Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 7, S. 186-190, 4, 2023

Araştırma Makalesi

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 7, pp. 186-190, 4, 2023

Research Article

An overview of the mechanical characterizations and applications of chopped fiber reinforced composites

Sakine KIRATLI[1*]

[1]Department of Mechanical Engineering / Faculty of Engineering, Çankırı Karatekin University, Türkiye

*Email of corresponding author: skiratli@karatekin.edu.tr

(Received: 21 April 2023, Accepted: 10 May 2023)

(DOI: 10.59287/ijanser.2023.7.4.648)

(1st International Conference on Recent Academic Studies ICRAS 2023, May 2-4, 2023)

ATIF/REFERENCE: Kıratlı, S. (2023). An overview of the mechanical characterizations and applications of chopped fiber reinforced composites. *International Journal of Advanced Natural Sciences and Engineering Researches*, 7(4), 186- 190.

Abstract – Composite materials are widely used in many industries due to their basic properties such as high strength, high rigidity, and lightness. However, composites with desired properties differ in each sector. Fiber reinforcement and matrix selection vary depending on application requirements. Composites consisting of reinforcement and matrix elements are classified according to these elements. Chopped fiber reinforced composites, which are included in the classification depending on the reinforcement element, have a wide range of applications. Apart from lightness, it has many advantages, such as high strength, high rigidity, low thermal conductivity, corrosion resistance, and ease of production. Their lower cost of production compared to other composites makes them attractive. It is very important to make various characterizations of these composites in order to improve their properties and expand their use in the places where they are used. Researchers have done many studies on this subject. In this article, a review of the studies is presented. Various mechanical and thermal tests and their results were examined. Different internal structure observations are handled with analysis methods. In addition, the application of chopped fiber reinforced composites is detailed. Suggestions were made for the problems limiting the use of these materials.

Keywords – Chopped Fiber, Polymer Matrix, Mechanical Characterization, Processing, Application.

I. INTRODUCTION

Great efforts have been made to design and use lightweight structures in order to use energy effectively in various sectors [1-5]. Especially in the automotive and aviation sectors, lightness is important in terms of energy savings. In these sectors, continuous fiber reinforced composites are generally used. However, these composites are costly, difficult to process, and time consuming to manufacture. Chopped fiber reinforced composites, on the other hand, are both low in cost and suitable for mass production. Therefore, they are an alternative to continuous fiber reinforced composites [5]. Jacob et al. have shown applications in the automotive industry in their studies [1-2].

This study summarizes the production, characterization, and possible applications of chopped fiber modified composites. The importance of the effect of these composites with various mixture designs in applications is briefly examined with various test techniques in terms of mechanical durability and functionality. Since the examinations include many examples in terms of usage prevalence, they include polymer matrix composites rather than metal and ceramic matrix composites. Various studies are being reviewed for processes considered to improve the properties of chopped fibers. The findings of the literature study point to the potential use of chopped fiber reinforced composites.

A. Chopped fibers

Fibers are examined in two groups as natural and synthetic. Fibers such as glass, carbon, and aramid, which are widely used, are in the synthetic group, while fibers such as banana, hemp, sisal, linen, and jute are in the natural group. Although current applications are for examining a single fiber type, the use of hybrid fiber is also becoming widespread. There are continuous and discontinuous uses of synthetic fibers. The discontinuous form of chopped synthetic fibers is shown in Figure 1.

Figure 1. Glass, carbon and aramid chopped fibers.

Glass fiber is the most widely used type in fiber reinforced composites, especially in terms of cost. As seen in Table 1, there are types of glass fiber such as A, C, D, and E. However, carbon fibers are among the high-strength materials among all fibers. For this reason, it is preferred in the aviation and automotive sectors. Aramid fibers, on the other hand, find a place, especially in the defense industry, due to their high-speed impact resistance.

Table 1. The physical properties of glass fibers [6].

Classes of GFs	Physical properties
A glass	High durability, strength and electrical resistivity
C glass	High corrosion resistance
D glass	Low dielectric constant
E glass	Higher strength and electrical resistivity
AR glass	Alkali resistance
R glass	Higher strength and acid corrosion resistance
S glass	Higher tensile strength

The dimensions of various production methods for short fiber in discontinuous form are given in Table 2. As can be seen from Table 2, a wide variety of fiber lengths will be available, depending on the type of material used and the method chosen to bring it into its final shape [7].

