

論文の内容の要旨

論文題目 Effects of superheated steam on the tensile and interfacial adhesion properties of recycled carbon fiber

(リサイクル炭素繊維の引張および界面接着性に及ぼす過熱水蒸気処理方法の影響に関する研究)

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With the growth of demand in aircraft and automotive industries, considerable efforts are being devoted to developing recycling technologies for managing carbon fiber reinforced plastics (CFRP) waste. Recycling is recognized as one of the most efficient ways for managing the CFRP waste concerning economic and environmental benefits. However, the recycled carbon fibers (RCF) can only replace a small amount of freshly produced fibers in products since sustainable closed-loop recycling can be done indefinitely with an acceptable performance of recyclates. If there is a recycling technique enables optimal recovery, suppression of deterioration, and simultaneously improvement in adhesion to matrix resin, then extensive reuse of RCF could be expected.

Chapter 1 described the need for recycling CFRP, as well as the state-of-the-art in recycling technologies. In particular, the theoretical background of superheated steam (SHS) treatment, which technology was mainly adopted in this dissertation, was reviewed to understanding the potential of such a treatment in recycling CFRP. The subsequent discussions were established to understanding the factors which restricted the reclamation.

Chapter 2 denoted the suitability of SHS treatment in recycling CFRP. The carbon fiber (CF) recovery was assessed microscopically and based on weight reduction. Meanwhile, the matrix resin decomposition was demonstrated through thermal analysis performed under SHS-like condition. The influence of SHS on the CF was evaluated by comparing tensile properties of recovered fibers to those of corresponding virgin ones. Weibull distribution was employed to describe the change in the strength.

Chapter 3 introduced novel treatment conditions for minimizing CF deterioration. The recovery and matrix decomposition were clarified in accordance with the methods developed in the former chapter. The tensile properties of both virgin fibers and the RCFs, which were discussed in Chapter 2, were selected as the reference for validating the effect of newly developed condition on the suppression of strength degradation. Furthermore, the mechanism of CF deterioration was elucidated through analyzing fracture surfaces and oblique sections of CF samples.

Chapter 4 examined interfacial adhesion between of RCFs and matrix resin. As-received fibers were used as reference material for evaluating the effect of SHS on CF surface states. The surface chemical states were characterized to confirm the experimental results. In addition, the critical fiber length and bundle strength values were estimated to provide fundamental information toward the development of CFRP recycling using SHS treatment.

Chapter 5 summarized concluding remarks of this dissertation. The prospect of SHS treatment in CFRP recycling and the recommendations for future works were discussed.