EFFECT OF SURFACE-TREATING OF GLASS FIBER ON THE GF/PET COMPOSITES FRACTURE TOUGHNESS

The performance of the composite material is not a simple addition of the performance of its component material, but rather produces synergistic properties that are different from the material of its constituents. The interface is one of the fundamental reasons for the synergistic effect of composite materials.The interface binds the fiber and the matrix into a whole and transfers the applied stress from the substrate to the reinforcing fibers to give full play to the strength and modulus of the fibers.Therefore, the performance of the composite material depends not only on the properties of the reinforcing fibers and the substrate, but also to a large extent on the strength of the interfacial bond. In order to ensure effective stress transfer and to obtain high strength, good interface bonding is necessary,However, strong bonding usually leads to cracks in the composite material through the matrix and the expansion of the fiber and brittle fracture. According to the fracture mechanism, the weaker interface junction is beneficial to the energy absorption of the material during the fracture process.Because of the fiber-reinforced composites, the ability of fracture energy absorption is an important measure of its performance, so people have done a lot of research work in order to minimize the strength of the material under the premise of improving its fracture toughness.These work are summarized in two categories, one is to improve the inherent properties of composite components, such as the use of high toughness of the thermoplastic matrix or reinforced fiber to achieve the hybrid; the other is based on the appropriate interface control, such as the use of appropriate polymerization Material coating and intermittent fiber bonding.In this paper, we used three groups of dewaxing, coating treatment and without any treatment of glass fiber reinforced fiber, PET fiber as the matrix fiber, the use of mixed yarn impregnation technology to prepare continuous glass fiber reinforced PET mixed yarn composite material one - way plate. The effect of glass fiber surface treatment on the fracture toughness of glass fiber reinforced PET composites was studied by comparing the mechanical properties of the prepared materials.

Raw materials and materials performance test

Raw materials and manufacturing technology

Glass fiber is 120 × 2 E-glass fiber, the density of 2.55g / cm3.

The base fiber uses 125D polyester fiber, the density is 1.33g / cm3, the melting point is 260.6 ℃.

Three kinds of glass fiber surface treatment methods are: dewaxing, coating treatment and without any treatment

The above-mentioned three sets of glass fibers are respectively mixed with PET fibers in the proper ratio to form mixed yarns. The obtained mixed yarns are wound on a metal frame, then pressed, preheated to the desired temperature and pressurized , At pressure and temperature to maintain a certain time, and then a certain rate of cooling stripping, and finally made of composite materials into a variety of test pieces.

Material performance test

Bending performance test, the sample size: 80.00mm × 12.5mm × 2.0 ± 0.2mm, according to GB3356-87 standard, in the computer control electronic universal testing machine, record the intensity - deflection curve.

Interlayer shear test, sample size: 20.00mm × 6.0 ± 0.5mm × 2.0 ± 0.2mm, according to GB3357-87 standard, also in the computer control electronic universal testing machine, record the intensity - deflection curve.

Impact fracture toughness test, sample size: 60.00mm × 6.0 ± 0.5mm × 4.0 ± 0.2mm, prefabricated crack treatment, in the XCJ-4 impact testing machine.

The fracture morphology was observed and photographed on a CamScan-4 scanning electron microscope.

PET melting temperature is in the DSCV2.01 Dupont900 test equipment on.

Experimental Results

Three sets of continuous glass fiber reinforced composite materials with different surface treatment, the impact of fracture toughness shown in Figure 1. The bending strength and impact strength of the material are listed in Table 1. Table 1 also lists the maximum impact fracture toughness values for the three groups of materials with a prefabricated fracture depth of about 15 mm. A typical impact fracture specimen of the three groups of materials after impact fracture is shown in Fig 2.

Figure 3 for the three groups of composite material impact fracture electron microscopy.

Discussion and Analysis

According to the fracture model of the fiber composite material, the fracture of the material is broken by the matrix, the shear failure of the fiber and the matrix interface, the frictional work of the fiber and the matrix after debonding, the fiber breaking at the weak point, the retraction of the fiber in the matrix And the broken fibers are removed from the separation matrix. If Rt is used to represent the total fracture toughness, according to the above fracture mechanism,Rt can be expressed as: Rt = Rs + RdfRr + Pp

