The Preparation and Property Analysis of Polyester Fabrics/Polypropylene Thermoplastic Composites

Ting Wei Chang¹, Ching Wen Lou², Chien Teng Hsieh³ and Jia Horng Lin⁴ ⁵

¹Laboratory of Fiber Application and Manufacturing, Department of Fiber and Composite Materials, Feng Chia University, Taichung 407, Taiwan, R.O.C.
²Center for General Education/ Institute of Biomedical Engineering and Material Science, Central Taiwan University of Science and Technology, Taichung 406, Taiwan, R.O.C.
³Department of Fashion Design and Merchandising, Shih Chien University Kaohsiung 845, Taiwan, R.O.C.
⁴Laboratory of Fiber Application and Manufacturing, Graduate Institute of Textile Engineering, Feng Chia University, Taichung 407, Taiwan, R.O.C.
⁵Graduate Institute of Chinese Medical Science, China Medical University, Taichung, Taiwan, R.O.C.

Abstract: Polyester fiber (PET) has lower public water rate (0.4 %) and higher Young’s modulus (1100-2000 kg/cm³) compared with common chemical fiber, while polypropylene (PP) has lower density (0.90 g/cm³) and bending fatigue resistance. In this study, PP sheets (thickness 0.40 mm) and PET fabrics were used to fabricate PET/PP composite laminates (thickness 1.5 mm) by changing thermal-compressing temperature (180°C), pressure (40-80 Kg/cm²) and period (0.5 min-2.5 min). Afterward, PET/PP composite laminates were tested for tensile strength according to ASTM D 638. The relationship between mechanical properties and formability to obtain the optimum manufacturing parameters is discussed.

Introduction

Typical composite have two components, one is matrix, and the other is reinforcement. Compounding of these components results in a type of multiphase material. In a narrow definition of composite materials, the matrix can be divided into four main categories: Polymer Matrix Composite(PMC), Metal Matrix Composite(MMC), Ceramic Matrix Composite(CMC), and Carbon/Carbon Composite(C/C). So far, polymer composites are the mainstream of the composite materials industry. Among them, Fiber Reinforced Polymer Composite (FRPC), also known as Resin Matrix Composite(RMC), is a type of composite material that features more mature technology and wider application.

The main functions of fiber reinforcement: are bearing of the main stress, prevention of microcrack extension, enhancement of composite strength and solid, and improve ment of composite fatigue resistance and creep resistance. In the field, matrix can be divided into thermosetting polymer and thermoplastic polymer. Thermoplastic composites have several advantages: raw materials do not need refrigeration, and there is better impact resistance, shorter curing period and better recyclability. Reinforcement is play dispersing stress rule in the composite. The matrix can protect reinforcement from corrosion and attrition[1-2].

The thermoplastic composite has apply in Exercise Equipment such as golfs club. However, CF/Nylon6 can absorb water easily, and that influences the solidity and strength of the clubs[3]. Thus, hydrophobic materials should be considered when making composites, to avoid the influence of water on the mechanical properties. In this study, PET fiber was selected as the reinforcement. PET fiber has lower moisture regain (about 0.4%) and higher tensile strength (about 4022.10 MPa) when compared with common chemical fiber[4]. PET fiber has a wide range of applications, such as tire builder fabric, industrial rope, carrier tape and so on. PP was selected to be the matrix. PP has lower density (about 0.90 g/cm³), and lower melting point (about 170°C) than engineering plastics. In addition, if possesses the properties of good comprehensive mechanical performance, easy processing of form, and wide ranging use in packaging materials, and transport materials.

In this study, PP sheets and PET fabrics were used to fabricate PET/PP composite laminates under the conditions of thermal-compressing temperature, changing pressure stable and changing period. Afterward, PET/PP composite laminates were tested tensile strength according to ASTM D 638. The relationship between mechanical properties and formability to obtain the optimum manufacturing parameters is discussed.

Experimental

2.1 Experimental materials
(1) Sheets: Polypropylene sheets, Length 250 mm, Width 250 mm, Thickness 0.4 mm, Density 0.90g/cm³, Tensile strength at yield 34.34 MPa, YUNG CHIA CHEMICAL INDUSTRIES CORPORATION.


2.2 Samples produced

2.2.1 Polypropylene laminates

Lay up of 4 PP sheets, which were placed inside the thermo press with thermal-compressing temperature (180°C), pressure (40 Kg/cm², 50 Kg/cm², 60 Kg/cm², 70 Kg/cm², 80 Kg/cm²) and period (0.5 min, 1.0min, 1.5 min, 2.0 min, 2.5 min). Samples were removed, cooled to room temperature, and PP laminates were produced.

