

氏名	LIU BING (劉 兵)
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論文審査委員	主査 教 授 鮑 力民 教 授 森川 英明 准教授 夏木 俊明 准教授 若月 薫 教 授 青木 隆平 (東京大学) 教 授 潘 志娟 (蘇州大学)

論 文 内 容 の 要 旨

In recent years, demands for low-weight and high-strength materials that are adaptable to space re-entry vehicles, supersonic aircrafts, and resistant tool jigs, have significantly increased. Fiber-reinforced composites (FRPs) constitute a major breakthrough in the progress of this field owing to their important attributes such as fatigue resistance, high strength, low weight, and corrosion resistance. Because FRPs that involve thermosetting resin cannot be re-melted or re-form after molding, they are typically landfilled, thereby potentially instigating serious environmental pollution. Fiber-reinforced thermoplastic composites (FRTPs) possess higher recycling properties has become substitute for FRPs.

However, the main problem is the difficulty in impregnating the thermoplastics into fiber bundles owing to their considerable higher viscosities at melting temperatures. Poor impregnation may lead to low fiber volume fractions, which is related with the poor mechanical property. To solve this problem, a solution impregnation method was proposed by our group and carbon fibers-reinforced polyester (CF/PET) composite with a high fiber volume fraction above 60% was prepared successfully using the method. However, the usage temperature of the composite was only ~70°C, indicating that it cannot be applied in a high-temperature environment.

Engineering plastics that possess excellent heat-resistance properties are potential candidates. However, the melt viscosity of resins is considerably higher than PET. The aim of the first part of the present research is to verify the versatility of this method that also can be applied to those resins with higher melt viscosity. All results confirmed the effectiveness and feasibility of solution impregnation molding method.

Another concern in many aircraft applications is the damage of composite surfaces caused by solid particles in the air, which can lead to lengthy maintenance, security risks, and other serious problems. Thus, engineering materials must not only have high specific strength but also resist wear and damage. For the past few years, many researchers have investigated how highly heat-resistant thermoplastics and their composites eroded by solid particles. The vast majority of these studied composite materials were reinforced with CF or glass fiber (GF). In contrast, there is little research on PBO fibers, aramid fibers, or other high-performance ductile fibers. These fibers are important to study mainly because aramid and other high-performance fibers have better erosion resistance than CF or GF. Also, there are no convenient

methods to predict the erosion rate of composites made from high-performance ductile fabrics. With a mathematical model erosion rates can be predicted with less need for experiments; however, studying the erosion of these composites currently demands substantial time, energy, and materials. By studying how changes in fabric orientation affected the erosion behavior of composites from an energy perspective, a mathematical model of the erosion rate as a function of impact angle was developed. To verify this model, the erosion behaviors of composites reinforced with high-performance ductile fabrics was studied, and then compared those experimental findings with our predictions. The results showed that the theoretical and experimental values had relatively high correlation.

Using PBO fibers or aramid fibers can improve the erosion resistance of composites, however, the tensile module and bending properties of these fibers are too poor to meet the requirements for certain applications. A combination of good mechanical and erosion resistance properties is needed for some applications. There has been increasing interest in the use of hybrid composite materials because their properties are better than those of the individual material constituents. Layered hybrid composites have therefore attracted the attention of researchers. However, because traditional layered hybrid composites have lots of drawbacks. A new non-crimp hybrid composite reinforced with carbon and PBO fibers was prepared in this chapter. The cross section of the prepared hybrid prepreg sheet was observed by SEM and found that no obvious curves of carbon fibers were seen in it. Moreover, it can be found that the erosion rates of the prepared hybrid composites decreased with increasing weft density. According to the results of mechanical tests and erosion behavior test, it can be confirmed that the obtained composites had excellent mechanical properties and erosion resistance.

Although there are many successful applications of carbon and glass fiber composite materials, it has raised environmental and economic awareness for the need to recycle fiber-reinforced plastic waste. There has been a lot of research that has focused on the recycling of FRPs. However, there is less research and information about the recycling of FRTPs. Therefore, it is necessary to assess the recyclability of FRTPs, both technically and economically. Similar to thermoset composites, FRTPs can be recycled by mechanical, thermal and chemical recycling methods.

Because compared with mechanical recycling and thermal recycling, the chemical recycling technique provides fibers with the highest tensile strength values, some researchers have been focused on this method. However, most of the current chemical recycling methods were conducted on a very small scale in laboratories, therefore, a novel, effective and simple recycling technology that can be conducted on a large scale has been proposed in this chapter. The feasibility of a solvent recycling technology for continuous fiber-based thermoplastic composites was confirmed by comparing the tensile and bending properties between virgin chopped fabric tape reinforced thermoplastics (V-CTTs) and recycled chopped fabric tape reinforced thermoplastics (R-CTTs). In addition, the SEM analysis of the fracture morphologies of the composites after the three-point bending test indicated that the surface of the fibers was strongly coated with the resin, which could explain the high interfacial bonding strength between the matrix and the fibers.