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CHARACTERIZATION OF FIBER HYBRID INJECTION MOLDINGS FOR NATURAL FIBER COMPOSITES

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SUMMARY: Glass fiber reinforced injection moldings have been widely used in industrial applications. For instance, short glass fiber reinforced polypropylene injection moldings are used in automobile, housings and electrical appliances due to their good mechanical properties, excellent water resistance and low cost to performance ratio. Recently there have also been interests to develop natural fiber reinforced injection moldings for automotive and home electronics applications. The use of purely natural fibers as reinforcement, however, is insufficient to provide the composites with good mechanical performance. Another growing interest in fiber reinforced injection moldings is the use of high aspect ratio reinforcements, i.e. increasing the length of the fibers in end products, thereby improving the reinforcing ability of the fibers. The long fiber reinforced injection moldings have the potential to be applied not only in the above-mentioned fields but also as structural members. In this study, long glass (GF) and jute fiber pellets impregnated with either polypropylene (PP) pellets were fabricated by the pultrusion method. The GF/PP and GF/jute hybrid PP composite samples were later produced by injection molding. The jute fiber content in the hybrid composites was varied from 0 to 30wt%. Fiber lengths in each sample were measured by image analysis from optical microscopy images. Mechanical tests were performed on the composites while morphological properties were observed by using a scanning electron microscope.

KEYWORDS: injection molding, long fiber pellet, natural fiber, hybrid

INTRODUCTION

Glass fiber reinforced injection moldings have been widely used in industrial applications. For instance, short glass fiber reinforced polypropylene injection moldings are used in automobile, housings and electrical appliances due to their good mechanical properties, excellent water resistance and low cost to performance ratio. Recently there have also been interests to develop natural fiber reinforced injection moldings for automotive and home electronics applications. The use of purely natural fibers as reinforcement, however, is insufficient to provide the composites with good mechanical performance.

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There is another problem which is related to processing of pellet by natural fibers. Basically bulk densities of short natural fibers are very large. Fig. 1 shows photo of polymeric pellet and bamboo particles. Apparently the ratio is 2 to 1, however actual volume fraction of bamboo particles are only 6 %. For fabricating pallet there are two ways, one is side feeder process and another is simple dry blending process. In the case of the former process vibration technique has been used for glass fiber. The melt polymer flow from the upper stream in twin or single screw extruder and glass fibers drop off the polymer stream at constant rate, so that the fraction of glass fibers can be maintained in the pallet. This side feeder process is very simple, but it can apply to only high density reinforcements such as glass fibers which has 2.4-2.5 g/cm3 of density. Instead natural fibers are very light, for example; Hemp is 1.4-1.5 g/cm^3 , Bamboo is 0.9-1.2 g/cm^3 and Jute is 1.4-1.5 g/cm^3. Therefore the side feeder system is not working properly. Fig. 2 shows an example of heterogeneous states.

In the case of simple dry blending process, before polymer pellet and reinforcing fibers are put into the hopper of injection molding machine two materials should be mixed together, for example in plastic bag. However, here, the difference of density between polymer and reinforcement causes the problems. Light weight natural fibers remain in the hopper and only polymer pellet drop off the screw. Therefore we need to develop a new compounding system for natural fibers.

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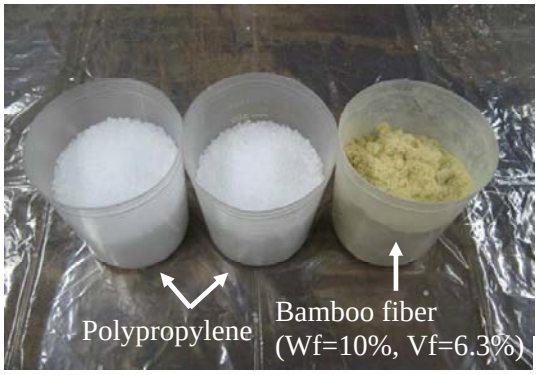

Fig. 1 Photograph of material.

(a) Hopper (b) Feeder

Fig. 2 Photograph during extrusion.

FABRICATION OF NATURAL FIBER COMPOSITE BY LONG FIBER PELLET MAKING MACHINE

Fig. 3 shows schematics of Long fiber pellet making machine. In this system the most important point is that continuous fibers are used. From roving stand on the right continuous fibers are supplied. The melt polymer is discharged from twin extruder. The impregnation of resin into the natural fiber bundle is accomplished at impregnation die head. After impregnation, cooling and pulling stage are done and finally at the pelletizer cutting process is finished. By using this process compounding problems of natural fiber composites should be overcome and uniform, constant volume fraction pellet can be obtained.

