

Chapter 4

Mechanical and Tribological Properties of Polymer Composites Developed by FDM

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ABSTRACT

In the coming years, researchers and manufacturers will be more concerned with the demand for products that are easy to construct and can be rendered seamlessly, even at complicated geometries, with the touch of a button. These requirements will be met by the advent of additive manufacturing. This will serve as the catalyst for a revolution. Additive layer manufacturing (ALM), also known as additive manufacturing (AM) or more commonly referred to as 3D printing, is a modern fabrication technology that uses a variety of raw materials to produce items such as medical implants and aircraft wing components by printing layers of material based on 3D digital models. In this chapter, the authors provide a comprehensive overview of the mechanical and tribological behaviour of ceramic, metallic, and fiber-reinforced polymer composites that are made by a range of additive manufacturing (AM) techniques. These composites can be used in a variety of applications, including aerospace, automotive, and medical.

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INTRODUCTION

Nature provides every new thought if perceived carefully. Composites are one such form of materials that exist in nature. Composite material is generally amalgamation of two or more materials, having different properties, which do not blend into each other and provide better results in comparison to original individual material. The natural substance like wood and parts of human body are best examples of composite materials. Utilization of composite materials for human need have been evolving from 1500 BC and is still in continuation (Johnson, 2018). In the recent past the advancement in composite material has been evolving very rapidly. Ease of compatibility with various forms of utilization has seen major boost and has been applied to newer domains of application. Initially the usage of composite materials was restricted in aerospace, defense and high value goods industry; however, with its usage in various forms it has been evolved in every domain and we can see its applications in and around us. The advantages of using composite materials are low cost, better performance, light weight, environment compliance and safe for usage (M. P. Todor & Kiss, 2016; P. Todor et al., 2017)

Composite materials consists of three basic components viz; matrix, reinforcement and interphase region (Ghosh, 1991). The improvement in desired properties can be established with these parameters by choosing the right form of matrix, reinforcement and the manufacturing process (Jim, 2015). Figure 1 and 2 shows classification of composites based on matrix and reinforcement respectively. The categorization of matrix materials is in three forms, metal, ceramics and polymer. Polymer composites are widely used in current applications in various fields. There are two forms of polymer matrix available which are thermoplastic and thermoset plastic. Thermosets are kind of plastics that transform from liquid to solid due to certain reactions or curing. This change from liquid to solid state is irreversible and permanent. Once the plastic is completely set, heating it will lead in degrading the material. Melting of material won't occur in thermoset as the degradation temperature is near to melting temperature and hence degradation occurs. On the other hand, thermoplastics are melt process able plastics. The processing of these plastics takes place by heating. Addition of quantifiable amount of heat leads in increase in temperature above the melting point where melting occurs and it liquefies and softens for the processing. Withdrawal of heat from this plastic leads in glasslike solidification. The process of heating and solidifying can be carried out for these plastics, however, repeated cycles leads in deterioration of properties of plastic. Reinforcements used in composites are categorized into fibers, flakes or particles. Addition of each of these reinforcements help in enhancing the properties of the composites and can be used for certain applications. Fibers as reinforcement is most commonly used reinforcement in polymers matrix like ABS, PLA, PC, PEEK etc. Fibers provide great strength to matrix because of its aspect ratio in terms of L/D , enhanced shear stress transfer due to its alignment in matrix, forms a great bonding between matrixes providing good interface. There are numerous forms of fibers used as reinforcement; among them most commonly used are carbon fibers, glass fibers, aramid fibers and boron fibers. There are numerous methods for development of composites. The method of manufacturing is chosen depending on the part to be developed, material chosen, design and application.

Open contact moulding is commonly used form of manufacturing process which includes hand layup and spray up process. These both processes are used in tandem to reduce the labor cost. The process is basically used in making large components which are simple in their design. Another form of manufacturing processes are resin infusion processes which are more sophisticated than open moulding processes and more automated. Resin transfer moulding, reaction injection moulding, vacuum-assisted resin transfer moulding and resin film infusion are some of the processes under this category. Compression moulding

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