. Natural fiber composites have already been applied for fabricating some products such as car interior parts and architectural materials. On the other hand, the fluctuation in fiber orientation occurs in the green composites because the natural fibers are often supplied as a sliver which has a wavy shape. In this study, the effect of fluctuation in fiber orientation on the tensile properties of green composites reinforced by slivers of curaua fibers was explored.

2 EXPERIMENTAL

The matrix resin used in this study was an emulsion type biodegradable resin (Randy CP-300; Miyoshi Oil & Fat Co. Ltd., Japan). The biodegradable polymer resin is thermoplastic, has hydrophilic properties and is made from a blend of polycaprolactone (PCL) and cornstarch. And slivers of curaua fibers were used as reinforcement. In this study, a hot press-molding machine was used for fabrication of the composites. The resin-pasted pre-forms were dried at room temperature for 24 hours and then the pre-forms were inserted into the metallic mold and hot-pressed at 150°C. The resultant composite thickness was about 1 mm. In order to measure the tensile properties, tensile specimens with 50mm gage length and 15mm width were made from the obtained composites. The tensile tests were carried out at room temperature using an Instron-type testing machine with the cross-head speed of 1 mm/min.

The photograph of each specimen was taken as shown in Fig. 1, and was divided into a “unit composite” with short length of \( \Delta x \) (1.0mm) as shown in Fig. 1. One unit composite was also divided into 1.0mm lengths along the transverse direction, called “segment”. Fiber orientation angle \( \theta \) of each segment was measured from the photo through an image software.
analysis. This model is composed of 750 segments, i.e. 50 segments along the x-axis and 15 segments along the y-axis.

3 RESULTS AND DISCUSSION

In general, it is known that fiber orientation angles are deeply related with mechanical properties of unidirectional fibrous composites [1]. We also selected the autocorrelation coefficient (a.c.c.) in fiber orientation angles to relate it to those of the composites. The effects of averages of $\theta$ and a.c.c. (these are denoted as $\overline{\theta}$ and a.a.c.c.) on the tensile strength and Young’s modulus were shown in Figs. 2(a) and 2(b), respectively. It is proved that, while the tensile strength slightly decreases with increasing $\overline{\theta}$, it increases clearly with increasing a.a.c.c. The former correlation coefficient was -0.237, and the latter was 0.843. In general, tensile strength of unidirectional fibrous composites follows fiber orientation angle. However, when there is fluctuation in fiber orientation as given in this study, its effect is not so significant. On the other hand, it was newly found that the magnitude of a.c.c. was more sensitive to variation in strength level. It is considered that, since smaller a.c.c. provides more fluctuation, the fluctuated portions behave as a defect in the specimen, and results in decrease in tensile strength. It is also proved that, while the Young’s modulus clearly decreases with increasing $\overline{\theta}$, the modulus did not vary with increasing a.a.c.c. That is, Young’s modulus is related with average fiber orientation angle, not with individual fluctuated angle.

4 CONCLUSIONS

The results show that the tensile strength of green composites depends on autocorrelation coefficients, which express the degree of fluctuation in the fiber orientation of the composites, while the Young’s modulus strongly depends on the average fiber orientation angle.

REFERENCES