学位論文内容の要旨

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１．　論文題目

Processing and Mechanical Characterization of Cellulose Based Composites

２．　論文要旨

The appropriate specific mechanical properties, biodegradability and cost-effective of natural fibers have made them as attractive alternatives to synthetic fibers used in polymer composites. Natural fiber reinforced composites are considered to be very promising materials in numerous engineering applications especially in automotive sectors. However, the hydrophilic nature, high moisture absorption and low mechanical properties of natural fibers were reported negatively affects the performance of the composites. In addition, the characteristics of natural fibers will also cause different problems in different manufacture process. In order to improve the properties of the natural fiber composites, settle the optimal manufacturing condition for different molding processes, researches on the processing and mechanical characterization of natural composites have been presented in this thesis which mainly consists of two parts. The first part was focused on recycled jute woven fabric reinforced unsaturated polyester composite molded by hand lay-up molding process. While the second part was researches on wood particle reinforced polypropylene composite molded by injection molding process.

In chapter 2, as a primal investigation, the effect of moisture contents of the recycled jute woven fabric on the mechanical properties of the composites was discussed. It is found that the mechanical properties of composite decrease with the decrease of the moisture due to the decrease of the tensile strength of jute fiber itself although better interface property can be obtained by deeply dried jute fabric reinforced composite.

On the other hand, in chapter 3, the hydrothermal aging performance of recycled jute

woven fabric reinforced composite was evaluated and comparison of the weight change mechanism between glass fiber reinforced composite and natural fiber reinforced composite was also discussed. It was found that with a comparatively long immersion times, there was no obvious differences of water absorption and weight loss behavior and bending properties of the composites with two different moisture contents. Therefore, it is considered it may be not necessary to perform dry process on recycled jute woven fabric before hand lay-up molding process. This conclusion is helpful to lessen the energy consumption during processing and increased the molding effectiveness. While compared to glass fiber, since jute fiber is easily to absorb water by itself and some compositions will also possible to dissolve in water, it will therefore lead to high weight gain (M_g), weight loss (M_l) and higher decrease of the mechanical property. After clarifying the water absorption mechanism of jute reinforced composites, the detail compositions of M_l can be calculated. The corresponding model is considered also suitable for other natural fiber reinforced composite.

In addition, in order to extend the application of the jute composites, the effects of the laminated structures of recycled jute woven fabric hybrid with glass woven fabric were investigated in chapter 4, the hybrid structure with glass layer can increase the impact resistance of the composite not only due to the higher strength of the glass fiber but also, the glass layer can increase the damage area of the composite during impact. And the position of the glass layer result in variations in the impact behavior of composites. When the glass layer was at the bottom of the dropped impacted surface, the composite exhibited highest impact energy than those glass layers on top or middle.

In chapter 5, the effect of filler content on the physical and mechanical properties of the wood/PP composites and the comparison between talc/PP and wood/PP has been carried out. It could be concluded using wood/PP in the automotives instead of talc/PP is reasonable and could lead to a high fuel economy due to the composite’s low weight as well as the low thermal conductivity. However, wood particles aggregated at a high wood content and consequently lead to a decrease of the mechanical properties.

Therefore, in chapter 6, proper molding conditions and effect of additives were proposed to solve the feeding problem of the wood particle due to the low bulk density

and enhance the interfacial adhesion property and distribution condition. Pre-molding process (dry-blending and compounding) and the effect of adding the additives (maleated polypropylene (MAPP) and crystalline polyalpha olefin (CPAO)) on the mechanical properties of the wood/PP composites were discussed firstly. Results showed the mechanical properties of the wood/PP composites molded through compounding process are better than the ones molded by direct dry-blending process because the less voids contents and the distribution of the wood particle in the PP matrix was well improved. The optimal MAPP content in this research is determined at 2wt% which could best improve the properties of composite because of the improvement of the interfacial adhesion property. While incorporating CPAO could improve the wood particle distribution condition and consequently lead to the increasing of the composite's property. In addition, other technique approaches such as the effect of compounding screw geometry and perform twice compounding process before injection molding at high wood content were also discussed. Result showed by using weak extruder screw, the color of cellulose/PP will be lighter and compared to the ones with strong extruder screw, the mechanical properties won't decrease so much. While by performing twice compounding process, the feeding difficulty could be solved as well as keep comparable high mechanical properties.

In chapter 7, the hybridization effect of wood particle with glass short fiber was discussed and the elastic modulus of hybrid composites was predicted by using the rule of hybrid mixtures (RoHM) equation and classical lamination theory (CLT) and the accuracy of the two estimation models has been discussed. It could be concluded that with appropriate material design, it is possible to get hybrid material with comparable high mechanical properties with high green degree. While to better predict the elastic modulus of the hybrid composite, the interaction between glass short fiber and wood particle and the reinforcing effect including fiber orientation factor, fiber length distribution factor, particle dispersion factor, and particle aspect ratio factor and so on need to be considered in the prediction model.

This research showed the potential of molding recycled jute woven fabric reinforced unsaturated polyester composite by hand lay-up process without dry process on the fabric in advance and developed a suitable calculation method to analyze the detail

compositions of M_l after hydrothermal aging test of natural fiber reinforced composite. In addition, it also presents the proper molding conditions and optimal additive agent's content for injection high wood particle content reinforced polypropylene composite. And the elastic modulus of glass short fiber/wood particle/PP composite could be predicted by appropriate modifying of the RoHM prediction model.