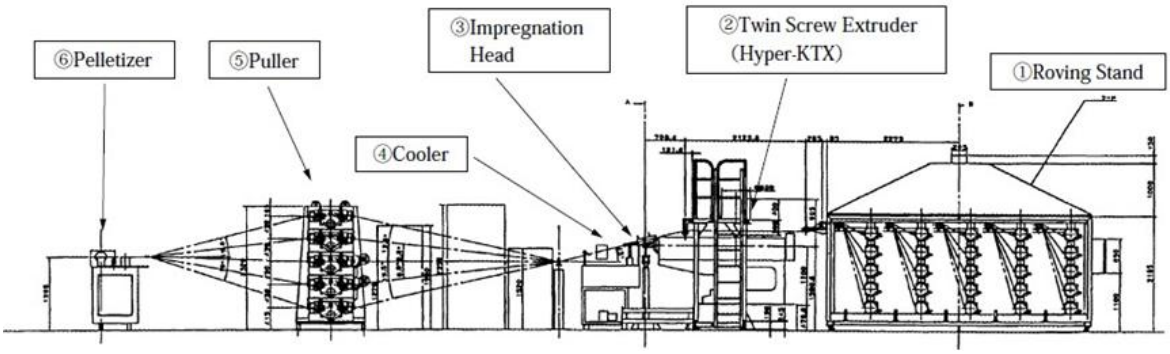

Fig. 3 Machine for manufacturing the long fiber pellet.

FIBER HYBRID COMPOSITE PROPOSED

In the mechanical properties of natural fiber composites we image several problems. One of them is low mechanical properties. This is due to low mechanical properties of natural fibers themselves, weak interfacial properties, less impregnation states, water contents of natural fibers and so on.

Fig. 4 shows tensile strength of Jute fiber composites and for comparison the tensile strength of Glass fiber composite is also shown. GF composite contains 10wt% glass fibers and shows 60 MPa of tensile strength, however in the case of Jute fibers ever if composite contains 30wt% Jute fibers, the tensile strength is only 45 MPa. Therefore if we need equivalent composite of Glass fiber 10wt%, extreme high volume Jute fiber contents should be required. Of course this result make compounding problems, although the long fiber pellet making machine is need. The second one is high scatter of composites.

This problem is caused the scatter of fiber properties. Here the concept of Fiber Hybrid composite is proposed. ‘’Hybrid’’ is common technological word in continuous fiber composite field. For example, Carbon fiber and Glass fiber Hybrid composite is famous example. Two different fiber materials can be used in one composite in order to conquer the problem of sole composite. Hybrid composite means that in the case of natural fiber composite glass fibers are also used together with natural fibers to reduce the scatter of mechanical properties and increase of mechanical properties.

By using glass fibers Hybrid composite is not fully environmentally friend materials, however usage of natural resources might contribute the environmental problem. Therefore in the case of Hybrid composite ‘degree of green’ the concept of is introduced. The degree of contribution of material to the environments is evaluated. For example when 20wt% of Jute fibers are used, the degree of green is 20% and when 20wt% of Jute fibers and 10wt% of Glass fibers and 70wt% of biodegradable polymer is used, the degree of green should be 90%. At latter chapter the mechanical properties of Hybrid composites are shown.