Table 2. Typical size parameters for discontinuous short fibers [7].

Material	Preprocessed fiber length (mm)	Processed fiber length (mm)
Polyester-epoxy-CSM	50	50
Polyester Molding compounds SMC	25	25
Polyester Molding compounds BMC	12	<4
Injection molding thermoplastics	3	<3

B. Chopped fiber reinforced composites

Using small fibers that are randomly oriented and distributed in a matrix material, chopped fiber reinforced composites are one type of fiber-reinforced composite. Chopped fiber modified composites are combined with various matrix elements. Matrix elements are also available as polymers, metals, and ceramics. Epoxy, polyester, and vinylester take the first place in polymer matrices, which are the most widely used types. Chopped fiber-reinforced thermoset composites are suitable for production methods such as hand lay-up and resin transfer molding [7]. E-glass fibers embedded in polyester, which is the cheapest combination, are the most widely used types [8-9]. The use of vinylester matrix has also become widespread [10-11]. Short-fiber-reinforced polymer composites exhibit anisotropy in their mechanical characteristics, which is direction-dependent, as a result of the partial orientation distribution of the fibers in the final components [7].

C. Application of chopped fiber reinforced composites

Automotive, aerospace, and sporting goods are just a few of the industrial uses for chopped fiber reinforced composites. Chopped fiber reinforced composites are utilized in the automotive industry to make body panels, bumpers, and spoilers because of its high strength-to-weight ratio, solid impact resistance, and affordable price. Due to their high strength-to-weight ratio, rigidity, and superior fatigue resistance, chopped fiber reinforced composites are utilized in the aerospace sector to produce elements including fuselage, wing structures, and engine components. Due to their superior qualities, including high rigidity, strength, and shock absorption, chopped fiber reinforced composites are used to make components for sports equipment like bicycle frames, golf club shafts, and tennis rackets.

II. Materials and Method

In this study, composites with different polymer matrixes reinforced with various synthetic chopped fibers were investigated. For this purpose, commonly used matrices such as epoxy, polyester, vinylester, and fibers such as glass, carbon, and aramid were investigated. Characterizations (mechanical, thermal, etc.) were made in accordance with various standards. An appropriate standard was used for each test.

Cutting, mixing, compounding, and molding are some of the phases in the processing of chopped fiber reinforced composites. The mechanical characteristics and performance of chopped fiber reinforced composites are heavily influenced by the fiber, polymer matrix, and manufacturing conditions. Chopped fiber reinforced composites have been produced using a variety of processing techniques, such as hand layup, compression molding, and injection molding. For tiny and straightforward elements, the most popular technique is hand layup. Using a brush, roller, or spray gun, the resin is then placed over the chopped fibers in the process. The fibers are initially laid out randomly on a mold surface. The part is cured at room temperature or in an oven following the application of the resin. The process of compression molding, which is frequently used for large and complex items, involves pre-forming the fibers into the mold cavity and then using pressure and heat to consolidate the fibers and cure the resin.

And finally, the process of injection molding is utilized to create parts in large quantities. This procedure involves mixing chopped fibers with resin before injecting the mixture into a mold, where it is pressure-cured.

Figure 2 shows an example of mixing reinforcement and matrix materials. In Figure 3, the operation of the injection molding process and the samples obtained as a result of this process are given.

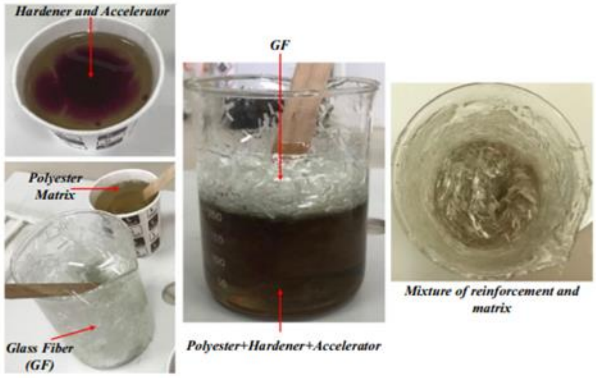

Figure 2. Production stages of the reinforcement and matrix material mixtures [12].

