DEVELOPMENT OF AN IN-SITU PREPREG FORMING TECHNIQUE WITH A DIODE LASER

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Introduction

The final goal of this study is to apply an in-situ prepreg forming technique to an existing Laser-assisted tape placement (LATP) facility. Such a prepreg forming technique can be used as a pre-processing procedure in the LATP facility to supply a thermoplastic prepreg tape. At present, the LATP facility is attractive for a low cost and time-saving production system of a three-dimensional Carbon Fiber Reinforced ThermoPlastics (CFRTP). In order to manufacture CFRTP products, the LATP needs a commercially produced thermoplastic prepreg tape, but it is known that the commercially-available prepreg tape is costly. If the proposed in-situ prepreg forming technique is promising, the LATP facility can be operated without using such an expensive prepreg tape. As a result, the proposed in-situ technique may contribute to further reduce the cost of CFRTP products by using the LATP.

We have preliminarily tested a prepreg forming technique, and our on-going research is reported in this paper. A combined system consisting of a diode laser and a glass roller is proposed in this study. This system is able to simultaneously provide pressing and heating with laminated materials in principle. In order to reduce an impregnation time, we use a thin laminated test specimen of a carbon fiber spread tow and a polyamide 6 (PA6) film. In addition, the diode laser provides a process temperature very quickly. These efforts to minimize the prepreg forming time will contribute to keep the advantages of the LATP: time-saving and the applicability to a broader range of processing speeds.

Experiment

Figure 1 shows the experimental device developed in this study. It consists of rollers, air cylinder, a laser head with a beam homogenizer, and bobbins. One of the rollers is made of quartz glass. The diode laser has a near-infrared wavelength range, and is used as a heat source to melt PA6. Because the laser beam transmits the glass roller, the beam can be delivered remotely near the nip part of the two rollers. As a result, a test specimen is simultaneously heated and pressed therein. The test specimen is a lamination of a PA6 film and a carbon fiber spread tow, as shown in Fig. 1. Note that a polyimide (PI) film is used to avoid adhering of the laminated specimen to rollers.

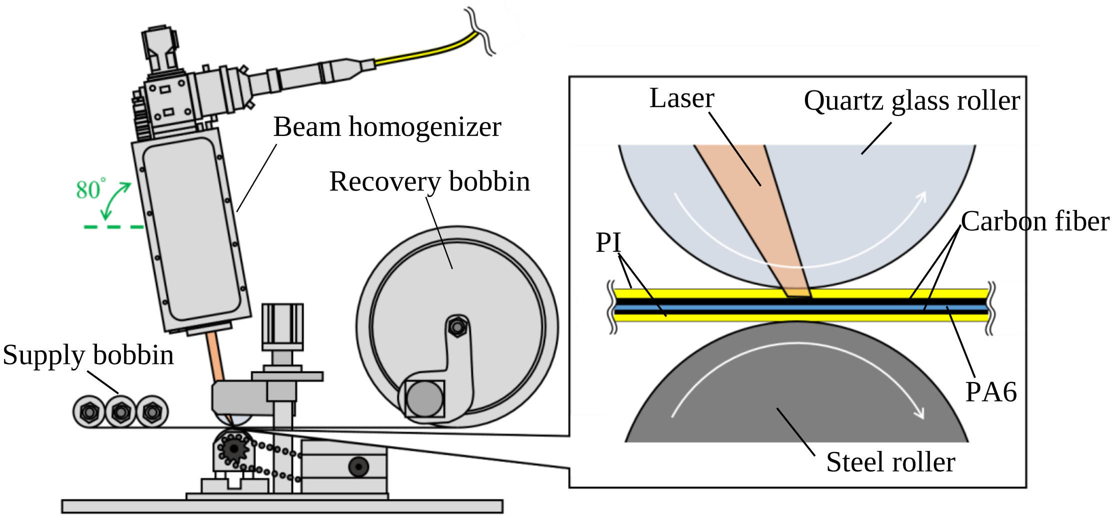

Figure 1: *The experimental device used in this study*

Table 1 shows the experimental conditions. The steel roller is kept at a constant temperature of 473 K to promote the heat transfer from the test specimen to the steel roller. The experimental device is operated at the two conditions with or without laser heating for a given pressing force in order to examine the effect of laser heating. The specimens after the experiment are compared by microscope.