Among them, Rs, Rdf, Rr and Pp, respectively, said surface energy, debonding after the friction, stress redistribution and fiber removal. And Rs includes the breaking force Rf of the fracture fiber, the fracture work Rm of the fracture matrix and the interface debonding power Rd. In this paper, the same glass fiber reinforced PET thermoplastic resin matrix composites were developed. The Rf and Rm were the same, while the debonding was the most important contribution to Rs. Rr, Rdf and Rp were mainly by the flexibility of the interface , The length of the fiber is determined by the length of the fiber with the interface between the changes in the interface will be very different.This difference is the main reason for the fracture toughness of the material. For the three groups of different surface treatment of glass fiber reinforced PET composite materials, the specific situation is analyzed as follows. Figure 1 shows the relationship between the impact toughness of the three materials and the depth of the prefabricated fracture. The figure clearly shows that the material treated by the functional coating has the highest impact fracture toughness, followed by dewaxing, and the worst of the material without any treatment.As the preparation of the three materials are used in the same molding process conditions (molding temperature: 270 ℃, molding pressure 3.6MPa, holding time 20min,Cooling rate of 16 ℃ / min), the material in the reinforcing fiber and the matrix fiber ratio of the same, the three materials, fiber volume content (Vf) were 55% Therefore, the difference of the fracture toughness of the three materials can be attributed to the difference of the three kinds of materials. materials.

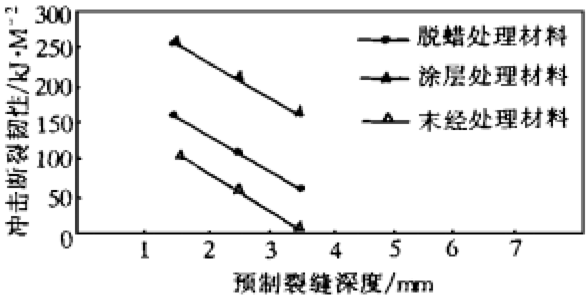


Fig.1 The relationship between impact fracture toughness and prefabricated crack depth of GF / PET composites

Table 1 Comparison of performance of composite materials with different glass fiber surface treatment

Material	Impact fracture toughness /Kj • m^{-2}			Bending strength /MPa			Impact strength /Kj • m^{-2}		
	average value	standard deviation	Discrete coefficient	average value	standard deviation	Discrete coefficient	average value	standard deviation	Discrete coefficient
Untreated material	110.8	6.38	0.06	594.0	29.6	0.49	126.3	6.25	0.05
Coating treatment materials	258.6	1.10	0.01	683.2	10.1	0.02	263.2	1.23	0.01

Dewaxing treatment material	159.3	2.05	0.01	716.0	12.3	0.02	165.0	3.21	0.02

From the comparison of the performance of the three materials in Table 1, the dewaxing treatment has the highest bending strength, since the bond between the glass and the substrate is the strongest. The flexural strength of the coated material is slightly lower than that of the former, indicating that the bond between the glass and PET in the material is slightly weaker than the former.However, from the table can be seen,the maximum impact fracture toughness value , the material of this point of bending strength in exchange for the impact of fracture toughness greatly improved, the percentage increased to 62%. This kind of strong and tough material is what we expect.As shown in Table 1, the performance of the material without any treatment, not only the minimum impact strength, and the bending strength is also the lowest. This indicates that the overall performance of the material is poor.

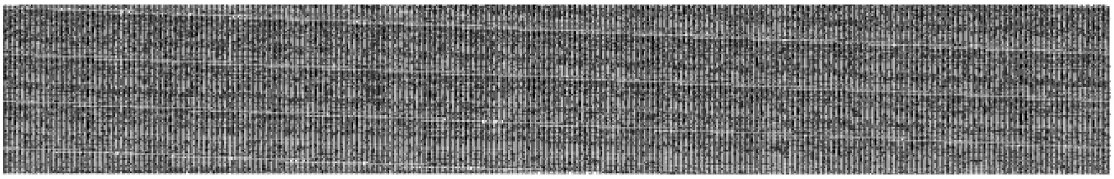
Based on the experimental data of Table 1 and the situation in Fig. 1, we can conclude that the effect of PET on the glass fiber infiltration is good and the interface bond is strong after the dewaxing treatment. Therefore, the external load is effectively transmitted to the substrate by force The glass fiber, the macro performance of the material for the highest bending strength.