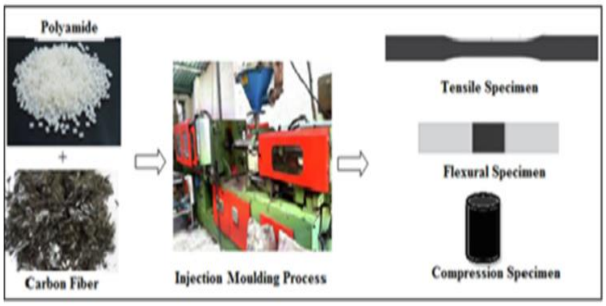

Figure 3. General manufacturing procedure for specimens [13].

III. Results and Discussion

The mechanical behavior of fiber-reinforced composites varies depending on the fiber strength, matrix strength, and interfacial adhesion strength between fiber and matrix [14-15]. Evaluation of the mechanical, thermal, and morphological characteristics of chopped fiber reinforced composites is necessary for their characterization. Chopped fiber reinforced composites' mechanical characteristics have been evaluated using a variety of methods, including tensile and flexural testing, impact tests, and hardness tests. The greatest stress a material can sustain before failing under a tensile load is determined using tensile tests. The greatest stress a material can withstand before failing under a bending load is determined via flexural tests. The energy needed to shatter a material under an impact load is measured via impact testing. In order to determine a material's resistance to being indented, hardness tests are utilized. Microscopy, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and dynamic mechanical analysis (DMA) are other sophisticated characterisation methods.

For lightweight applications, Chen et al. [16] looked into the production and characterisation of chopped carbon fiber reinforced polypropylene composites. They discovered that the mechanical characteristics of the composites, such as tensile strength and flexural modulus, were improved by the addition of carbon fibers. The mechanical and thermal characteristics of chopped glass fiber reinforced polypropylene composites were investigated by Zhang et al. [17]. They noticed that adding glass fibers improved the composites' flexural strength and modulus but decreased their impact strength. Chopped carbon fiber's impact on the mechanical and thermal characteristics of composites made of carbon fiber-reinforced polyamide 6 was investigated by Ahn et al. [18]. They discovered that the tensile and flexural properties of the composites were enhanced by the inclusion of chopped carbon fibers. The production and characterisation of chopped carbon fiber-reinforced thermoplastic composites were reviewed by Yang et al. [19]. They discovered that the fiber length, orientation, and content had a significant impact on the composites' mechanical characteristics. The impact of chopped carbon fiber content on the mechanical characteristics of epoxy resin composites was examined by Zhou et al. [20]. They discovered that while adding carbon fibers improved the composites' tensile and flexural capabilities, it had no impact on their impact strength. Chopped fiber-reinforced composites have been used for energy storage applications, according to Zahid et al. [21]. They discovered that adding chopped fibers to the polymer matrix improved the composites' electrical conductivity and capacity for energy storage. The mechanical characteristics of chopped strand mat composites reinforced by natural fibers were reviewed by Shivaee et al. [22]. They discovered that using natural fibers not only reduced the mechanical qualities of the composites but also lessened their impact on the environment.

IV. CONCLUSION

Chopped fiber-reinforced composites are a promising class of materials that offer several advantages over continuous fiber-reinforced composites. The processing, characterization, and applications of chopped fiber reinforced composites have been extensively investigated in recent years. The various methods used to produce these composites are generally described. The characterization techniques and results used in the determination of mechanical properties such as tensile, bending, and impact are examined. In addition, various application areas, such as automotive and aerospace, were investigated. More research should be done to improve the performance of these composites and optimize their properties. New fiber and polymer types should be discovered for this purpose.

REFERENCES

[1] Jacob, G.C., Starbuck, J.M., Fellers, J.F., Simunovic, S. & Boeman, R.G. (2006). Fracture toughness in tandom-chopped fiber-reinforced composites and their strain rate dependence. *Journal of Applied Polymer Science*, 100, 695-701.

[2] Jacob, G.C., Starbuck, J.M., Fellers, J.F., Simunovic, S. & Beoman, R.G. (2006). Crashworthiness of various rancom chopped carbon fiber reinforced epoxy composite materials and their strain rate dependence. *Journal of Applied Polymer Science*, 101, 1477-1486.

[3] Corum, J.M., Battiste, R.L., Ruggles, M.B. & Ren, W. (2001). Durability-based design criteria for a chopped-glass-fiber automotive structural composite. *Composites Science and Technology*, 61, 1083-1095.

[4] Dahl, J.S., Smith, G.L. & Houston, D.Q. (2005). The influence of fiber tow size on the performance of chopped carbon fiber reinforced composites. In: materials and processing technologies for revolutionary applications, *37th ISTC Conference Proceedings*, Seattle, Washington.