Table 1: *The experimental conditions.*

Laser power	*Laser width*	*Rotation speed*	*Nip width*	*Steel roller temperature*	*Pressing force*
0W, 100W	3.4mm	50deg/sec	2.0mm	473K	598N

Result

Figure 2 shows the cross-sectional images of the test specimen. The results are compared between with and without laser heating by using the proposed experimental device. For the purpose of visualization, the test specimen is post-processed using embedding resin. One can see a qualitative difference of the cross sections from the figure. Carbon fibers and PA6 are separated for the case of Fig. 2(a). On the other hand, from Fig. 2(b), a PA6 layer is impregnated into carbon fibers. Based on this observation, our preliminary experiment is believed to be successful.

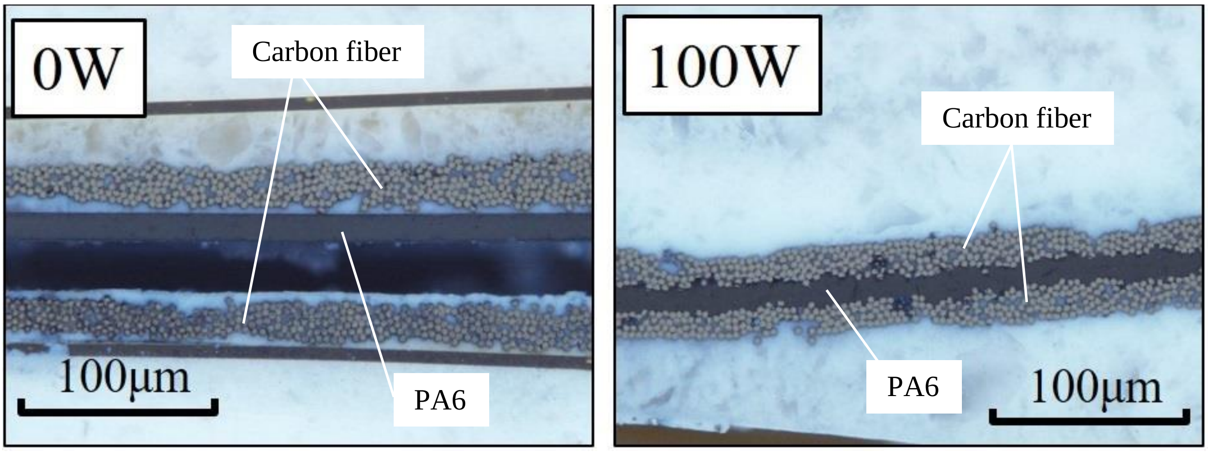

Figure 2: *Comparison of the cross-sectional images of the specimen between before and after experiment.*

Conclusion

A prototype of an in-situ prepreg forming device is developed, and a preliminary impregnation experiment is conducted by using the developed device. The result shows that the PA6 film and the carbon fiber spread tow is tightly bonded, suggesting that the proposed method with the laser and the glass roller has a potential to realize an in-situ prepreg forming. However, the observed depth of impregnation of PA6 into the carbon fibers is found to be relatively small. The exact cause of the reason for this result remains unknown. Our next efforts are being directed to improve the degree of impregnation for the test specimen laminated using the proposed device.

References

[1] W. Grouve, L. Warnet, B. Rietman, R. Akkerman, On the weld strength of in situ tape placed reinforcements on woven fabric reinforced structures, *Composites Part A*, 43:1530-1536, 2012.

[2] A. Barasinski, An Improvement in Thermal Modelling of Automated Tape Placement Process, *AIP Conference Proceedings*, Vol. 1315, 2011