論文の内容の要旨

Thesis Summary

論文提目　Research on carbon fiber mat reinforced thermoplastics for advanced use of recycled carbon fibers
(リサイクル炭素繊維の高度利用のための炭素繊維マット強化熱可塑性樹脂に関する研究)

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Carbon fibers reinforced composites have been applied in aerospace, wind power generation, automotive and sport facilities industries. There is a large amount of products made of carbon fiber reinforced composites have met the end of their lives. Even though landfilling is a strategy to deal with these wastes, there are more and more law regulations requiring companies to recycle the CF from them. Therefore, researches of recycling CF from correlative wastes has been a hot topic recent years. Several studies have confirmed that current available recycling technologies are able to maintain the rCF (recycled carbon fiber) with promising mechanical properties. And even some recycling technologies are practically commercial now.

The undamaged rCF compared with fresh CF has the characteristics in morphology: shortened fiber length distribution (FLD) and misaligned fiber orientation distribution (FOD). The aim of this research, using papermaking technology is to fabricate rCF with matrix resin fibers and to discuss solutions to the problems of reusing rCF: mixed different types of rCF and addition of a secondary reinforcement fibers.

Before discussing the effect of mixing different fiber types, the proper compression molding pressures and the basic material properties of CPT materials were discussed. After comparing the flexural properties under 5 levels of compression molding pressure, 1 MPa, 3 MPa, 5 MPa, 8 MPa and 10 MPa, were investigated.　The flexural properties of CPT reinforced by R-T300 (recycled T300 fibers) and CPT reinforced by R-T800 (recycled T800 fibers) are good during 3 MPa and 8 MPa. After further discussion of the results of Izod tests, the impact energy absorption is highest under 5 MPa and 8 MPa. Therefore, it is recommended that the molding pressure should be set from 5 MPa to 8 MPa.

In order to increase the cost-benefit efficiency of reusing rCF, alignment process is necessary to be introduced into re-manufacturing process. Even though there are a few studies proposing

alignment concepts, they cannot be used into mass-production due to the lack of proper assessments of reinforcement efficiency and alignment degree of misaligned discontinuous CFRTP. In this thesis, two indexes were introduced.

The first one is the reinforcement efficiency factors, Factor Cs, which is derived from the modified rule of mixtures (MRoM). Based on the experiment results of three point bending tests and component material properties, the Factor C_1 of flexural modulus and C_2 of flexural strength were also calculated. In order to discuss the value of Factor Cs, carbon fiber card web reinforced thermoplastics (CWT) made by a carding process were used to investigate the flexural properties. Based on the continuous movement of carding process, the molded CWT plates were different in mechanical properties along the L-direction (moving direction) and along T-direction. Based on the calculations, Factor Cs are suitable to illustrate the internal fiber architectures due to different manufacturing process by removing the interference of component material properties and that of volume fraction (V_f) of the components. In order to further extend the value of Factor Cs, a development map was built based on Factor Cs of different materials by considering the isotropic and anisotropic properties. The map is able to help the manufacturers to understand where their products locate among the similar materials in market. Additionally, this map can help to adjust the alignment process, which is a critical process in manufacturing rCF, in a direct way.

The second index is the alignment degree. Even though the Factor Cs can contribute to developing the manufacturing process and the relative rCFRTP materials, they are negatively affected by the internal defects, such as void content. Therefore, a new index is needed to identify the quality of alignment process in re-manufacturing rCF. In thesis, a simple quantitative value was introduced based a two-parameter exponential equation. Different from conventional qualitative approach, the alignment degree can be used to connect the FOD of rCFRTP materials with the alignment quality, mechanical properties and V_f in an analytical way. A brief discussion was conducted to compare the Factor Cs and the alignment degree. Factor Cs are more practical to guide the development of rCFRTP materials and help to describe the possible mechanical properties based on relative manufacturing process. Alignment degree is more practical to determine the quality of alignment process. One single value made it possible and analytical to compare the FOD of different materials by different alignment processes.