[5] Pan, Y., Iorga, L. & Pelegri, A.A. (2008). Numerical generation of a random chopped fiber composite RVE and its elastic properties. *Composites Science and Technology*, *68*(13), 2792-2798.

[6] Sathishkumar, T.P., Satheeshkumar, S. & Naveen, J. (2014). Glass fiber-reinforced polymer composites: A review. *Journal of Reinforced Plastics and Composites*, 33, 1258-1275.

[7] Monfared, V. (2020). Problems in short-fiber composites and analysis of chopped fiber-reinforced materials. In New Materials in Civil Engineering (pp. 919-1043). Butterworth-Heinemann.

[8] Barre, S., Chotard, T., & Benzeggagh, M.L. (1996). Comparative study of strain rate effects on mechanical properties of glass fibre-reinforced thermoset matrix composite. *Composites Part A: Applied Science and Manufacturing*, *27*(12), 1169-1181.

[9] Ibrahim, S., Polyzois, D., & Hassan, S. K. (2000). Development of glass fiber reinforced plastic poles for transmission and distribution lines. *Canadian Journal of Civil Engineering*, *27*(5), 850-858.

[10] Srivastava, V. K. (1999). Influence of water immersion on mechanical properties of quasi-isotropic glass fibre

reinforced epoxy vinylester resin composites. *Materials Science and Engineering: A*, *263*(1), 56-63.

[11] Srivastava, V. K., & Hogg, P. J. (1998). Moisture effects on the toughness, mode-I and mode-II of particles filled quasi-isotropic glass–fibre reinforced polyester resin composites. *Journal of Materials Science*, *33*, 1129-1136.

[12] Çelik, Y.H., & Türkan, C. (2020). Investigation of mechanical characteristics of GFRP composites produced from chopped glass fiber and application of taguchi methods to turning operations. *SN Applied Sciences*, 2, 1-12.

[13] Choudhari, D.S., & Kakhandki, V.J. (2021). Comprehensive study and analysis of mechanical properties of chopped carbon fibre reinforced nylon 66 composite materials. *Materials Today: Proceedings*, 44, 4596-4601.

[14] Erden, S., Sever, K., Seki, Y. & Sarikanat, M. (2010). Enhancement of the mechanical properties of glass/polyester composites via matrix modification glass/polyester composite siloxane matrix modification. *Fibers and Polymers*, 11, 732-737.

[15] Prashanth, S., Subbaya, K.M., Nithin, K., & Sachhidananda, S. (2017). Fiber Reinforced Composites - A Review. *Journal of Material Sciences & Engineering*, *6*(3), 2-6.

[16] Chen, S., Xu, Q., Zhang, X., Li, Y., Wang, H., & Li, H. (2019). Processing and characterization of chopped carbon fiber reinforced polypropylene composites for lightweight applications. *Polymer Composites*, 40(11), 4593-4602.

[17] Zhang, J., Li, Y., Zhang, Q., Wang, H., & Li, H. (2018). Mechanical and thermal properties of chopped glass fiber reinforced polypropylene composites. *Journal of Reinforced Plastics and Composites*, 37(2), 87-96.

[18] Ahn, S., Kwon, S., Kim, S., & Lee, B. (2017). The effect of chopped carbon fiber on the mechanical and thermal properties of carbon fiber-reinforced polyamide 6 composites. *Polymer Engineering & Science*, 57(9), 933-942.

[19] Yang, Y., Dong, J., Zhang, Q., & Guo, L. (2020). Manufacturing and characterization of chopped carbon fiber-reinforced thermoplastic composites: A review. *Journal of Composites Science*, 4(1), 9-20.

[20] Zhou, X., Hu, Y., & Wei, L. (2018). Effect of chopped carbon fiber content on the mechanical properties of epoxy resin composites. *Journal of Reinforced Plastics and Composites*, 37(3), 170-179.

[21] Zahid, M., Khoo, S.Y., Huang, N.M., & Lim, H.N. (2019). Chopped fiber-reinforced composites for energy storage applications: A review. *Journal of Materials Research and Technology*, 8(1), 1207-1220.

[22] Shivaee, H.A., Aliheidari, N., & Rahmanian, S. (2020). Mechanical properties of chopped strand mat composites reinforced by natural fibers: A review. *Journal of Industrial Textiles*, 49(8), 1113-1143.