2.2.2 PET/PP composite laminates

Two PET fabrics were added between the three PP sheet levels and placed inside the thermo press with thermal-compressing temperature (180°C), pressure (40 Kg/cm², 50 Kg/cm², 60 Kg/cm², 70 Kg/cm², 80 Kg/cm²) and period (0.5 min, 1.0min, 1.5 min, 2.0 min, 2.5 min). Samples were removed, cooled at room temperature, and PET/PP composite laminates were produced.

2.3 Experimental parameters

(1) Thermal period: 0.5 min, 1.0 min, 1.5 min, 2.0 min, 2.5 min.

(2) Pressure: 40 Kg/cm², 50 Kg/cm², 60 Kg/cm², 70 Kg/cm², 80 Kg/cm².

(3) Thermal-compressing temperature: 180°C.

2.4 Experimental instruments

(1) Thermo press: Taiwan Reid Electrical Appliances.

(2) Testing instrument: Universal testing tester, HT-9101, HUNG TA INSTRUMENT CO., LTD.

(3) Thermometer: TES-1322A, TES ELECTRICAL ELECTRONIC CORP.

2.5 Experimental testing

(1) Tensile strength test: Carried out according to ASTM D 638 test standards, with chuck distance of 115 mm, and stretching rate of 5 mm/min.

Results and Discussion

3.1 The effect of thermal treatment (heat setting) on tensile property of PP laminates

Tensile test results following lay up of 4 PP sheets, and thermal-press pressure fabrication of PP laminates, are shown in Figure 1. From Figure 1 it can be seen, that at fixed thermal-press pressure of 50 Kg/cm², preset hold period increased to 2.5 minutes, and the resulting tensile strength is 28.92 MPa.

In the same preset hold period of 1.5 minutes, thermal-press pressure increased to 80 Kg/cm², and the tensile strength is 33.78 MPa. There was no significant in tensile strength of PP laminates.

The samples is non-closed, owing to mold lower mold plate upward pressure was at a fixed height (1.50 mm), and the distance pieces limit the gauge of thermal compressing at 1.50 mm, so the pressure was fixed in the same value. As the PP laminates thermal compress to the fixed at 1.50 mm the pressure is not useful for holding the PP laminates on the mold.

When preset hold period was increased, melted PP flowed out of the mold. Because the mold is open, the PP laminates might change the shape, the effect of thermal-press pressure on tensile property of PP laminates cannot be control.

3.2 The effect of thermal treatment on tensile property of PET/PP composite laminates

Lay up of one layer PP sheet, one layer of PET fabric, a second layer of PP sheet, second layer of PET fabric, and final layer of PP sheet form PET/PP laminated plate, as well as, thermal press fabrication of PET/PP composite laminates. Tensile test results following are shown in Figure 2. Figure 2 shows tensile strength of PET/PP composite laminates was augmented with increasing preset hold period. This is due to increased flow following PP melt which allows PP melt more time to impregnate PET fabric.

At fixed thermal-press pressure of 50 Kg/cm², preset hold period increased to 2.5 minutes. The sample has a optimum tensile strength is 74.94 MPa.

At fixed preset hold period of 1.5 minutes, thermal-press pressure to increased 80 Kg/cm², and the resulting tensile strength is 63.95 MPa. There was no apparent change in tensile strength of PET/PP composite laminates.
The sample was manufactured with non-closed, lower mold plate to make the pressure upward at a fixed height (1.50 mm). As the PET/PP composite laminates melt to the fixed height (1.50 mm), the pressure is significant useful for holding the PET/PP composite laminates. As the preset hold period increased, melted PP flowed out of the mold. In this case, the effect of thermal-press pressure on tensile property of PET/PP composite laminates cannot be ascertained. Figure 3 shows, fixed the thermal-press pressure of 50 Kg/cm², preset hold period increased to 2.5 minutes, elongation rate was 29.35%. As PET fabric is the material that bears the main stress of composite laminates, the elongation of PET fabric is the main factor affecting PET/PP composite laminate elongation.

**Fig.2** The tensile strength of PET/PP composite laminates at different thermal-press pressures and preset hold periods

**Fig.3** The elongation of PET/PP composite laminates at different thermal-press pressures and preset hold periods

**Conclusions**

Under the following thermal treatment parameters: thermal-compressing temperature of 180°C, pressure of 50 Kg/cm² and period of 2.5 minutes, the tensile strength value of PET/PP composite laminates is higher than that of PP laminates reached 45.57 MPa. At thermal-compressing temperature is 180°C, thermal-press pressure is 50 Kg/cm², and preset hold period is 2.5 minutes, PET/PP composite laminates have optimum strength value is 74.49 MPa. At thermal-compressing temperature of 180°C, thermal-press pressure is 80 Kg/cm², preset hold period is 5 minutes, PET/PP composite laminates have minimum yield elongation rate is 19.68%.

**References**