But it is because of the strong bonding of the interface, the material in the impact load, the crack can not effectively spread along the interface between the fiber and the substrate, resulting in material energy absorption is limited, so the material prone to sudden brittle fracture, macro The impact of the material for the impact of fracture toughness value is low.Without any treatment of the material, the situation is just the same with the dewaxing of the material. As the textile type of wetting agent, the substrate on the glass fiber infiltration is very poor, the interface between them is a weak bond interface, the integrity of the material is not reflected, so the overall performance of the material are very poor.The experimental results show that the fracture toughness of the material treated by coating is the highest, and the bending strength is slightly lower than that of the dewaxing treatment, which indicates that the bonding condition of the interface is between the untreated and the dewaxing process, Interface status.That is, between the glass fiber and PET matrix formed with a glass fiber bond is not very strong flexible transition layer, the flexible layer can effectively crack along the fiber and the matrix interface to expand the material when the energy absorbed more , So the impact of the material fracture fracture value of the highest. Although such a transition layer makes the bonding of the glass fiber and the substrate weakened, but because of the matrix of the fiber infiltration is good, so little effect on the bending strength.

In combination with the above-mentioned fiber-reinforced composite fracture mechanism, and then according to Figure 2 typical impact fracture fracture toughness after the sample photo and Figure 3 composite impact picture of the fracture,it can further prove our inference.

It can be seen from Fig. 2 (a) that the composite material of the glass fiber has no obvious bending deformation, and there are many cracked monofilaments gathered in the middle of the compression. From Fig. 2 (b) we see that the main failure mode of the dewaxed material is the integral fracture of the material, the length of the fiber is small, and the phenomenon of slight fracture propagation along the fiber direction occurs.Figure 2 we see the coating of the material in the form of fracture damage both fiberglass fracture, dial out, fiber length is longer; another fiber and the matrix between the debonding, stratification, cracks along the fiber The direction of the expansion of the various forms of destruction.Therefore, according to the above-mentioned fiber composite fracture model, the glass fiber reinforced composite material, the glass fiber and the matrix formed by the coating between the glass fiber is not a strong bond between the flexible transition layer, the flexible layer can crack (Rf), fiber deodorization (Rdf), stress redistribution (Rr), fiber debonding (Rf), stress re-distribution (Rr)) Value, the toughness of the material has a greater improvement, and because the fiber and the matrix of the infiltration is better, so the bending strength decreased is also smaller.Dilute treatment of fiberglass composite materials prepared by the fiber and the substrate than the non-treatment of any material to improve many of the bending strength value of the highest, but because of the bonding of the material is too strong, which resulted in fracture cracks can not be effective The Rf, Rdf, Rr values are much smaller than the former, so the overall fracture toughness of the material is poor.The material prepared by the glass fiber without any treatment has a great effect on the overall properties of the material due to the poor impregnation between the fiber and the substrate, not only the fracture toughness value is small but also the bending strength is small.Figure 3 (a) fiberglass surface smooth, fiberglass adherent matrix rarely, Figure 3 (b), (c) fiberglass surface roughness, adhesion More of the matrix, which also confirmed the previous inference.

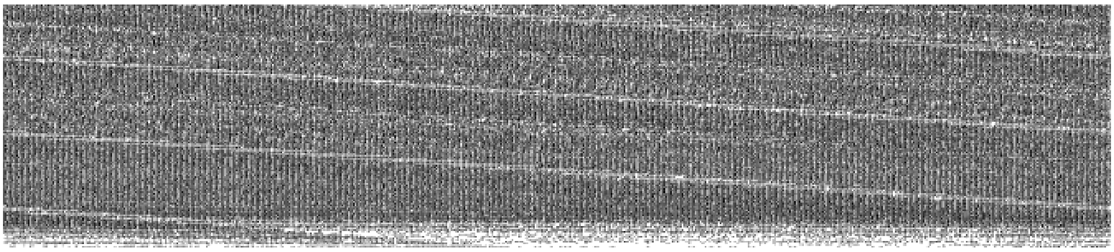
Finally, from the standard deviation and the discrete coefficient of the test value, the standard deviation and the discrete coefficient of the material treated with the coating and the dewaxing treatment are small, which indicates that the experimental data have high reliability and the material without any treatment Its standard deviation and discrete system are large, indicating that the experimental data data dispersion, low credibility.



(a) (b) (c)

Figure 2 Typical impact fracture toughness sample

A-untreated sample; b-dewaxing sample; c-coating sample



(a) (b) (c)

Fig.3 Electron micrograph of impact fracture of composite material

A-untreated sample; b-dewaxing sample; c-coating sample

Conclusion

The impact toughness of the composite coated fiberglass / PET composites was 62% and the flexural strength decreased by 4% compared with the uncoated and dewaxed composites. The functional coating of glass / PET composites increased by 133% and bending strength by 15% compared to those without any treated composites.