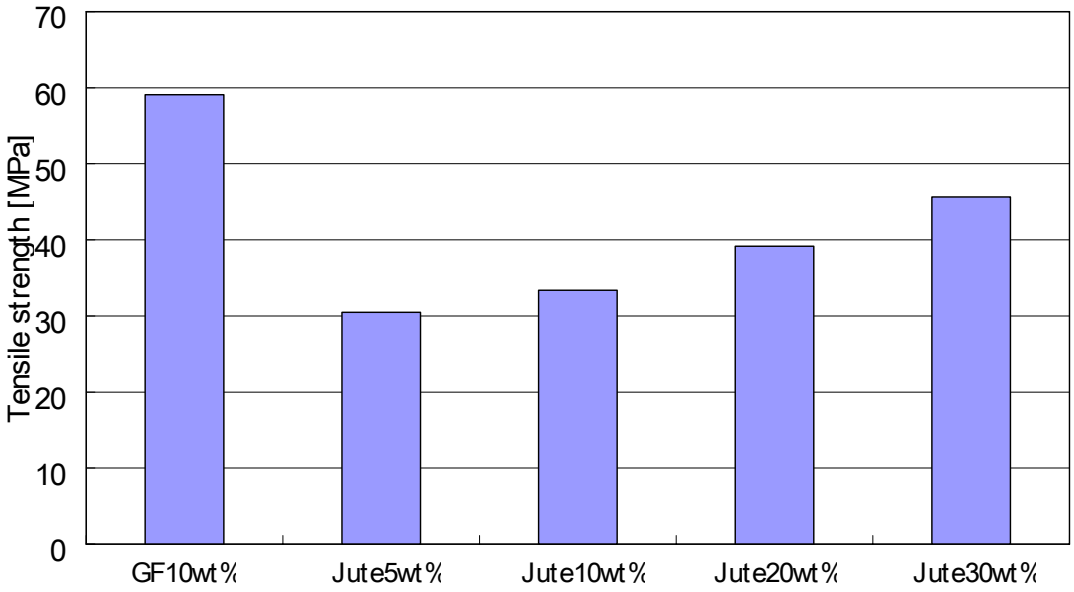

Fig. 4 Comparison between GF/PP and Jute/PP.

MECHANICAL PROPERTIES OF HYBRID COMPOSITES

In this paper two different pellets which were fabricated by the long fiber pellet making machine are used ;Jute/PP and GF/PP. For Hybrid composite, dry blending process was employed. Table 1 shows the list of specimen; Hybrid material, Jute only and GF only material were used. In the Hybrid composite GF content was kept at 10wt%. The degree of green in these Hybrid composites corresponded with Jute fiber contents.

Fig. 5 shows tensile modulus and tensile strength results. Tensile modulus increased with increase of Jute fiber content linearly in both Jute only material and Hybrid material. However, tensile strength of Hybrid material shows constant value up to 20wt% of Jute fiber content, and at 30wt% it decreases drastically. On the other hand, the tensile strength of Jute only material shows liner increment with Jute fiber contents. These results would be caused by fiber orientation state.

Table 1 List of samples

Sample ID	GF (wt%)	JUTE (wt%)	PP (wt%)
G10J30	10	30	60
G10J20	10	20	70
G10J10	10	10	80
G10J05	10	5	85
G00J30	0	30	70
G00J20	0	20	80
G00J10	0	10	90
G00J05	0	5	95
G10J00	10	0	90

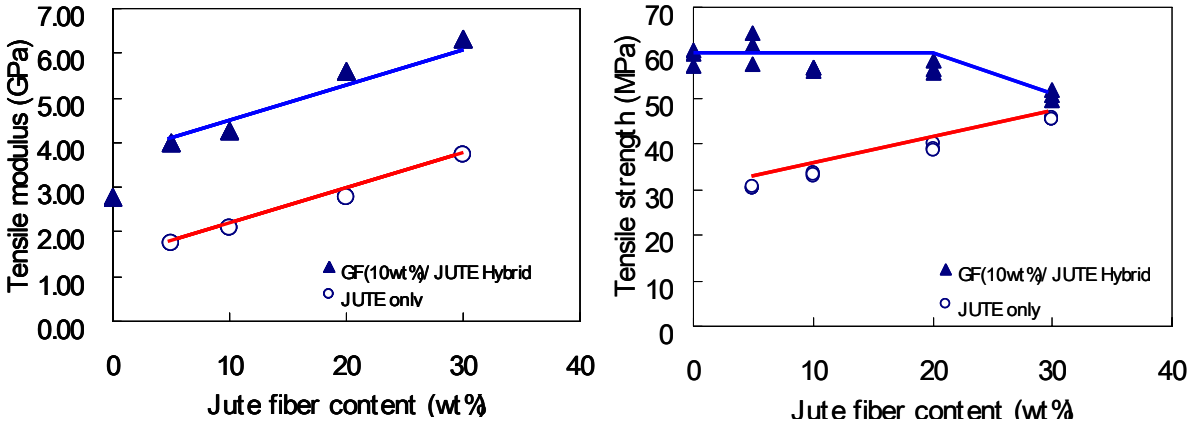

Fig. 5 Relationship between tensile properties and jute fiber contents.

CONCLUSIONS

For natural fiber composite materials the long fiber pellet making machine was introduced in order to overcome compounding problem. The concept of Fiber Hybrid composite manufactured by injection molding was proposed. A degree of green as contribution index for environment was also proposed. Finally, some mechanical properties of hybrid composite were shown.